Study on energy prices, costs and their impact on industry and households

Final report

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Abbreviations

Abbreviation	Full name
ACER	Agency for the Cooperation of Energy Regulators
AER	Australian Energy Regulator
Bbl	Barrel of oil
CAPEX	Capital expenditures
CEIC	An international data provider company
CNG	Compressed Natural Gas
DG ENER	European Commission's Directorate-General for Energy
EBP	Estimated Border Price (natural gas)
EC	European Commission
EIA	Energy Information Administration (US)
EMOS	(EU) Energy Markets Observatory System
ERRA	Energy Regulators Regional Association
ETS	(EU) Emissions Trading Scheme
EU	European Union
EU27	27 Member States of the European Union
EUR	Euro
EV	Electric vehicle
FiT / FiP	Feed-in tariffs / Feed-in premiums
G20	Group of 20
GDP	Gross Domestic Product
GJ	Gigajoule
GVA	Gross Value Added
IEA	International Energy Agency
IESO	Independent Electricity System Operator (Ontario)
IRR	Internal rate of return
kWh	Kilowatt hour
LMDI	Log Mean Divisia Index
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MS	Member State
Mt	Megatonne (1 million tonnes)
Mtoe	Million tonnes of oil equivalent
MWh	Megawatt hour
NACE	The statistical classification of economic activities in the EU, from the French *Nomenclature statistique des activités économiques dans la Communauté européenne*
NRA	National Regulatory Authorities
OECD	Organisation for Economic Cooperation and Development
OECD STAN	Organisation for Economic Cooperation and Development Structural Analysis Database
OPEC	Organisation of the Petroleum Exporting Countries
PPS	Purchasing Power Standard
USD	United States Dollar
TSO	Transmission System Operators
VAT	Value Added Tax
WTI	West Texas Intermediate (crude oil)

Table 0-1 Country abbreviations list (ISO 2-digit codes)

EU28	Code	Non-EU G20	Code
Austria	AT	Argentina	AR
Belgium	BE	Australia	AU
Bulgaria	BG	Brazil	BR
Croatia	CZ	Canada	CA
Cyprus	CY	China	CN
Czech Republic	CZ	India	IN
Denmark	DK	Indonesia	ID
Estonia	EE	Japan	JP
Finland	FI	Mexico	MX
France	FR	Russia	RU
Germany	DE	Saudi Arabia	SA
Greece	EL	South Africa	ZA
Hungary	HU	South Korea	KR
Ireland	IE	Turkey	TR
Italy	IT	United States	US
Latvia	LV		
Lithuania	LT		
Luxembourg	LU		
Malta	MT		
Netherlands	NL		
Poland	PL		
Portugal	PT		
Romania	RO		
Slovakia	SK		
Slovenia	SI		
Spain	ES		
Sweden	SE		
United Kingdom	UK		

Executive summary

This final report presents the final results on each of the three tasks of this work. The final report is complemented by the following supporting deliverables:

- Task 1 Analytical tool PP (Petroleum Products);
- Task 1 data tool EL (Electricity);
- Task 1 data tool NG (Natural Gas);
- Task 2 data tool;
- Task 3 database.

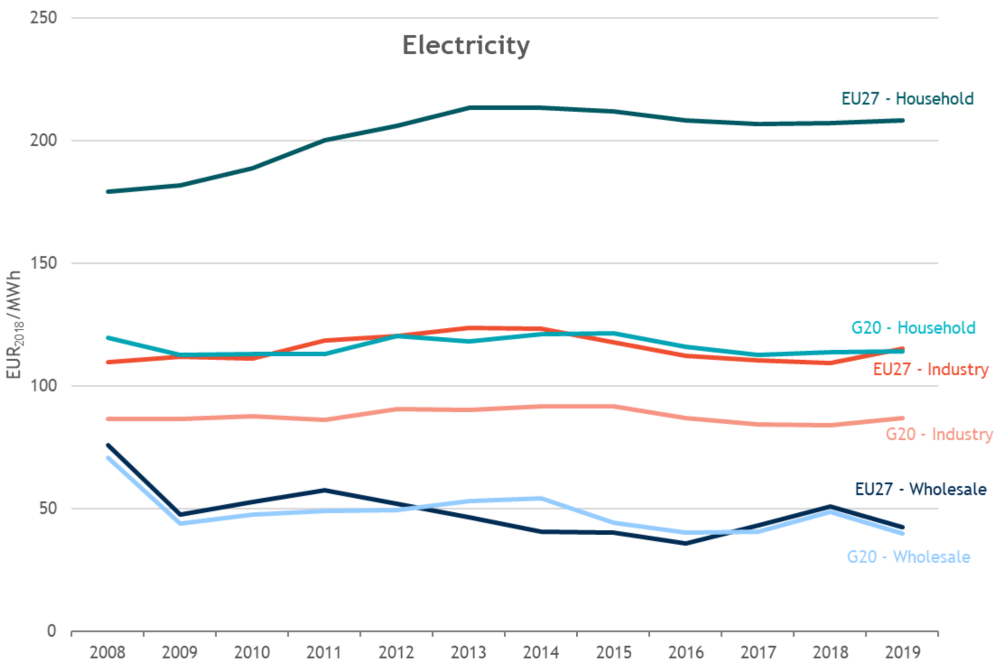
Summary of findings

Task 1

Our work on task 1 focussed on extending the analysis presented in the previous report (2018) to include data covering 2018 and 2019 and to provide new and more detail on prices of biofuels and alternative fuels used in transport, such as electric vehicle charging costs. A key difference from the previous edition is that we group EU data excluding the UK (EU27). Data coverage for 2018 and 2019 is good overall. The following paragraphs present the key findings associated with the four main sections of the Task 1 chapter.

Electricity prices

Figure 0-1 Comparison of EU27 weighted average with G20 (trade) weighted average



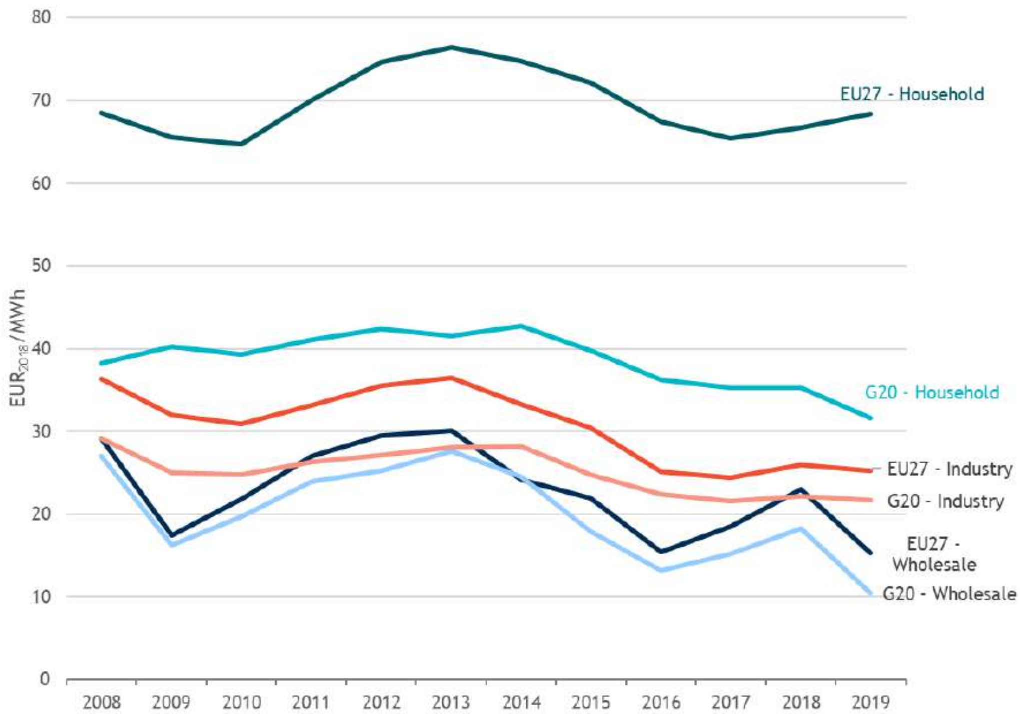
Sources: Own calculation,
Note: the G20 weighted averages are calculated on the basis of all available price data for a particular year, weighted in the total price by the share a country had in EU imports + exports 2017-2019. Coverage ratios of total trade range from 84-99% (household prices), 76-99% (industrial prices) and 36-74% (wholesale prices).

- Wholesale prices - EU27 average wholesale prices are comparable to most G20 countries and lower than some (Japan, Australia, Mexico, Turkey), and have seen favourable developments relative to many G20 countries between 2008-2019, but not compared to the US, China or Japan;

- Household prices - EU27 average retail prices are increasing over time, although relatively stable since 2013, while G20 prices are mainly stable or decreasing; EU27 prices are higher than most G20 countries and similar to some. Relatively high consumer taxes and levies in the EU and price regulation/subsidies in the G20 are amongst the main reasons for this. Relatively high network costs may also play a role although data on these in the G20 is very limited:
    - o Analysis of prices at Purchasing Power Standard (PPS) and in the context of average household income shows that prices in EU27 countries remain relatively high compared to other G20 OECD countries, and that for countries with relatively low GDP per capita, low nominal prices become much higher in PPP terms. When considering household consumption and income, this is further apparent, with electricity costs representing 3.3% of average household income on average but shares above 6% in Bulgaria, Romania and Portugal. Much higher average electricity consumption in the US does not translate to a similar burden on households as household income is much higher.
- Industrial prices - EU27 average industrial prices increased by around 5% between 2008 and 2019. Prices are comparable to China and lower than Japan, but almost double US levels. EU prices remain higher than most other G20 countries. Relatively high non-recoverable taxes in the EU and price regulation/subsidies in the G20 play an important role in this difference;
- As to the role of taxes and levies, network charges and mark-ups - by comparing wholesale and retail prices we find that the difference between the two is by far the highest in the EU (for households) with only a handful of G20 countries (US, CA, JP) having a significant difference between their wholesale and retail prices. This highlights that most G20 countries still regulate household prices. The same issue also exists for industry but is less acute than for households.

Natural Gas prices

Figure 0-2 Comparison of EU27 weighted average with G20 (trade) weighted average

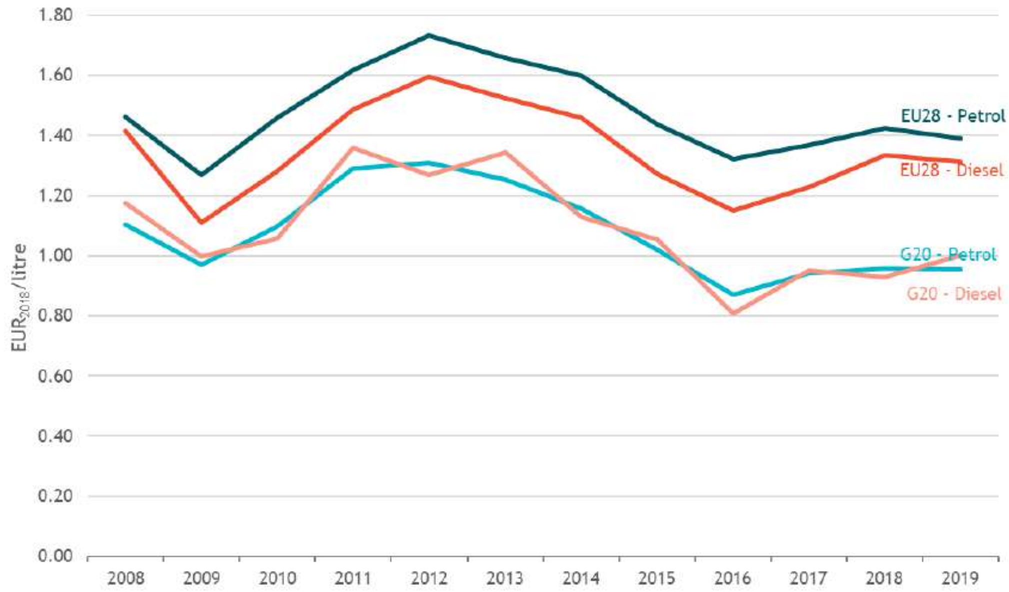


Source: Own calculations
Note: the G20 weighted averages are calculated on the basis of all available price data for a particular year, weighted in the total price by the share a country had in EU imports + exports 2017-2019. Coverage ratios of total trade range from 84-98% (household prices), 77-99% (industrial prices) and 60-97% (wholesale prices).

- Wholesale prices in the EU are similar to most other G20 countries, with the exceptions of the US, which benefitted from the onset of shale gas around 2010, and other major producers (Russia, Canada and (until recently) Australia) which have lower prices. Price developments have been relatively positive compared to East Asia (CN, JP, KO) but negative compared to the producers;
- Household prices - average EU27 prices are considerably higher than most other G20 countries (except JP and KO), although at the same level in 2019 as 2008. Relatively high consumer taxes in the EU and price regulation/subsidies in the G20 play an important role in the differences;
- Industrial prices – average EU27 prices are lower than East Asian countries (Japan, South Korea, China), but higher than most other G20 countries, including the US. Prices have declined since 2008 in the EU, but apart from East Asia and Mexico prices have declined faster elsewhere in the G20. As before non-recoverable taxes in the EU and price regulation/subsidies in the G20 play a role in the difference;
- As to the role of taxes and levies, network costs and mark-ups - by comparing wholesale and retail prices we find that the difference (for households) between the two is the highest in Japan, and second highest in the EU. In most non-EU G20 countries the difference is less than half EU average levels and in some (AR, MX, TR) less than, or near, zero. For industry there is a difference of around 5 EUR/MWh between the weighted averages of both the EU27 and non-EU G20, representing around 20% of the total price. The difference compares relatively favourably with JP, CN, US and CA, but other G20 countries (TR, BR, AR, RU) have near zero or negative differences, highlighting likely price regulation/subsidies.

Petroleum product and alternative fuels prices

Figure 0-3 Comparison of EU27 weighted average prices with G20 (trade) weighted average prices



Source: Own calculations

Note: the G20 weighted averages are calculated on the basis of all available price data for a particular year, weighted in the total price by the share a country had in EU imports+exports 2017-2019.

- EU prices, particularly for conventional automotive fuels (petrol, diesel), tend to be higher than in other G20 countries, highly driven by differences in taxes. Excluding taxes, EU average prices are comparable or lower than most G20 countries for petrol and diesel;
- For high and low sulphur fuel oils (primarily for marine transport), EU prices are comparable to international prices, both with and without taxes, as, in contrast to petrol and diesel. EU

taxes are also similar to international taxes. Taxes on these fuels are relatively low globally due to the relative ease with which shipping can refuel in lower cost jurisdictions and consequent tax competition. Increased international restrictions on the use of high sulphur fuels from 2020 is expected to have an impact on prices in future;

- For heating oil EU average prices are amongst the lowest in the G20 both including and excluding taxes. EU taxes on this product are relatively low compared to EU taxation of other fuels, although in a handful of EU countries (DK, SE, IT, PT) high taxes do lead to relatively high prices;
- EU LPG prices are amongst the lowest internationally both including and excluding taxes. Prices have generally declined since 2012;
- For CNG price data is limited for the G20, but comparison to the United States and G20 countries suggests EU prices are on average higher. EU prices have shown a small increase between 2013 and 2019;
- EU ethanol prices are higher than their US equivalents, but EU biodiesel prices are similar to comparable US and Asian benchmarks;
- Prices in all countries for oil-derived fuels tend to follow the crude oil price trend;
- For Electric Vehicles, the available price data suggests public charging prices of €150-€250/MWh in China, the United States and Japan. These prices are lower than those observed in Europe, with prices of €200-€350/MWh observed in the UK, Austria and Netherlands, and the highest prices of €250-€450/MWh observed in Norway, France, Germany and Spain. This points to a differential in pricing similar to that also observed for household retail electricity consumption.

Task 2

Task 2 analysis has updated and expanded on the calculations presented in the previous study (2018). The Task 2 database includes information on energy costs for industries in all EU Member States, non-EU G20 countries, and close EU trading partners including Norway, Switzerland, and Iceland. The data spans 2008-2019, but only data from 2010-2017 is used in our analysis, as comprehensive data availability could only be ensured for these years.

The dataset has been revised from its previous version: the EU28 has been adapted into the EU27, with the UK now labelled a non-EU G20 country. Additionally, data on Iceland have been included for the first time. Updated datasets and calculations have resulted in the following key findings. It is important to note that subsequent findings pertain to the whole value chain of the sectors (thus including upstream and downstream companies). It is specified where this is not the case (with a focus on the upstream companies i.e. the most energy intensive ones).

EU manufacturing sectors

Energy costs as a share of total (operational) production costs

- In the period 2008-2017, energy costs for the selected manufacturing sectors typically constituted between 1-10% of total (operational) production costs, although for several sectors the costs significantly exceeded 10% (e.g. Cement, lime and plaster, and Clay building materials);
- Energy costs for several sectors reached 10% or more of their total production costs in at least one year. These energy intensive sectors - including Pulp and paper, Glass, Clay building materials, Cement, lime and plaster, and Iron and steel - are most sensitive to energy prices, and cost changes and differentials;

- Among less energy intensive manufacturing sectors, energy costs typically constitute only 1-3% of operational (production) costs and are therefore a relatively minor cost component for most businesses in these sectors. In several manufacturing sectors – including Computer and electronics, Machinery and Equipment, Motor Vehicles, and Other Transport Equipment – energy costs do not exceed 1% of production costs;
- Over the period 2010-2017, energy cost shares fell in every sector:
  - The largest proportional percentage point decline in cost share amongst the most energy intensive sectors in manufacturing can be observed in the Pulp and paper sector, in which costs fell from a 11.4% share in 2010 to a 6.7% share in 2017 (i.e. a decline of the share of 4.7%, which however represents about 40% in proportional terms);
  - Other energy intensive industries including Iron and Steel, Cement, lime and plaster, and Clay building materials, experienced declining energy cost shares between 3-5% as well during the same time period;
  - Some of the sectors with smaller percentage point declines still saw proportionally high decreases in their energy cost share ratios, such as Non-ferrous metals, Basic chemicals, and Plastics products;
  - Less energy-intensive sectors presented lower decreases in energy cost shares in absolute terms, although in some cases very substantial in relative terms.
- Energy cost shares have fallen across all sectors not only over the full period covered, but more steeply in recent years, where declining energy costs between 2014-2017 made up for slightly increasing energy cost shares between 2010-2013 for Fruits and vegetables, Sawmills, Clay building materials, Non-ferrous metals, and Beverages;
- For the majority of manufacturing sectors, declining energy costs shares are primarily attributable to a decrease in energy costs, but also partly attributable to simultaneous increase in production costs. Some exceptions are sectors where:
  - Energy costs increased in absolute terms, but total operating production costs increased at a larger scale, therefore the share of energy costs as a share of production costs did not increase. This was the case for the sectors Fruits and vegetables, Abrasive products, Machinery and equipment and Motor vehicles;
  - Energy costs decreased in absolute terms, but production costs decreased at a smaller scale, as in the case of the Stone sector.

Energy consumption per fuel type and energy intensities[1]

- All sectors are affected by fluctuations in electricity prices, but these particularly impact total energy costs in Plastics, Non-ferrous metals, and Computers and electronics;
- Natural gas consumption drives energy costs in particular for the sectors Glass, Refractory products, Clay building materials, and Porcelain and ceramics;
- Coal still plays a major role in the manufacturing of Cement, lime and plaster, Abrasive products, and Iron and steel;
- Oil plays a substantial role in Refineries (mainly used as feedstock) and in the manufacturing of Basic chemicals and Cement, lime and plaster;
- “Other energies”, particularly biomass, contribute significantly to energy consumption for selected sectors including Sawmills (where it comprises more than 80% of the energy consumed), Man-made fibres (with 57%), Stone (with 38%) and Pulp and paper (with 29%);

[1] Where Energy intensity = Energy consumption (in tonnes of oil equivalent)/Gross Value Added (Euros)

- Energy intensity varies considerably depending on the sector:
    - Refineries, the Iron and steel sector and the Cement, lime and plaster sector are the most energy intensive sectors. They typically require more than 2 toe/energy consumption per thousand Euros of GVA;
    - These are followed by the Pulp and paper and Basic chemicals sectors, which require around 1 toe/energy consumption per thousand Euros of Gross Value Added (GVA).
- The energy intensities of the Refineries, Iron and steel, Clay building materials, and Man-made fibres sectors are most volatile, primarily due to fluctuations in GVA in these sectors:
    - Volatility in GVA for Refineries was driven by international oil prices dynamics;
    - Volatility in GVA for Iron and steel, Clay building materials, and Man-made fibres was driven by changes in economic activity and reduced output following the 2014 crisis in the EU.

Profitability

Given Gross Operating Surplus (GOS) as a proxy for profitability across industries:

- Most EU sectors maintained an average GOS share between 5-15%;
- The Pharmaceuticals and Cement sectors maintained the highest GOSs as shares of production costs, with an average of 26.6% and 22.9% respectively between 2010 and 2017;
- Non-ferrous metals and the Iron and steel sectors maintained the lowest GOSs as shares of production costs with averages of 7.6% and 4% respectively;
- Between 2010 and 2017, average gross operating surplus in general increased across most sectors;
- The highest proportional increases in GOS were experienced in the Iron and steel sector (103%), the Textiles sector (52%), and the Casting of metal sector (41%);
- GOS did proportionally decrease in several sectors, including Man-made fibres (-43%), Cement, lime and plaster (-23%), and Refineries (-21%);
- EU manufacturing sectors are on average less profitable than non-EU G20 counterparts including India, Mexico, Korea, Russia, and the United States, but as profitable as Norway and Switzerland and more profitable than Brazil.

EU non-manufacturing sectors

Energy costs as a share of total (operational) production costs

- Energy cost shares are particularly high in five sectors, at levels comparable to or even higher than the cost shares of energy intensive manufacturing sectors;
- Sectors with the highest energy cost shares include Land transport (30%), Air transport (18%), Mining of metal ores (19%), Electricity, gas and steam (11%), and Other mining (9%);
- Fuel costs are important drivers of production costs in the transport, electricity and gas sectors, and mining as they are inherently energy intensive activities;
- Energy cost shares for Accommodation and restaurants are between 3-5%, levels comparable to many energy-intensive manufacturing sectors;
- Energy cost shares are lower for the Construction (1%) and Wholesale and retail trade sectors (0.4%).

Energy intensities

- The highest energy intensities (in toe/thousand EUR) are consistently observed in the Air transport (1.7), Electricity, gas and steam (0.9), and Land transport (0.5) sectors;

- The Agriculture and Other Mining sectors have the next-highest energy intensities (around 0.2 toe/thousand EUR), at levels comparable to many non-intensive manufacturing sectors.

Profitability

- The Oil and gas and Mining of metal ores sectors maintained much higher GOSs than manufacturing sectors on average (80% and 36% respectively), though surpluses in the Mining sector steadily decreased between 2010-2016;
- Other non-manufacturing sectors maintain surpluses on par with their manufacturing counterparts, on average between 5-20%.

International comparisons

Energy costs as a share of total (operational) production costs

Trends in energy cost shares internationally vary per sector. Notably, across energy intensive subsectors:

- Norway has the highest energy cost shares in the Pulp and paper (16.2%) and Non-ferrous metals (7.9%) sectors in spite of lower electricity and natural gas prices than the EU's, due to their relatively higher energy consumption;
- Turkey has the highest energy cost share in the Refineries sector at almost 10%, followed by Japan (7.5%);
- Japan has the highest energy cost share in the Glass sector (18.8%);
- The United States has the highest energy cost shares in the Basic chemicals (35.2%) and Cement, lime and plaster (36.5%) sectors;
- In general, the EU27 has energy cost shares comparable to those of most international trade partners, although there are differences by sectors and regions;
- The EU27 has a relatively high energy cost share in Iron and steel (7.7%) and Non-ferrous metals (4.1%);
- The EU27 has a relatively low energy cost share in Refineries (1.9%).[2]

Energy intensities

The energy intensities of manufacturing and non-manufacturing sectors likewise varied considerably across countries:

- In Pulp and paper, the EU27's average energy intensity is more than twice as high as Japan and Korea's due to higher energy consumption on average in EU plants;
- In Refineries, again due to higher energy consumption levels, energy intensity for the EU27 is higher than all its international trade partners for which data were available;
- In Basic Chemicals, the EU27 has a lower than average energy intensity due to larger gross value added figures on average;
- In Iron and steel and in Non-ferrous metals, the EU27 has higher intensity levels than Switzerland but lower levels than Norway due to higher energy consumption levels in Norway;
- In Glass, the EU27 has lower energy intensity levels than Mexico and the United States, but higher intensity than Norway and Canada;
- In Agriculture, all countries and the EU27 have comparable energy intensities, with the exception of Mexico, where energy intensity is nearly three times as high as in Canada, which has the next highest intensity for agriculture;
- Turkey and China have the highest comparative energy intensities.

[2] When analysed with data from available sources at macro level (Eurostat SBS, IEA, etc.)

Profitability

Analysis of the profitability of international manufacturing sectors indicates that:

- India, Mexico, Korea, Russia, and Argentina exhibit consistently high ratios of GOS to total value added;
- The EU27 exhibits average profitability compared to international counterparts, with less volatility year-to-year;
- Profitability in several countries - Argentina, Indonesia, Mexico, and Japan - has oscillated sharply in recent years;
- Profitability in many countries increased from 2015 on, including in the EU27;
- EU manufacturing sectors are on average less profitable than non-EU G20 counterparts including India, Mexico, Korea, Russia, and the United States, but as profitable as Norway and Switzerland and more profitable than Brazil.

In non-manufacturing sectors:

- Mexico, Saudi Arabia, and Russia consistently exhibit the highest ratios of GOS to value added;
- Generally, the EU27 exhibits slightly lower-than average profitability levels compared to G20 countries, though higher profitability levels than Switzerland and China and levels comparable to the US and Japan;
- Profitability levels of the EU27's non-manufacturing sectors are slightly higher (2-3% higher) than profitability levels of its manufacturing sectors, whereas in Japan and in the US, profitability levels of manufacturing sectors are higher than those of non-manufacturing sectors.

Findings on energy intensive industries selected for bottom-up analysis

The results of bottom-up analysis are based on data collected from 96 plants across five industrial sectors: flat glass, zinc, ferro-alloys and silicon, fertilisers, and refineries.

In line with the inverse relation between electricity prices and the level of consumption found in the 2018 CEPS and Ecofys study on energy prices and costs in energy intensive industries[3], electricity prices and intensities across all analysed sectors are also found to be inversely related. Given higher energy consumption, sectors pay lower prices for electricity. Similarly, given higher energy intensity, sectors plants will most likely have higher consumption levels and thus tend to pay lower prices for electricity This effect is slightly less pronounced in the flat glass sector, where electricity price is higher on average than electricity price in the refineries sector in spite of its higher energy intensity. Likewise, sectors' natural gas intensities are inversely related to their natural gas prices. However, natural gas prices vary less widely across sectors than electricity prices as natural gas prices are largely set by international producers and cannot be negotiated down as easily as electricity prices.

The influence of energy prices and costs on the competitiveness of Energy Intensive Industries (EIIs) varies by sector:

- In flat glass, energy costs contributed positively to the restoration of the sector's profitability after 2016, but had a limited impact overall on the external competitiveness of the EU's flat glass sector with respect to its non-EU competitors. This is due to the fact that competitor countries have experienced even sharper declines in energy costs than the EU in recent years. The flat glass sector in the EU27 is at a strong cost disadvantage compared with competitors with a low-cost access to natural gas resources (including Russia, Belarus, Algeria, Turkey, and

[3] CEPS and Ecofys (2018), Composition and Drivers of Energy Prices and Costs: Case Studies in Selected Energy Intensive Industries - 2018.

Egypt). The EU flat glass sector compensates for differences in energy prices by competing on the technical quality of its products.;

- In zinc, international competitiveness of the EU sector can only be assessed by analysing the full cost structures of plants, but interviews with the International Zinc Association confirmed that EU production costs have approached average (and occasionally higher-than-average) international values in recent years;
- Ferro-alloys manufacturers view energy costs as key determinants of product competitiveness, since prices are determined by production costs in the sector. In ferro-alloys and silicon, a 2016-2019 increase in electricity prices reduced the profitability of the EU sector, but because the share of energy costs compared to production costs remained steady, the industry was able to maintain a relatively steady trade balance;
- In fertilisers, international gas cost dynamics can be key determinants of competitiveness; fertiliser producers in countries with very low cast costs undercut EU producers even when gas prices in the EU are low; with some fluctuations, international gas price differences have however remained relatively stable in recent years.
- In refineries, the costs of purchased energy (electricity & natural gas) account for a significant portion of their total production costs (between 8 and 14% on average).[4] When considering self-produced fuels, these play a significant role in the total production costs of refineries: between 8 and 13% [5] if crude oil price is taken into account as production costs. If crude oil costs are excluded from production cost (industry standard method), energy costs are estimated to be between 49 and 55%[6]. The operating costs of refineries are therefore dominated by the “other costs” (essentially the supply of the raw material, namely crude oil). Consequently, the profitability of refineries is essentially determined by the international markets: the price of crude oil is determined by the international oil market (Brent quotation), while refined products are priced as well on an international market driven by supply/demand equilibrium. The limited ability to make more specialised products, and the resulting inability to fully pass on increased costs reduces the profit margin of some European refineries. As a result, exposure of some refineries to international competition is relatively high.

Impacts of COVID-19 pandemic and its impacts on energy costs of selected EIIs

During the interactions and discussions with the different industry associations between June and September 2020, we received feedback regarding the possible impacts of COVID-19 on energy costs and their economic consequences for the different industries.

Most of the manufacturing sectors consulted have been substantially impacted by the COVID-19 crisis. COVID-19 has curbed significantly demand for products, reducing the sales revenues of industrial sectors and triggering reductions of production output in plants.

- For the Refineries sector, the lockdown measures had huge consequences on the petroleum product demand, particularly in countries with a strict lock-down, where demand for diesel and gasoline dropped by 60 to 80% yoy. Regarding jet fuel, the impact was even worse with

[4] For this project the definition of production costs included the costs of crude oil as feedstock. According to Concawe and Fuels Europe, the refining industry standard method to calculate production costs excludes the costs of crude oil. Therefore, the energy costs as a share of production costs presented in this table are lower than those calculated by the industry.
[5] Based in the results of own analysis from collected questionnaires of EU27 refineries.
[6] Solomon Associates (2019) via Concawe. Shares are the result of dividing energy costs (USD/bbl) by Cash OpEx (USD/bbl) for the EU28 for years 2016 and 2018. Cash OpEx is the sum of personnel costs, energy costs and other costs.

the demand reduced by 80 to 95% yoy, and slower recovery post lock down. In response to negative net margins, many refineries have reduced to minimum operating capacity;

- In the Flat glass sector half of the manufacturing sites were put "on hold"[7] by reducing flat glass furnace temperatures to 1200°C (normally they work at 1500-1600°C). As a result, energy costs per tonne of product will likely spike in 2020, reaching around 20 to 40% higher levels compared to 2019;
- Manufacturing operations were able to continue in the Zinc sector, however Zinc consumers often stopped their operations. This resulted in depressed demand and large stockpiling of zinc. The sector expects that production output will fall by around 15% in 2020 (compared to 2019 levels);
- In the Ferro-alloys and silicon sector production cutbacks and closures of companies already started. COVID-19 impacts in the medium to long-term are also expected by the sector. Since Global steel production has dropped, Ferro-alloys stocks increased. A surge of international imports is expected after the immediate crisis, together with aggressive policies from non-EU countries to revitalise their economies (e.g. product dumping into EU) in order to reduce excess stocks;
- Finally, the EU fertiliser industry has been able to maintain its production operations during the crisis mainly due to the sector being recognised as indispensable part of the food-chain. As a result, the Fertilisers sector was the only one that reported only a limited impact in their products demand and operations due to COVID-19.

In this context of low production and sales, it is important to assess what role energy costs play in the economic situation of most energy intensive industries. COVID-19 induced economic crisis and mobility restrictions prompted a very significant fall in energy prices during the first half of 2020. The fall in energy prices is not being followed by equivalent declines in the costs of other non-energy production inputs. Operational production costs were reduced as much as possible (especially thanks to the technical unemployment and other short-term aid programmes), but most of the other costs (e.g. renting of offices, plants and payments of interests) didn't change.

- This implies that that for sectors that are able to continue or modulate their production and adapt their energy consumption, the purchases of energy (the energy costs) should fall much more than the expenditure related to other non-energy production costs, resulting in lower shares of energy costs compared to production costs;
- In certain cases, energy costs still have a role in eroding profits in certain energy intensive sectors. This is the case for sectors with an important amount of their energy fixed, or cannot be reduced along with the decline in output. In these cases, the firms could be suffering a disproportionate increase in the share of their energy costs in production costs (as is the case of the Flat glass sector).

Decomposition analysis

- At an aggregate level across all the considered manufacturing sectors, energy costs for EU industry over the period 2010-2017 decreased by ~13%. Increasing industrial sector output, predominantly driven by domestic demand, has boosted the industrial demand for energy as a production input and increasing energy prices, especially electricity prices, have pushed energy input costs upward. However, this upward pressure on energy costs has been entirely

[7] The "hot hold" is a means through which to avoid shutting down furnaces, as furnaces need to be completely rebuilt after full shutdowns, at the cost of tens of millions of euros and several months dedicated to the rebuild.

offset by improvements in energy intensity, which for the most part have come directly from improvements in energy efficiency rather than structural change or fuel switching;

- Output increased in most EU27 industry sectors boosting industrial energy use and costs (in absolute terms). Highly energy intensive sectors had the lowest output growth, while sectors with lower energy intensity generally saw higher output growth;
- For aggregated industrial sectors in the EU27, an improvement in energy intensity contributed to a reduction in energy costs between 2010-2017;
- The energy intensity effect was analysed further to see the extent to which industry structural change or fuel switching contributed to the improvements in energy intensity observed over the period. Overall, neither structural change nor fuel switch were found to be a substantial driver of the energy intensity effect. This suggests that real energy efficiency improvements drove the reduction in energy intensity over the period;
- The largest reduction in energy intensity was observed in the less energy intensive sectors. There are two plausible explanations for this. First that the reduction in energy intensity came through economies of scale. Second, fast output growth might have also led to investments in new, more efficient, industrial equipment and factories. The most energy intensive industries saw much smaller improvements in energy intensity over the period. This could be because these industries have already invested heavily in energy efficiency to maintain international competitiveness;
- In most EU27 industry sectors, increases in average energy prices have contributed to an increase in energy costs over the period 2010-2017. This is largely driven by increases in industrial electricity prices. Sectors where oil, coal or gas make up a larger share of the energy mix have seen smaller impact of energy prices on energy costs, as prices have fallen for these fuels over the period;
- At the EU27-level, Eurostat SBS data shows that an increase in total industry production costs over the period is almost entirely explained by increases in other (non-energy) costs. Energy costs have contributed to a very small, almost insignificant, reduction in total production costs;
- Comparing the EU27 energy costs estimated from its components (price and energy consumption) with the Eurostat SBS purchase of energy products shows there is a residual effect contributing to the evolution of energy costs. The residual effect for most sectors shows a negative bias implying we are not capturing some factor reducing energy cost over the period. This residual effect encapsulates some known limitations of the analysis including not capturing the price trend of other fuels (Biomass waste & heat), additional exemptions from taxes & levies and the limited availability of energy consumption data for some individual sectors.

Task 3

The aim of this task was to collect, monitor and organise hourly data (prices and generation by type) on organised power markets in G20 countries, along with information on subsidies and investments, to assess the impact of realised prices (power generation weighted average market price) and support interventions on the profitability of investments in different power generation technologies and fuel types.

Data collection and database

- Regarding hourly data on power generation, the current database compiles a significant amount of data with more than 100 million values and 2 000 series coming from around 50 sources. The database covers the following technologies: solar PV, wind onshore, wind offshore, hydro, coal, gas and nuclear and around 50 countries, including Europe and G20 countries;
- Support intervention data were **collected from EMOS EC's study** and additional data collection from national regulators. The main difficulty laid in converting all the specific sub technology, system or system size dependent subsidies into aggregated values for one technology;
- A dashboard was developed with the help of MS Power BI to process and extract data (e.g. extraction of realised price);
- The profitability analysis relies on a central scenario **- Baseline (Metis' 2050_LTS_15TECH)**, that is in line with existing 2030 & 2050 EU objectives and existing energy and policy measures.

Power markets

Assumptions/observations

- The main marketplaces for standardized traded products are power exchanges and over the counter 'OTC' operations – same volume for both markets on EEX;
- Traded volumes account for around 2-3 times the total physical power generation;
- There is a convergence between power exchanges prices and OTC prices for equivalent products;
- In this study the revenues from power generation sales are estimated from day ahead price which is a good proxy of the different time horizon traded products over the lifetime of the power plant;
- Potential additional revenues from trading practices monetizing the optimality value of power plants are not accounted for in this analysis;
- The assessment of revenues from system services indicates that conventional power plants typically realize additional revenues that amount to 5 to 15% of the revenues from electricity sales on wholesale markets;
- For the profitability analysis, we assume that conventional power producers (gas, coal, nuclear) generate additional revenues from system service equal to 7% mark-up on average wholesale prices.

Results

- Market value[8] (ratio realised price/average market price) shows a decreasing trend between 2008 and 2020 for wind and solar. Wind market value is significantly below 100% (around 95%) on the period and is especially low in the case of Germany-Onshore wind with a 80-85% market value;
- In projections, market values derived from the Baseline scenario (METIS) show a price erosion for wind and solar as penetration of those technologies increases and can reach relatively low values in 2050 with 50% for Solar PV in Spain and Italy.

[8] Market value is the ratio realised price/average market price which means a value below 100% result in realised price lower than average market price (typically RES with cannibalization) and conversely a value higher than 100% result in realised price higher than average market price (typically peak production: fossil fuel turbines for instance)

Support interventions

Assumptions/observations

- Because of their beneficial effects for the environment and energy security, EU Member States and EU Trading Partners have supported RES generators with various public support schemes over the past decades that were making up for their insufficient technology and market maturity;
- Via direct support to the electricity prices, the price-based support scheme is the most common mechanism used by the countries as it gives a predictable regulatory framework that reduces the market risk for investors and thus the cost of capital;
- RES support schemes differ on the market exposure level of the revenues they provide to RES producers. Thus, feed-in-tariffs or FiTs are granted to RES generators for the sale of electricity at a pre-determined fixed price, irrespective of the market price volatility. Alternatively, feed-in premiums or FiPs are granted to RES generators on top of the electricity market price; either fixed or variable, capped or not, they are dependent of market price variations. Eventually, support schemes vary in function of their allocation mode, either through administrative procedures or through competitive bidding procedures, such as public auctions;
- Since the introduction of RES support schemes and as the RES technologies are getting more and more mature, we observe an underlying trend towards a better market integration of the price-based public supports via the use of feed-in-premiums allocated by auctions procedures.

Results of the profitability analysis

Top EU27, the UK and other non-EU G20 countries have been selected on the basis of the importance of their iinstalled capacities to conduct the profitability analysis. Selected countries per technology vary in function of raw data availability used to compute profitability indicators, i.e. costs and LCOEs, subsidized or market-based revenues, and Internal Rate of Returns (IRRs). We summarize the results of the analysis per studied technology hereafter:

Solar PV

Costs

- Costs for solar PV technology are mainly driven by CAPEX values and the load factor. Across similar regions or even at the global level CAPEX is not expected to change a lot for a given year. The main change factor then lays in the distribution between system size and type, which can be estimated with the share of centralized/distributed installations;
- Over the period 2008-2018, solar PV CAPEX dramatically decreased by a factor of three between to stand below 1 000 €/kW for most selected European countries and around 1 500 €/kW for the US and Japan;
- **LCOEs follow this decreasing trend to range in 2018 between 55 €/MWh and 135 €/MWh**. China, the USA and Spain registered the lowest LCOEs driven by high share of centralized systems for China (70%) and the USA (60%) in the global solar PV power generation and good load factors for Spain due to relatively high solar irradiation.

Revenues

- FiT-based support schemes in all selected countries provide very high revenues compared to what is expected from the wholesale market. An overall decreasing trend of the FiT allocated to Solar PV projects over the 2008-2018 period is observed, of which sharpest

reductions concern the countries with the highest level starting in 2008, i.e. Germany, Italy and the UK;
- An erosion of revenues from market prices is observed between 2008 and 2018 as the realised price tends to decrease with increasing solar PV market share. The realised prices in Germany, France, and Italy are significantly below the average market prices from 2015.

IRR

- IRR results from market revenues (i.e. realised price) stand well below the FiT-based IRRs, in line with the fact that there is room for maturity and competitivity gains for the solar PV technology over the 2008-2018 period. However, market-based IRRs are progressing steadily for all selected countries as CAPEX is getting lower.

Wind Onshore

Costs

- A decrease in overall CAPEX levels over the 2008-2016 period before a rebound from 2017 is observed but without any clear significant trends. China shows significantly lower CAPEX levels than the other countries;
- Wind onshore LCOEs follow similar trends for most selected countries with an average LCOE set at around 60 €/MWh except for Italy which reports the highest LCOE (around 90€/MWh on average) due to higher CAPEX levels and relatively low load factor over the 2008-2018 period.

Revenues

- In the EU, the FiT-based revenues remain stable between 2008 and 2018. This is not the case for the UK. Feed-in-tariffs in both the UK and Italy provide high revenues compared to what is expected from the wholesale market (realised price). In Italy, FiTs are almost twice higher than in France or Germany between 2013 and 2016;
- Concerning market-based revenues, the realised prices are significantly below the average market price with a market value below 100%. In particular, wind experienced relatively lower market values in Canada, Germany and the US. Higher market penetration of the wind onshore during the 2008-2018 period can explain this long-term trend.

IRR

- Except for Germany, IRRs from support schemes are relatively high in most of the EU countries. The countries which exhibit the higher on average IRRs from support schemes are the UK and Italy, at around 16% , and Spain and in France, at 8%. In the other countries (i.e. Germany, China, Brazil), IRRs are lower standing between 0% and 6% and varied slightly upward on average;
- On the direct market side, a long-term trend takes shape where positive market-based IRRs slowly increased over the period for all selected countries except for Canada (Ontario). Highest IRR is attributed to the UK exceeding 5% from 2016 and Brazil (8.2% in 2018).

Wind Offshore

Costs

- No explicit trend is observed in CAPEX values for the observed EU countries as cost structure significantly depends on project design and vary with location, distance from shore, depth of installations, etc.;
- Wind offshore LCOEs follow the same trend as CAPEX. In the last two years of the period, costs ranged between 65 and 150 €/MWh. The highest LCOE values over the 2008-2018 period

are observed in China (with an average of 147 €/MWh), where low CAPEX levels do not offset the low observed load factor (19% on average) compared to other countries. Denmark displays the lowest LCOE in 2018 at 67€/MWh thanks to a reduction of CAPEX, O&M fixed costs and a relatively high load factor;

- Several reasons lead to be cautious when comparing computed LCOEs levels with the auctions results of recent wind offshore projects; the main one lies in the time lag between auction date and commissioning date of the wind farms, where costing may vary greatly. Indeed, current auction results may indicate the expected costs for projects constructed in a few years from now. Costs of projects recently commissioned may represent the cost level of a few years ago (at the start of the construction phase) and the auction results of even further time ago.

Revenues

- Like wind onshore, FiT-based support schemes in the UK for wind offshore initially provided very high revenues compared to other countries before reducing dramatically and passing below the others. Overall revenues from support intervention are higher than revenues from the market;
- The market-based revenues read through the wind offshore realised prices were below the average market price with a market value below 100% over the 2008-2018 period, caused by a significant penetration of wind offshore inducing cannibalization effect.

IRR

- IRRs from support scheme revenues were overall higher than IRRs from market revenues, which turned positive over the last years for Germany, Belgium, Netherlands and Denmark. This upward trend in market market-based revenues is mainly explained by the combination of increasing realised price from 2016, relatively high load factors (35% on average) and decreasing LCOEs.

Gas

- The study focuses on CCGT power plants;
- In the Baseline scenario, carbon price is expected to reach 350 €/tCO_2 in 2050 and gas price is expected to double resulting in LCOE above 70€/MWh for most EU countries;
- Collected data suggest a slight increase in overall investment costs for CCGT over the 2008-2018 period;
- Revenues are falling in the mid-long term due lower load factors;
- IRRs are significantly negative for most EU countries due to high CO_2 costs and lower load factors.

Coal

- In the Baseline scenario, carbon price is expected to reach 350 €/tCO_2 in 2050 and coal price is expected to double resulting in LCOE above 80€/MWh for most EU countries;
- No specific trends in CAPEX variations are observed over the historical period except that, as expected, larger power plants (1.5 GW+) stand in the lower spectrum;
- Developed regions/countries such as the EU and the US present higher investment costs for the technology;
- Revenues are falling in 2050 due very low utilization rates;

- A significant part of coal power plants commissioned during 2008-2018 would not be economically viable in some EU countries due to high CO_2 costs and lower load factors.

Nuclear

- In LCOEs collected from international (e.g. IEA, NEA-OECD) and national (e.g. French Court of Auditors, etc.) sources, we observe an overall increase in nuclear costs over the 2010-2018 period. Projected 2020 and long-term LCOEs do not anticipate a cost decrease neither as new generation IV reactors may require significant CAPEX;
- 2030-2050 projected realised prices (from baseline scenario - METIS) for Spain, France and the United Kingdom give a sligt upward trend of the nuclear power market value from 100% in 2018 to 105-110% in 2030 and 2050. Projected revenues would remain stable in France in 2030 and 2050. In the UK, we may project an equivalent level between 2018 and 2030 before a slight decrease in revenues for 2050 (around -10%) caused by a similar decrease in 2050 average market price. In Spain, revenues would decline in 2030 before increasing in 2050, but standing below the 2018's initial level;
- As too few nuclear power plants were commissioned in the world over the 2008-2018 period (e.g. none in Europe), data availability on market revenues is a major obstacle preventing from computing future discounted cash flows, IRRs and thus from achieving a profitability analysis for the nuclear branch.

Hydro

- In main EU power markets, hydro (dam) benefits from a realised price around 5-15% higher than the average market price;
- Smaller hydropower (dam) projects show LCOE's in the higher spectrum, above 80 €/MWh;
- Large scale projects in China and Brazil present low LCOEs at around 20-40€/MWh.

Résumé exécutif

Ce rapport final présente les résultats finaux de chacune des trois tâches de ce travail. Le rapport final est complémenté par les résultats suivants :

- Outil analytique PP (produits pétroliers) de la tâche 1 ;
- Outil de données de la tâche 1 EL (Électricité) ;
- Outil de données de la tâche 1 NG (Gaz naturel) ;
- Outil de données de la tâche 2 ;
- Base de données de la tâche 3.

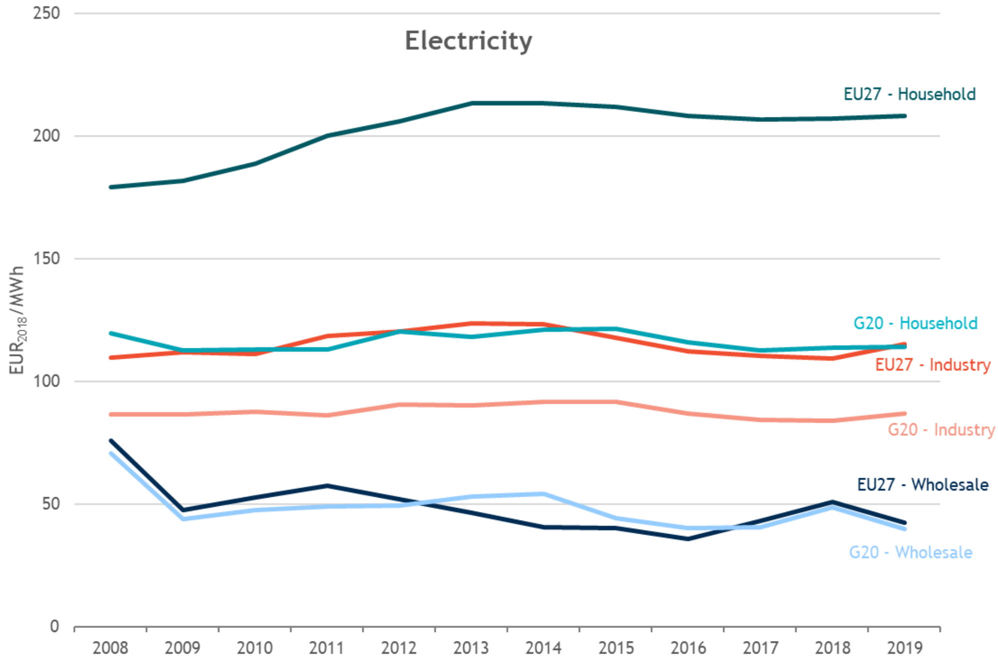
Résumé des conclusions

Tâche 1

Notre travail sur la tâche 1 s'est concentré sur l'extension de l'analyse présentée dans le précédent rapport (2018) afin d'inclure des données couvrant 2018 et 2019 et de fournir de nouveaux détails sur les prix des biocarburants et des carburants alternatifs utilisés dans les transports, tels que les coûts de recharge des véhicules électriques. Une différence essentielle par rapport à l'édition précédente est que nous regroupons les données de l'UE à l'exclusion du Royaume-Uni (UE27). Dans l'ensemble, la couverture des données pour 2018 et 2019 est bonne. Les paragraphes suivants présentent les conclusions clés associées aux quatre sections principales du chapitre sur la Tâche 1.

Prix de l'électricité

Figure 0-01Comparaison de la moyenne pondérée de l'UE27 avec la moyenne pondérée du G20 (commerce)



Sources : Elaboration personnelle
Note : les moyennes pondérées du G20 sont calculées sur la base de toutes les données de prix disponibles pour une année donnée, pondérées dans le prix total par la part qu'un pays avait dans les importations + exportations de l'UE 2017-2019. Les taux de couverture du commerce total varient entre 84-99 % (prix des ménages), 76-99 % (prix industriels) et 36-74 % (prix de gros).

- Prix de gros - Les prix de gros moyens de l'UE27 sont comparables à ceux de la plupart des pays du G20, et inférieurs à ceux de certains d'entre eux (Japon, Australie, Mexique, Turquie).

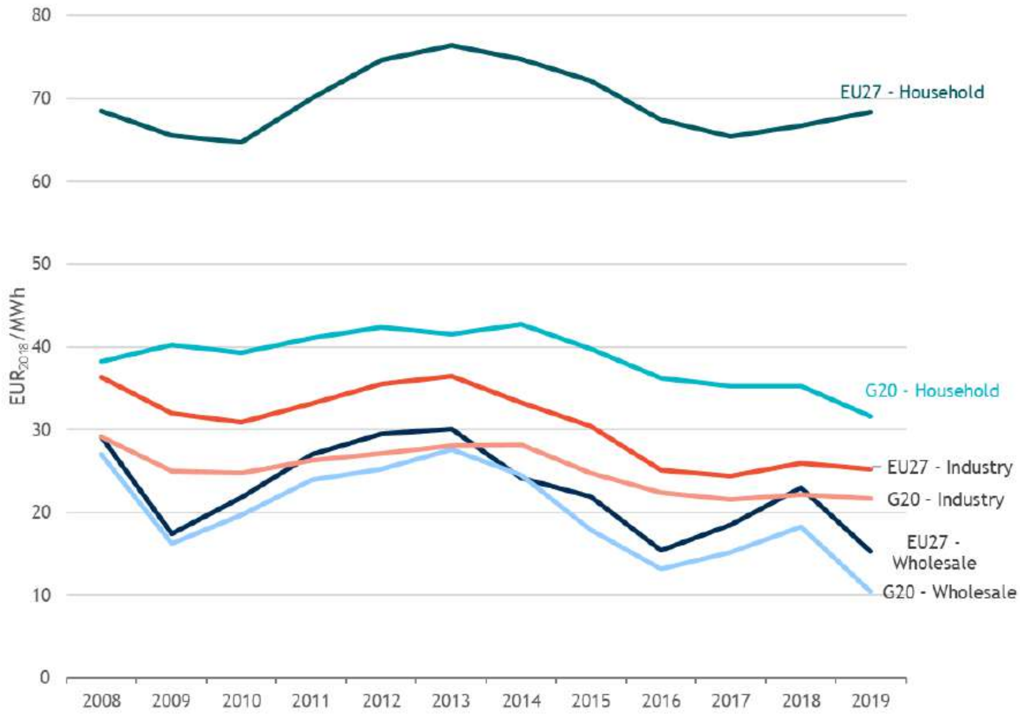
Ils ont connu une évolution favorable par rapport à de nombreux pays du G20 entre 2008 et 2009, mais pas par rapport aux États-Unis, à la Chine ou au Japon ;

- Prix des ménages - Les prix de vente moyens dans l'UE27 augmentent au fil du temps, bien que relativement stables depuis 2013, tandis que les prix du G20 sont principalement stables ou en baisse. Les prix dans l'UE27 sont plus élevés que dans la plupart des pays du G20 et similaires à ceux de certains d'entre eux. Les taxes et les prélèvements relativement élevés sur la consommation dans l'UE, ainsi que la régulation des prix/subventions dans le G20, sont parmi les principales raisons qui expliquent cette situation. Les coûts de réseau relativement élevés peuvent également jouer un rôle, bien que les données sur ces aspects au sein du G20 soient très limitées :
    - L'analyse des prix en standard de pouvoir d'achat (PPS) et dans le contexte du revenu moyen des ménages montre que les prix dans les pays de l'UE27 restent relativement élevés par rapport aux autres pays du G20 de l'OCDE, et que pour les pays dont le PIB par habitant est relativement faible, les prix nominaux bas deviennent beaucoup plus élevés en termes de PPA. Si l'on considère la consommation et le revenu des ménages, cela devient encore plus évident, avec les coûts de l'électricité représentant en moyenne 3,3 % du revenu moyen des ménages, mais des parts supérieures à 6 % en Bulgarie, en Roumanie et au Portugal. Une consommation moyenne d'électricité beaucoup plus élevée aux États-Unis ne se traduit pas par une charge similaire pour les ménages, car le revenu des ménages est beaucoup plus élevé.
- Prix industriels - Les prix industriels moyens de l'UE27 ont augmenté d'environ 5% entre 2008 et 2019. Les prix sont comparables à ceux de la Chine et inférieurs à ceux du Japon, mais ils ont presque doublé par rapport aux États-Unis. Les prix de l'UE restent supérieurs à ceux de la plupart des autres pays du G20. Les taxes non récupérables relativement élevées dans l'UE et la réglementation des prix/subventions au sein du G20 jouent un rôle important dans cette différence ;
- En ce qui concerne le rôle des taxes et des prélèvements, des redevances de réseau et des marges, la comparaison des prix de gros et de détail montre que la différence entre les deux est de loin la plus élevée dans l'UE (pour les ménages), seuls quelques pays du G20 (États-Unis, Californie, Japon) affichant une différence significative entre leurs prix de gros et de détail. Cela montre bien que la plupart des pays du G20 continuent de réglementer les prix pour les ménages. Le même problème existe également pour l'industrie, mais il est moins aigu que pour les ménages.

Source: Study on energy prices, costs and their impact on industry and households

Prix du gaz naturel

Figure 0-02Comparaison de la moyenne pondérée de l'UE27 avec la moyenne pondérée du G20 (commerce)



Source : Elaboration personnelle

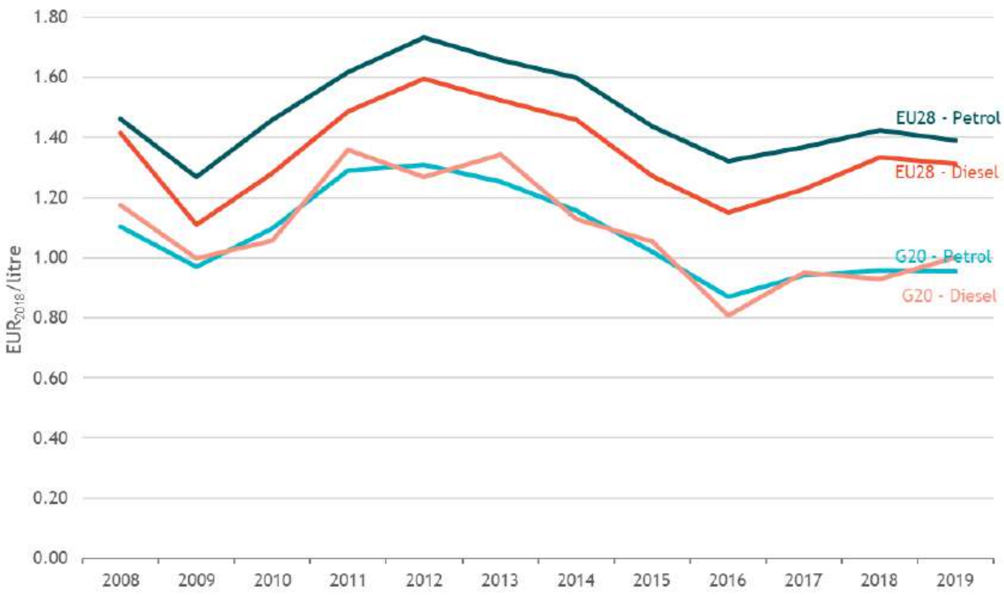
Note : les moyennes pondérées du G20 sont calculées sur la base de toutes les données de prix disponibles pour une année donnée, pondérées dans le prix total par la part qu'un pays avait dans les importations + exportations de l'UE 2017-2019. Les taux de couverture du commerce total varient entre 84-98 % (prix des ménages), 77-99 % (prix industriels) et 60-97 % (prix de gros).

- Les prix de gros dans l'UE sont similaires à ceux de la plupart des autres pays du G20, à l'exception des États-Unis, qui ont bénéficié de l'arrivée du gaz de schiste vers 2010, et d'autres grands producteurs (Russie, Canada et (jusqu'à récemment) Australie) qui ont des prix plus bas. L'évolution des prix a été relativement positive par rapport à l'Asie de l'Est (CN, JP, KO), mais négative par rapport aux producteurs ;
- Prix des ménages - les prix moyens dans l'UE27 sont considérablement plus élevés que dans la plupart des autres pays du G20 (sauf JP et KO), bien qu'ils soient au même niveau en 2019 qu'en 2008. Les taxes à la consommation relativement élevées dans l'UE et la réglementation des prix/les subventions au sein du G20 jouent un rôle important dans ces différences ;
- Prix industriels - les prix moyens de l'UE27 sont inférieurs à ceux des pays d'Asie de l'Est (Japon, Corée du Sud, Chine), mais supérieurs à ceux de la plupart des autres pays du G20, y compris les États-Unis. Les prix ont baissé depuis 2008 dans l'UE, mais à l'exception de l'Asie de l'Est et du Mexique, les prix ont baissé plus rapidement dans les autres pays du G20. Comme auparavant, les taxes non récupérables dans l'UE et la réglementation des prix/subventions au sein du G20 jouent un rôle dans cette différence ;
- En ce qui concerne le rôle des taxes et des prélèvements, des coûts de réseau et des marges bénéficiaires, la comparaison des prix de gros et de détail montre que la différence (pour les ménages) entre les deux est la plus élevée au Japon, et la deuxième plus élevée dans l'UE. Dans la plupart des pays du G20 non membres de l'UE, la différence est inférieure à la moitié des niveaux moyens de l'UE et, dans certains (AR, MX, TR), elle est inférieure à zéro ou proche de zéro. Pour l'industrie, il y a une différence d'environ 5 EUR/MWh entre les moyennes pondérées de l'UE27 et des pays du G20 non membres de l'UE, ce qui représente environ 20 % du prix total. La différence est relativement favorable par rapport à JP, CN, US et CA, mais les

autres pays du G20 (TR, BR, AR, RU) ont des différences négatives ou proches de zéro, ce qui met en évidence une probable régulation des prix/subventions.

Prix des produits pétroliers et des carburants de substitution

Figure 0-03Comparaison des prix moyens pondérés de l'UE27 avec les prix moyens pondérés du G20 (commerce)



Source : Elaboration personnelle

Remarque : les moyennes pondérées du G20 sont calculées sur la base de toutes les données de prix disponibles pour une année donnée, pondérées dans le prix total par la part qu'un pays avait dans les importations+exportations de l'UE 2017-2019.

- Les prix dans l'UE, en particulier ceux des carburants automobiles classiques (essence, diesel), ont tendance à être plus élevés que dans les autres pays du G20, ce qui s'explique en grande partie par les différences de taxation. Hors taxes, les prix moyens de l'UE sont comparables ou inférieurs à ceux de la plupart des pays du G20 pour l'essence et le diesel ;
- Pour les fiouls à haute et basse teneur en soufre (principalement pour le transport maritime), les prix de l'UE sont comparables aux prix internationaux, avec et sans taxes, comme, par contraste, l'essence et le diesel. Les taxes de l'UE sont également similaires aux taxes internationales. Les taxes sur ces carburants sont relativement faibles au niveau mondial en raison de la facilité relative avec laquelle le transport maritime peut se ravitailler en carburant dans les juridictions à bas prix et de la concurrence fiscale qui en résulte. Le renforcement des restrictions internationales sur l'utilisation des carburants à haute teneur en soufre à partir de 2020 devrait avoir une incidence sur les prix à l'avenir ;
- Pour le mazout de chauffage, les prix moyens de l'UE sont parmi les plus bas du G20, taxes comprises et hors taxes. Les taxes de l'UE sur ce produit sont relativement faibles par rapport à la taxation des autres combustibles dans l'UE, bien que dans une poignée de pays de l'UE (DK, SE, IT, PT), des taxes élevées entraînent des prix relativement élevés ;
- Les prix du GPL dans l'UE sont parmi les plus bas au niveau international, taxes comprises et hors taxes. Les prix ont généralement baissé depuis 2012 ;
- Pour le GNC, les données sur les prix sont limitées pour le G20, mais la comparaison avec les États-Unis et les pays du G20 suggère que les prix de l'UE sont en moyenne plus élevés. Les prix de l'UE ont connu une légère augmentation entre 2013 et 2019 ;
- Les prix de l'éthanol dans l'UE sont plus élevés que leurs équivalents américains, mais les prix du biodiesel dans l'UE sont similaires aux prix de référence comparables aux États-Unis et en Asie ;

- Dans tous les pays, les prix des carburants dérivés du pétrole ont tendance à suivre l'évolution du prix du pétrole brut ;
- Pour les véhicules électriques, les données disponibles suggèrent des prix de charge publique de 150 à 250 €/MWh en Chine, aux États-Unis et au Japon. Ces prix sont inférieurs à ceux observés en Europe, avec des prix de 200 à 350 €/MWh observés au Royaume-Uni, en Autriche et aux Pays-Bas, et les prix les plus élevés de 250 à 450 €/MWh observés en Norvège, en France, en Allemagne et en Espagne. Cela indique un écart de prix similaire à celui également observé pour la consommation d'électricité au détail des ménages.

Tâche 2

L'analyse de la tâche 2 a mis à jour et développé les calculs présentés dans l'étude précédente (2018). La base de données de la tâche 2 comprend des informations sur les coûts de l'énergie pour les industries de tous les États membres de l'UE, des pays du G20 non membres de l'UE et des partenaires commerciaux proches de l'UE, dont la Norvège, la Suisse et l'Islande. Les données couvrent la période 2008-2019, mais seules les données de 2010-2017 sont utilisées dans notre analyse, car la disponibilité de données complètes n'a pu être assurée que pour ces années-là.

L'ensemble de données a été révisé par rapport à sa version précédente : l'UE28 a été adaptée à l'UE27, le Royaume-Uni étant désormais considéré comme un pays du G20 non membre de l'UE. En outre, des données sur l'Islande ont été incluses pour la première fois. La mise à jour des ensembles de données et des calculs a permis d'aboutir aux principales conclusions suivantes. Il est important de noter que les résultats ultérieurs concernent l'ensemble de la chaîne de valeur des secteurs (incluant donc les entreprises en amont et en aval). Les cas où ce n'est pas le cas sont précisés (en mettant l'accent sur les entreprises en amont, c'est-à-dire celles qui consomment le plus d'énergie).

Les secteurs manufacturiers de l'UE

Coûts énergétiques par rapport au total des coûts de production (opérationnels)

- Au cours de la période 2008-2017, les coûts énergétiques des secteurs manufacturiers sélectionnés représentaient généralement entre 1 et 10 % des coûts de production (opérationnels) totaux, bien que pour plusieurs secteurs, les coûts aient largement dépassé 10 % (par exemple, le ciment, la chaux et le plâtre, et les matériaux de construction en argile) ;
- Les coûts énergétiques de plusieurs secteurs ont atteint 10 % ou plus de leurs coûts de production totaux au moins une année. Ces secteurs à forte intensité énergétique - notamment la pâte à papier, le verre, les matériaux de construction en argile, le ciment, la chaux et le plâtre, ainsi que le fer et l'acier - sont les plus sensibles aux prix de l'énergie, aux variations et aux écarts de coûts ;
- Dans les secteurs manufacturiers à faible intensité énergétique, les coûts énergétiques ne représentent généralement que 1 à 3 % des coûts opérationnels (de production) et constituent donc un élément de coût relativement mineur pour la plupart des entreprises de ces secteurs. Dans plusieurs secteurs manufacturiers - notamment l'informatique et l'électronique, les machines et équipements, les véhicules à moteur et autres équipements de transport - les coûts énergétiques ne dépassent pas 1 % des coûts de production ;
- Sur la période 2010-2017, la part des coûts énergétiques a diminué dans tous les secteurs :
  - La plus forte baisse proportionnelle de la part des coûts parmi les secteurs manufacturiers les plus intensifs en énergie est observée dans le secteur des pâtes et papiers, où les coûts

  - sont passés d'une part de 11,4 % en 2010 à une part de 6,7 % en 2017 (soit une baisse de la part de 4,7 %, qui représente toutefois environ 40 % en termes proportionnels) ;
  - D'autres industries à forte intensité énergétique, notamment la sidérurgie, le ciment, la chaux et le plâtre, ainsi que les matériaux de construction en argile, ont également vu leur part des coûts énergétiques diminuer de 3 à 5 % au cours de la même période ;
  - Certains des secteurs qui ont enregistré des baisses de points de pourcentage moins importantes ont quand même vu leurs ratios de part des coûts énergétiques diminuer proportionnellement, comme les métaux non ferreux, les produits chimiques de base et les produits plastiques ;
  - Les secteurs à moindre intensité énergétique ont présenté des diminutions plus faibles de la part des coûts énergétiques en termes absolus, bien que dans certains cas très importantes en termes relatifs.
- La part des coûts énergétiques a diminué dans tous les secteurs, non seulement sur l'ensemble de la période couverte, mais aussi plus fortement ces dernières années. La baisse des coûts énergétiques entre 2014-2017 a compensé la légère augmentation de la part des coûts énergétiques entre 2010-2013 pour les fruits et légumes, les scieries, les matériaux de construction en argile, les métaux non ferreux et les boissons ;
- Pour la majorité des secteurs manufacturiers, la baisse de la part des coûts de l'énergie est principalement attribuable à une diminution des coûts de l'énergie, mais aussi en partie à une augmentation simultanée des coûts de production. Quelques exceptions sont les secteurs où :
  - Les coûts énergétiques ont augmenté en termes absolus, mais le total des coûts de production opérationnels a augmenté à une plus grande échelle, donc la part des coûts énergétiques par rapport aux coûts de production n'a pas augmenté. Cela a été le cas pour les secteurs des fruits et légumes, des produits abrasifs, des machines et équipements et des véhicules à moteur ;
  - Les coûts énergétiques ont diminué en termes absolus, mais les coûts de production ont diminué à une plus petite échelle, comme dans le cas du secteur de la pierre.

Consommation d'énergie par type de combustible et intensité énergétique [9]

- Tous les secteurs sont touchés par les fluctuations des prix de l'électricité, mais celles-ci ont un impact particulier sur le coût total de l'énergie dans les secteurs des plastiques, des métaux non ferreux, et de l'informatique et de l'électronique ;
- La consommation de gaz naturel entraîne des coûts énergétiques, en particulier pour les secteurs du verre, des produits réfractaires, des matériaux de construction en argile, et de la porcelaine et céramique ;
- Le charbon joue toujours un rôle majeur dans la fabrication du ciment, de la chaux et du plâtre, des produits abrasifs, du fer et de l'acier ;
- Le pétrole joue un rôle important dans les raffineries (principalement utilisé comme matière première) et dans la fabrication de produits chimiques de base et de ciment, de chaux et de plâtre ;
- Les "autres énergies", en particulier la biomasse, contribuent de manière significative à la consommation d'énergie pour certains secteurs, notamment les scieries (où elle représente plus de 80 % de l'énergie consommée), les fibres synthétiques (57 %), la pierre (38 %) et les pâtes et papiers (29 %) ;

[9] Où intensité énergétique = consommation d'énergie (en tonnes d'équivalent pétrole) / valeur ajoutée brute (euros)

- L'intensité énergétique varie considérablement selon le secteur :
  - o Les raffineries, le secteur sidérurgique et le secteur du ciment, de la chaux et du plâtre sont les secteurs les plus énergivores. Ils nécessitent généralement plus de 2 tep/consommation d'énergie par millier d'euros de valeur ajoutée brute ;
  - o Ils sont suivis par les secteurs de la pâte et du papier et des produits chimiques de base, qui nécessitent environ 1 tep/consommation d'énergie pour mille euros de valeur ajoutée brute (VAB).
- Les intensités énergétiques des secteurs des raffineries, du fer et de l'acier, des matériaux de construction en argile et des fibres synthétiques sont les plus volatiles, principalement en raison des fluctuations de la valeur ajoutée brute dans ces secteurs :
  - o La volatilité de la valeur ajoutée brute des raffineries a été dictée par la dynamique des prix internationaux du pétrole ;
  - o La volatilité de la valeur ajoutée brute pour le fer et l'acier, les matériaux de construction en argile et les fibres artificielles a été provoquée par les changements dans l'activité économique et la réduction de la production suite à la crise de 2014 dans l'UE.

Rentabilité

Compte tenu de l'excédent brut d'exploitation (GOS) comme indicateur de la rentabilité des différentes industries :

- La plupart des secteurs de l'UE ont maintenu une part moyenne de GOS entre 5 et 15 % ;
- Les secteurs des produits pharmaceutiques et du ciment ont conservé les GOS les plus élevés en termes de part des coûts de production, avec une moyenne de 26,6 % et 22,9 % respectivement entre 2010 et 2017 ;
- Les secteurs des métaux non ferreux et du fer et de l'acier ont maintenu les GOS les plus bas en tant que part des coûts de production avec des moyennes de 7,6 % et 4 % respectivement ;
- Entre 2010 et 2017, l'excédent brut d'exploitation moyen en général a augmenté dans la plupart des secteurs ;
- Les plus fortes augmentations proportionnelles des GOS ont été enregistrées dans le secteur de la sidérurgie (103 %), le secteur du textile (52 %) et le secteur de la fonderie (41 %) ;
- Les GOS ont proportionnellement diminué dans plusieurs secteurs, notamment les fibres synthétiques (-43 %), le ciment, la chaux et le plâtre (-23 %) et les raffineries (-21 %) ;
- Les secteurs manufacturiers de l'UE sont en moyenne moins rentables que ceux des pays du G20 non membres de l'UE, notamment l'Inde, le Mexique, la Corée, la Russie et les États-Unis, mais aussi rentables que la Norvège et la Suisse et plus que le Brésil.

Secteurs non manufacturiers de l'UE

Coûts énergétiques par rapport au total des coûts de production (opérationnels)

- La part des coûts de l'énergie est particulièrement élevée dans cinq secteurs, à des niveaux comparables, voire supérieurs à ceux des secteurs manufacturiers à forte intensité énergétique ;
- Les secteurs où la part des coûts énergétiques est la plus élevée sont les suivants : transport terrestre (30 %), transport aérien (18 %), extraction de minerais métalliques (19 %), électricité, gaz et vapeur (11 %) et autres activités minières (9 %) ;
- Le coût des combustibles est un facteur important des coûts de production dans les secteurs des transports, de l'électricité et du gaz, et de l'exploitation minière, car ce sont des activités intrinsèquement intensives en énergie ;

- La part des coûts énergétiques pour l'hébergement et la restauration se situe entre 3 et 5 %, des niveaux comparables à ceux de nombreux secteurs manufacturiers à forte intensité énergétique ;
- La part des coûts énergétiques est plus faible dans les secteurs de la construction (1 %) et du commerce de gros et de détail (0,4 %).

Intensités énergétiques

- Les intensités énergétiques les plus élevées (en tep/millier d'euros) sont constamment observées dans les secteurs du transport aérien (1,7), de l'électricité, du gaz et de la vapeur (0,9) et du transport terrestre (0,5) ;
- L'agriculture et les autres secteurs miniers ont les intensités énergétiques les plus élevées suivantes (environ 0,2 tep/millier d'euros), à des niveaux comparables à ceux de nombreux secteurs manufacturiers non intensifs.

Rentabilité

- Les secteurs du pétrole et du gaz et de l'extraction de minerais métalliques ont maintenu des GOS beaucoup plus élevés que la moyenne des secteurs manufacturiers (80 % et 36 % respectivement), bien que les excédents du secteur minier aient régulièrement diminué entre 2010 et 2016 ;
- Les autres secteurs non manufacturiers maintiennent des excédents équivalents à ceux de leurs homologues manufacturiers, en moyenne entre 5 et 20 %.

Comparaisons internationales

Coûts énergétiques par rapport au total des coûts de production (opérationnels)

L'évolution de la part des coûts de l'énergie au niveau international varie selon les secteurs. Notamment, entre les sous-secteurs à forte intensité énergétique :

- La Norvège a les parts de coûts énergétiques les plus élevées dans les secteurs de la pâte et du papier (16,2 %) et des métaux non ferreux (7,9 %), malgré des prix de l'électricité et du gaz naturel inférieurs à ceux de l'UE, en raison de leur consommation énergétique relativement plus élevée ;
- La Turquie a la part la plus élevée des coûts énergétiques dans le secteur des raffineries, soit près de 10 %, suivie du Japon (7,5 %) ;
- Le Japon a la part la plus élevée des coûts énergétiques dans le secteur du verre (18,8 %) ;
- Les États-Unis ont les parts de coûts énergétiques les plus élevées dans les secteurs des produits chimiques de base (35,2%) et du ciment, de la chaux et du plâtre (36,5 %) ;
- En général, l'UE27 a des parts de coûts énergétiques comparables à celles de la plupart des partenaires commerciaux internationaux, bien qu'il y ait des différences selon les secteurs et les régions ;
- Dans l'UE27, la part du coût de l'énergie est relativement élevée dans les secteurs du fer et de l'acier (7,7 %) et des métaux non ferreux (4,1 %) ;
- La part des coûts énergétiques des raffineries dans l'UE27 est relativement faible (1,9 %).[10]

[10] Lorsqu'elles sont analysées à l'aide de données provenant de sources disponibles au niveau macro (Eurostat SBS, IEA, etc.)

Intensités énergétiques

Les intensités énergétiques des secteurs manufacturiers et non manufacturiers varient également considérablement d'un pays à l'autre :

- Dans le secteur de la pâte et du papier, l'intensité énergétique moyenne de l'UE27 est plus de deux fois supérieure à celle du Japon et de la Corée en raison d'une consommation d'énergie plus élevée en moyenne dans les usines de l'UE ;
- Dans le secteur des raffineries, toujours en raison de niveaux de consommation d'énergie plus élevés, l'intensité énergétique de l'UE27 est supérieure à celle de tous ses partenaires commerciaux internationaux pour lesquels des données étaient disponibles ;
- Dans le secteur des produits chimiques de base, l'UE27 a une intensité énergétique inférieure à la moyenne en raison de chiffres de valeur ajoutée brute plus élevés en moyenne ;
- En ce qui concerne la sidérurgie et les métaux non ferreux, l'UE27 présente des niveaux d'intensité plus élevés que la Suisse mais plus faibles que la Norvège en raison de la consommation d'énergie plus élevée de ce pays ;
- Dans le secteur du verre, l'UE27 a des niveaux d'intensité énergétique inférieurs à ceux du Mexique et des États-Unis, mais supérieurs à ceux de la Norvège et du Canada ;
- Dans le domaine de l'agriculture, tous les pays et l'UE27 ont des intensités énergétiques comparables, à l'exception du Mexique, où l'intensité énergétique est près de trois fois plus élevée qu'au Canada, qui arrive en deuxième position pour l'intensité énergétique de l'agriculture ;
- La Turquie et la Chine ont les intensités énergétiques comparatives les plus élevées.

Rentabilité

L'analyse de la rentabilité des secteurs manufacturiers internationaux l'indique :

- L'Inde, le Mexique, la Corée, la Russie et l'Argentine présentent des ratios constamment élevés de GOS par rapport à la valeur ajoutée totale ;
- L'UE27 affiche une rentabilité moyenne par rapport à ses homologues internationaux, avec une moindre volatilité d'une année sur l'autre ;
- La rentabilité de plusieurs pays - Argentine, Indonésie, Mexique et Japon - a fortement oscillé ces dernières années ;
- La rentabilité a augmenté dans de nombreux pays à partir de 2015, y compris dans l'UE27 ;
- Les secteurs manufacturiers de l'UE sont en moyenne moins rentables que ceux des pays du G20 non membres de l'UE, notamment l'Inde, le Mexique, la Corée, la Russie et les États-Unis, mais aussi rentables que la Norvège et la Suisse et plus que le Brésil.

Dans les secteurs non manufacturiers :

- Le Mexique, l'Arabie Saoudite et la Russie affichent régulièrement les ratios les plus élevés de GOS par rapport à la valeur ajoutée ;
- De manière générale, l'UE27 affiche des niveaux de rentabilité légèrement inférieurs à la moyenne des pays du G20, bien que les niveaux de rentabilité soient plus élevés que ceux de la Suisse et de la Chine et comparables à ceux des États-Unis et du Japon ;
- Les niveaux de rentabilité des secteurs non manufacturiers de l'UE27 sont légèrement plus élevés (2 à 3 % de plus) que les niveaux de rentabilité de ses secteurs manufacturiers, tandis qu'au Japon et aux États-Unis, les niveaux de rentabilité des secteurs manufacturiers sont plus élevés que ceux des secteurs non manufacturiers.

Les résultats sur les industries à forte intensité énergétique ont été sélectionnés pour une analyse ascendante

Les résultats de l'analyse ascendante sont basés sur des données recueillies auprès de 96 usines dans cinq secteurs industriels : verre plat, zinc, ferro-alliages et silicium, engrais et raffineries.

Conformément à la relation inverse entre les prix de l'électricité et le niveau de consommation constatée dans l'étude de la CEPS et d'Ecofys de 2018 sur les prix et les coûts de l'énergie dans les industries[11] à forte intensité énergétique, les prix et les intensités de l'électricité dans tous les secteurs analysés sont également inversement liés. Pour une consommation d'énergie plus élevée, les secteurs paient des prix plus bas pour l'électricité. De même, étant donné une intensité énergétique plus élevée, les usines des secteurs auront très probablement des niveaux de consommation plus élevés et auront donc tendance à payer des prix plus bas pour l'électricité. Cet effet est légèrement moins prononcé dans le secteur du verre plat, où le prix de l'électricité est plus élevé en moyenne que dans le secteur des raffineries, en dépit de son intensité énergétique plus élevée. De même, l'intensité énergétique des secteurs est inversement proportionnelle à leur prix du gaz naturel. Toutefois, les prix du gaz naturel varient moins d'un secteur à l'autre que les prix de l'électricité, car les prix du gaz naturel sont en grande partie fixés par les producteurs internationaux et ne peuvent être négociés à la baisse aussi facilement que les prix de l'électricité.

L'influence des prix et des coûts de l'énergie sur la compétitivité des industries à haute intensité énergétique (EIIs) varie selon les secteurs :

- Dans le secteur du verre plat, les coûts énergétiques ont contribué positivement au rétablissement de la rentabilité du secteur après 2016, mais ont eu un impact global limité sur la compétitivité extérieure du secteur du verre plat de l'UE par rapport à ses concurrents non européens. Cela est dû au fait que les pays concurrents ont connu des baisses des coûts énergétiques encore plus importantes que l'UE ces dernières années. Le secteur du verre plat dans l'UE27 est fortement désavantagé en termes de coûts par rapport aux concurrents ayant un accès peu coûteux aux ressources de gaz naturel (notamment la Russie, le Belarus, l'Algérie, la Turquie et l'Égypte). Le secteur du verre plat de l'UE compense les différences de prix de l'énergie en rivalisant sur la qualité technique de ses produits. ;
- En ce qui concerne le zinc, la compétitivité internationale du secteur de l'UE ne peut être évaluée qu'en analysant les structures de coûts complets des usines, mais des entretiens avec l'Association internationale du zinc ont confirmé que les coûts de production de l'UE se sont approchés des valeurs internationales moyennes (et parfois supérieures à la moyenne) ces dernières années ;
- Les fabricants de ferro-alliages considèrent les coûts énergétiques comme des déterminants clés de la compétitivité des produits, puisque les prix sont déterminés par les coûts de production dans le secteur. Dans le cas des ferro-alliages et du silicium, une augmentation des prix de l'électricité entre 2016 et 2019 a réduit la rentabilité du secteur de l'UE, mais comme la part des coûts énergétiques par rapport aux coûts de production est restée stable, l'industrie a pu maintenir une balance commerciale relativement stable ;
- Dans le domaine des engrais, la dynamique des coûts internationaux du gaz peut être un facteur déterminant de la compétitivité ; les producteurs d'engrais dans les pays où les coûts

[11] CEPS et Ecofys (2018), Composition and Drivers of Energy Prices and Costs: Case Studies in Selected Energy Intensive Industries - 2018.

de fonte sont très bas ont sous-coté les producteurs européens même lorsque les prix du gaz dans l'UE sont bas ; les différences de prix du gaz au niveau international sont toutefois restées stables ces dernières années (et ont convergé après l'impact de la révolution du gaz de schiste)

- Dans les raffineries, les coûts de l'énergie achetée (électricité et gaz naturel) représentent une part importante de leurs coûts de production totaux (entre 8 et 14 % en moyenne).[12] Si l'on considère les combustibles auto-produits, ceux-ci jouent un rôle important dans les coûts de production totaux des raffineries : entre 8 et 13%[13] si le prix du pétrole brut est pris en compte comme coût de production. Si le prix du pétrole brut est exclu du coût de production (méthode standard de l'industrie), les coûts énergétiques sont estimés entre 49 et 55%[14]. Les coûts d'exploitation des raffineries sont donc dominés par les "autres coûts" (essentiellement l'approvisionnement de la matière première, à savoir le pétrole brut). Par conséquent, la rentabilité des raffineries est essentiellement déterminée par les marchés internationaux : le prix du pétrole brut est déterminé par le marché international du pétrole (cotation du Brent), tandis que le prix des produits raffinés est également fixé sur un marché international déterminé par l'équilibre entre l'offre et la demande. La capacité limitée de fabriquer des produits plus spécialisés, et l'incapacité qui en résulte de répercuter pleinement l'augmentation des coûts, réduit la marge bénéficiaire de certaines raffineries européennes. Par conséquent, l'exposition de certaines raffineries à la concurrence internationale est relativement élevée.

Impacts de la pandémie COVID-19 et ses répercussions sur les coûts énergétiques de certaines EIIs

Au cours des interactions et des discussions avec les différentes associations industrielles entre juin et septembre 2020, nous avons reçu des commentaires concernant les impacts possibles de COVID-19 sur les coûts de l'énergie et leurs conséquences économiques pour les différentes industries.

La plupart des secteurs manufacturiers consultés ont été fortement touchés par la crise COVID-19. La COVID-19 a considérablement freiné la demande de produits, réduisant les revenus des ventes des secteurs industriels et déclenchant des réductions de la production dans les usines.

- Pour le secteur des raffineries, les mesures de verrouillage ont eu d'énormes conséquences sur la demande de produits pétroliers, en particulier dans les pays où le verrouillage est strict, où la demande de diesel et d'essence a chuté de 60 à 80 % par rapport à l'année précédente. En ce qui concerne le kérosène, l'impact a été encore pire avec une réduction de la demande de 80 à 95 % par rapport à l'année précédente et un ralentissement de la reprise après le verrouillage. En réaction aux marges nettes négatives, de nombreuses raffineries ont réduit leur capacité d'exploitation au minimum ;
- Dans le secteur du verre plat, la moitié des sites de fabrication ont été mis "en attente"[15] en réduisant la température des fours à verre plat à 1200°C (normalement, ils travaillent à 1500-1600°C). En conséquence, les coûts énergétiques par tonne de produit vont probablement augmenter en 2020, pour atteindre des niveaux de 20 à 40 % supérieurs à ceux de 2019 ;

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[12] Pour ce projet, la définition des coûts de production incluait les coûts du pétrole brut comme matière première. Selon Concawe et Fuels Europe, la méthode standard de l'industrie du raffinage pour calculer les coûts de production exclut les coûts du pétrole brut. Par conséquent, les coûts énergétiques en tant que part des coûts de production présentés dans ce tableau sont inférieurs à ceux calculés par l'industrie.
[13] Basé sur les résultats de sa propre analyse à partir des questionnaires collectés auprès des raffineries de l'UE27.
[14] Solomon Associates (2019) via Concawe. Les parts sont le résultat de la division des coûts énergétiques (USD/bbl) par le Cash OpEx (USD/bbl) pour l'UE28 pour les années 2016 et 2018. Le Cash OpEx est la somme des coûts de personnel, des coûts énergétiques et des autres coûts.
[15] La "cale chaude" est un moyen d'éviter l'arrêt des fours, car ceux-ci doivent être entièrement reconstruits après un arrêt complet, au prix de dizaines de millions d'euros et de plusieurs mois consacrés à la reconstruction.

- Les opérations de fabrication ont pu se poursuivre dans le secteur du zinc, mais les consommateurs de zinc ont souvent cessé leurs activités. Cela a entraîné une baisse de la demande et un stockage important de zinc. Le secteur s'attend à ce que la production diminue d'environ 15 % en 2020 (par rapport aux niveaux de 2019) ;
- Dans le secteur des ferro-alliages et du silicium, les réductions de production et les fermetures d'entreprises ont déjà commencé. Le secteur s'attend également à ce que la COVID-19 ait des répercussions à moyen et long terme. La production mondiale d'acier ayant chuté, les stocks de ferroalliages ont augmenté. Une poussée des importations internationales est attendue après la crise immédiate, ainsi que des politiques agressives de la part de pays tiers pour revitaliser leurs économies (par exemple, dumping de produits dans l'UE) afin de réduire les stocks excédentaires ;
- Enfin, l'industrie européenne des engrais a pu maintenir ses activités de production pendant la crise, principalement parce que le secteur a été reconnu comme un élément indispensable de la chaîne alimentaire. En conséquence, le secteur des engrais a été le seul à ne signaler qu'un impact limité dans la demande de ses produits et ses opérations en raison de la COVID-19.

Dans ce contexte de faible production et de faibles ventes, il est important d'évaluer le rôle que jouent les coûts énergétiques dans la situation économique de la plupart des industries à forte intensité énergétique. La crise économique induite par la COVID-19 et les restrictions de mobilité ont provoqué une chute très importante des prix de l'énergie au cours du premier semestre 2020. La baisse des prix de l'énergie n'est pas suivie par des baisses équivalentes des coûts des autres intrants de production non énergétiques. Les coûts opérationnels de production ont été réduits autant que possible (notamment grâce au chômage technique et à d'autres programmes d'aide à court terme), mais la plupart des autres coûts (par exemple, la location de bureaux, les usines et le paiement des intérêts) n'ont pas changé.

- Cela implique que pour les secteurs qui sont en mesure de poursuivre ou de moduler leur production et d'adapter leur consommation d'énergie, les achats d'énergie (les coûts énergétiques) devraient diminuer beaucoup plus que les dépenses liées aux autres coûts de production non énergétiques, ce qui se traduit par des parts plus faibles des coûts énergétiques par rapport aux coûts de production ;
- Dans certains cas, les coûts énergétiques jouent encore un rôle dans l'érosion des bénéfices dans certains secteurs à forte intensité énergétique. C'est le cas des secteurs dont une part importante de l'énergie est fixe, ou ne peut être réduite en même temps que la baisse de la production. Dans ces cas, les entreprises pourraient subir une augmentation disproportionnée de la part de leurs coûts énergétiques dans les coûts de production (comme c'est le cas du secteur du verre plat).

Analyse de décomposition

- Au niveau agrégé de tous les secteurs manufacturiers considérés, les coûts de l'énergie pour l'industrie de l'UE ont diminué d'environ 13 % au cours de la période 2010-2017. L'augmentation de la production du secteur industriel, principalement due à la demande intérieure, a stimulé la demande industrielle d'énergie en tant qu'intrant de production. De plus, la hausse des prix de l'énergie, en particulier de l'électricité, a fait augmenter les coûts des intrants énergétiques. Toutefois, cette pression à la hausse sur les coûts de l'énergie a été entièrement compensée par les améliorations de l'intensité énergétique, qui, pour la plupart, sont directement issues des améliorations de l'efficacité énergétique plutôt que des changements structurels ou des changements de combustible ;

- La production a augmenté dans la plupart des secteurs industriels de l'UE27, ce qui a stimulé la consommation et les coûts énergétiques industriels (en termes absolus). Les secteurs à forte intensité énergétique ont connu la plus faible croissance de la production, tandis que les secteurs à faible intensité énergétique ont généralement connu une croissance de la production plus élevée ;
- Pour les secteurs industriels agrégés de l'UE27, une amélioration de l'intensité énergétique a contribué à une réduction des coûts énergétiques entre 2010 et 2017 ;
- L'effet de l'intensité énergétique a été analysé plus en détail pour comprendre dans quelle mesure les changements structurels de l'industrie ou les changements de combustible ont contribué aux améliorations de l'intensité énergétique observées au cours de la période. Dans l'ensemble, ni les changements structurels ni les changements de combustible n'ont été considérés comme un facteur important de l'effet de l'intensité énergétique. Cela suggère que les améliorations réelles de l'efficacité énergétique ont été le moteur de la réduction de l'intensité énergétique au cours de la période ;
- La plus forte réduction de l'intensité énergétique a été observée dans les secteurs les moins intensifs en énergie. Il y a deux explications plausibles à cela. Premièrement, la réduction de l'intensité énergétique est due à des économies d'échelle. Deuxièmement, la croissance rapide de la production pourrait également avoir entraîné des investissements dans de nouveaux équipements et usines industriels plus efficaces. Les industries les plus intensives en énergie ont connu des améliorations beaucoup moins importantes de l'intensité énergétique au cours de la période. Cela pourrait être dû au fait que ces industries ont déjà investi massivement dans l'efficacité énergétique pour maintenir leur compétitivité internationale ;
- Dans la plupart des secteurs industriels de l'UE27, les augmentations des prix moyens de l'énergie ont contribué à une hausse des coûts de l'énergie sur la période 2010-2017. Cette hausse est en grande partie due à l'augmentation des prix de l'électricité dans l'industrie. Les secteurs où le pétrole, le charbon ou le gaz représentent une part plus importante du bouquet énergétique ont vu les prix de l'énergie avoir une incidence moindre sur les coûts énergétiques, car les prix de ces combustibles ont baissé au cours de la période ;
- Au niveau de l'UE27, les données SSE d'Eurostat montrent qu'une augmentation des coûts de production totaux de l'industrie sur la période s'explique presque entièrement par des augmentations d'autres coûts (non énergétiques). Les coûts énergétiques ont contribué à une réduction très faible, presque insignifiante, des coûts de production totaux ;
- La comparaison des coûts énergétiques de l'UE27 estimés à partir de ses composantes (prix et consommation d'énergie) avec les achats de produits énergétiques du SSE d'Eurostat montre qu'il existe un effet résiduel contribuant à l'évolution des coûts énergétiques. L'effet résiduel pour la plupart des secteurs montre un biais négatif impliquant que nous ne saisissons pas certains facteurs réduisant le coût de l'énergie sur la période. Cet effet résiduel résume certaines limites connues de l'analyse, notamment le fait de ne pas saisir l'évolution des prix des autres combustibles (déchets de biomasse et chaleur), les exonérations supplémentaires de taxes et de prélèvements, et la disponibilité limitée des données sur la consommation d'énergie pour certains secteurs individuels.

Tâche 3

L'objectif de cette tâche était de collecter, de contrôler et d'organiser des données horaires (prix et production par type) sur les marchés organisés de l'électricité dans les pays du G20, ainsi que des informations sur les subventions et les investissements, afin d'évaluer l'impact des prix réalisés (prix moyen pondéré du marché de la production d'électricité) et de soutenir les interventions sur la rentabilité des investissements dans différentes technologies de production d'électricité et différents types de combustibles.

Collecte de données et base de données

- En ce qui concerne les données horaires sur la production d'électricité, la base de données actuelle compile une quantité importante de données avec plus de 100 millions de valeurs et 2 000 séries provenant d'une cinquantaine de sources. La base de données couvre les technologies suivantes : solaire photovoltaïque, éolienne terrestre, éolienne en mer, hydraulique, charbon, gaz et nucléaire, ainsi qu'une cinquantaine de pays, dont l'Europe et les pays du G20 ;
- Les données relatives aux interventions de soutien ont été collectées à partir de l'étude d'EMOS EC et de la collecte de données supplémentaires auprès des régulateurs nationaux. La principale difficulté consistait à convertir toutes les subventions spécifiques dépendantes de la sous-technologie, du système ou de la taille du système en valeurs agrégées pour une technologie donnée ;
- Un tableau de bord a été développé avec l'aide de MS Power BI pour traiter et extraire les données (par exemple, l'extraction du prix réalisé) ;
- L'analyse de rentabilité s'appuie sur un scénario central - Baseline (Metis' 2050_LTS_15TECH), qui est conforme aux objectifs actuels de l'UE pour 2030 et 2050 et aux mesures énergétiques et politiques existantes.

Marchés de l'énergie

Hypothèses/observations

- Les principales places de marché pour les produits standardisés sont les bourses de l'électricité et les opérations de gré à gré (OTC) - le même volume pour les deux marchés sur EEX ;
- Les volumes échangés représentent environ 2 à 3 fois la production physique totale d'électricité ;
- Il y a une convergence entre les prix des bourses d'électricité et les prix OTC pour des produits équivalents ;
- Dans cette étude, les revenus des ventes de la production d'électricité sont estimés à partir du prix du jour précédent, ce qui est une bonne approximation des différents produits échangés sur la durée de vie de la centrale ;
- Les revenus supplémentaires potentiels provenant des pratiques commerciales monétisant la valeur d'optimalité des centrales électriques ne sont pas pris en compte dans cette analyse ;
- L'évaluation des revenus des services de système indique que les centrales électriques conventionnelles réalisent généralement des revenus supplémentaires qui s'élèvent à 5 à 15 % des revenus des ventes d'électricité sur les marchés de gros ;
- Pour l'analyse de rentabilité, nous supposons que les producteurs d'électricité conventionnels (gaz, charbon, nucléaire) génèrent des revenus supplémentaires provenant du service de système, équivalents à une majoration de 7 % sur les prix de gros moyens.

Résultats

- La valeur marchande[16] (rapport prix réalisé/prix moyen du marché) montre une tendance à la baisse entre 2008 et 2020 pour l'éolien et le solaire. La valeur du marché de l'énergie éolienne est nettement inférieure à 100 % (environ 95 %) sur cette période et est particulièrement faible dans le cas de l'énergie éolienne côtière allemande avec une valeur de marché de 80 à 85 % ;
- Dans les projections, les valeurs du marché dérivées du scénario de base (METIS) montrent une érosion des prix pour l'éolien et le solaire à mesure que la pénétration de ces technologies augmente et peut atteindre des valeurs relativement faibles en 2050 avec 50% pour le solaire photovoltaïque en Espagne et en Italie.

Interventions de soutien

Hypothèses/observations

- En raison de leurs effets bénéfiques sur l'environnement et la sécurité énergétique, les États membres et les partenaires commerciaux de l'UE ont soutenu les producteurs de RES par divers programmes d'aide publique au cours des dernières décennies, qui compensaient leur manque de maturité technologique et commerciale ;
- Par le biais d'un soutien direct aux prix de l'électricité, le régime de soutien basé sur les prix est le mécanisme le plus couramment utilisé par les pays car il offre un cadre réglementaire prévisible qui réduit le risque de marché pour les investisseurs et donc le coût du capital ;
- Les régimes de soutien aux RES diffèrent selon le niveau d'exposition au marché des revenus qu'ils procurent aux producteurs de RES. Ainsi, des tarifs de rachat ou FiT sont accordés aux producteurs de RES pour la vente d'électricité à un prix fixe prédéterminé, indépendamment de la volatilité des prix du marché. Par ailleurs, des primes de rachat ou des FiP sont accordées aux producteurs de RES en plus du prix du marché de l'électricité ; qu'elles soient fixes ou variables, plafonnées ou non, elles dépendent des variations des prix du marché. Enfin, les régimes d'aide varient en fonction de leur mode d'attribution, soit par des procédures administratives, soit par des procédures d'appel d'offres, telles que les enchères publiques ;
- Depuis l'introduction des régimes d'aide aux RES et à mesure que les technologies RES gagnent en maturité, nous observons une tendance sous-jacente à une meilleure intégration sur le marché des aides publiques basées sur les prix grâce à l'utilisation de primes de rachat allouées par des procédures d'enchères.

Résultats de l'analyse de rentabilité

Les premiers pays de l'UE27, du Royaume-Uni et d'autres pays du G20 non membres de l'UE ont été sélectionnés en fonction de l'importance de leurs capacités installées pour effectuer l'analyse de rentabilité. Les pays sélectionnés par technologie varient en fonction de la disponibilité des données brutes utilisées pour calculer les indicateurs de rentabilité, c'est-à-dire les coûts et les LCOEs, les revenus subventionnés ou basés sur le marché, et le taux de rendement interne (IRRs). Nous résumons ci-après les résultats de l'analyse par technologie étudiée :

[16] La valeur marchande est le rapport entre le prix réalisé et le prix moyen du marché, ce qui signifie qu'une valeur inférieure à 100 % entraîne un prix réalisé inférieur au prix moyen du marché (généralement les RES avec cannibalisation) et inversement, une valeur supérieure à 100 % entraîne un prix réalisé supérieur au prix moyen du marché (généralement la production de pointe : les turbines à combustibles fossiles par exemple)

PV solaire

Coûts

- Les coûts de la technologie solaire photovoltaïque sont principalement déterminés par les valeurs CAPEX et le facteur de charge. Dans des régions similaires ou même au niveau mondial, les CAPEX ne devraient pas changer beaucoup pour une année donnée. Le principal facteur de changement réside alors dans la répartition entre la taille et le type de système, qui peut être estimée avec la part des installations centralisées/distribuées ;
- Au cours de la période 2008-2018, les dépenses d'investissement dans le secteur photovoltaïque solaire ont été divisées par trois pour se situer en dessous de 1 000 €/kW dans la plupart des pays européens sélectionnés et autour de 1 500 €/kW aux États-Unis et au Japon ;
- Les LCOEs suivent cette tendance à la baisse pour se situer en 2018 entre 5**5 €/MWh et 135 €/MWh**. La Chine, les États-Unis et l'Espagne ont enregistré les LCOEs les plus faibles en raison de la part élevée des systèmes centralisés pour la Chine (70 %) et les États-Unis (60 %) dans la production mondiale d'électricité solaire photovoltaïque et des bons facteurs de charge pour l'Espagne en raison d'une irradiation solaire relativement élevée.

Revenus

- Dans tous les pays sélectionnés, les régimes d'aide basés sur le FiT fournissent des revenus très élevés par rapport à ce que l'on attend du marché de gros. On observe une tendance générale à la baisse du FiT alloué aux projets photovoltaïques solaires sur la période 2008-2018, les réductions les plus importantes concernant les pays ayant le niveau le plus élevé à partir de 2008, à savoir l'Allemagne, l'Italie et le Royaume-Uni ;
- Une érosion des revenus provenant des prix du marché est observée entre 2008 et 2018, car le prix réalisé tend à diminuer avec l'augmentation de la part de marché du solaire photovoltaïque. Les prix réalisés en Allemagne, en France et en Italie sont nettement inférieurs aux prix moyens du marché à partir de 2015.

IRR

- Les résultats IRRs des revenus du marché (c'est-à-dire le prix réalisé) sont bien inférieurs aux IRRs basés sur le FiT, ce qui s'explique par le fait que la technologie photovoltaïque solaire peut encore gagner en maturité et en compétitivité au cours de la période 2008-2018. Toutefois, le IRR basé sur le marché progresse régulièrement pour tous les pays sélectionnés, car les dépenses d'investissement sont de plus en plus faibles.

*L'**é**olien terrestre*

Coûts

- Une diminution des niveaux globaux de CAPEX sur la période 2008-2016 puis un rebond à partir de 2017 sont observés, mais sans tendance significative claire. La Chine affiche des niveaux de CAPEX nettement inférieurs à ceux des autres pays ;
- Les LCOEs de l'éolien terrestre suivent des tendances similaires pour la plupart des pays sélectionnés, avec un LCOE moyen fixé à environ 60 €/MWh, sauf pour l'Italie qui affiche le LCOE le plus élevé (environ 90 €/MWh en moyenne) en raison de niveaux de CAPEX plus élevés et d'un facteur de charge relativement faible sur la période 2008-2018.

Revenus

- Dans l'UE, les revenus basés sur le FiT restent stables entre 2008 et 2018. Ce n'est pas le cas au Royaume-Uni. Les tarifs de rachat garantis au Royaume-Uni et en Italie génèrent des recettes élevées par rapport à ce que l'on attend du marché de gros (prix réalisé). En Italie, les FiT sont presque deux fois plus élevés qu'en France ou en Allemagne entre 2013 et 2016 ;

- En ce qui concerne les revenus basés sur le marché, les prix réalisés sont nettement inférieurs au prix moyen du marché, avec une valeur marchande inférieure à 100 %. En particulier, l'énergie éolienne a connu des valeurs marchandes relativement plus faibles au Canada, en Allemagne et aux États-Unis. La plus forte pénétration du marché de l'éolien terrestre au cours de la période 2008-2018 peut expliquer cette tendance à long terme.

IRR

- À l'exception de l'Allemagne, les IRRs des régimes de soutien sont relativement élevés dans la plupart des pays de l'UE. Les pays qui affichent les IRRs moyens les plus élevés sont le Royaume-Uni et l'Italie, avec environ 16 %, et l'Espagne et la France, avec 8 %. Dans les autres pays (Allemagne, Chine, Brésil), les IRRs sont plus faibles, se situant entre 0 et 6 %, et varient légèrement à la hausse en moyenne ;
- En ce qui concerne le marché direct, une tendance à long terme se dessine : les IRRs positifs basés sur le marché ont lentement augmenté au cours de la période pour tous les pays sélectionnés, à l'exception du Canada (Ontario). Le IRR le plus élevé est attribué au Royaume-Uni, qui dépasse les 5 % à partir de 2016, et au Brésil (8,2 % en 2018).

L'éolien offshore

Coûts

- Aucune tendance explicite n'est observée dans les valeurs des CAPEX pour les pays de l'UE observés, car la structure des coûts dépend fortement de la conception du projet et varie en fonction de l'emplacement, de la distance du rivage, de la profondeur des installations, etc ;
- Les LCOEs éoliennes offshore suivent la même tendance que les CAPEX. Au cours des deux dernières années de la période, les coûts se sont situés entre 65 et 150 €/MWh. Les valeurs de LCOE les plus élevées sur la période 2008-2018 sont observées en Chine (avec une moyenne de 147 €/MWh), où les faibles niveaux de CAPEX ne compensent pas le faible facteur de charge observé (19 % en moyenne) par rapport aux autres pays. Le Danemark affiche le LCOE le plus bas en 2018 avec 67€/MWh grâce à une réduction des CAPEX, des coûts fixes d'exploitation et de maintenance et un facteur de charge relativement élevé ;
- Plusieurs raisons incitent à la prudence lorsque l'on compare les niveaux de LCOE calculés avec les résultats des enchères des récents projets d'éoliennes offshore ; la principale réside dans le délai entre la date des enchères et la date de mise en service des parcs éoliens, où les coûts peuvent varier considérablement. En effet, les résultats actuels des enchères peuvent indiquer les coûts prévus pour les projets construits dans quelques années. Les coûts des projets récemment mis en service peuvent représenter le niveau de coûts d'il y a quelques années (au début de la phase de construction) et les résultats des enchères d'il y a encore plus longtemps.

Revenus

- Comme l'éolien terrestre, les régimes de soutien basés sur le FiT au Royaume-Uni pour l'éolien offshore ont d'abord généré des revenus très élevés par rapport aux autres pays avant de diminuer considérablement et de passer en dessous des autres. Les recettes globales de l'intervention de soutien sont plus élevées que les recettes du marché ;
- Les revenus basés sur le marché lus à travers les prix réalisés de l'éolien offshore étaient inférieurs au prix moyen du marché avec une valeur marchande inférieure à 100% sur la

période 2008-2018, causée par une pénétration importante de l'éolien offshore induisant un effet de cannibalisation.

IRR

- Les IRRs provenant des revenus des régimes de soutien étaient globalement plus élevés que les IRRs provenant des revenus du marché, qui sont devenus positifs ces dernières années pour l'Allemagne, la Belgique, les Pays-Bas et le Danemark. Cette tendance à la hausse des revenus du marché s'explique principalement par la combinaison de l'augmentation du prix réalisé à partir de 2016, des taux de remplissage relativement élevés (35 % en moyenne) et de la diminution des coûts d'exploitation.

Gaz

- L'étude se concentre sur les centrales électriques CCGT ;
- Dans le scénario de base, le prix du carbone devrait atteindre 350 €/tCO2 en 2050 et le prix du gaz devrait doubler, ce qui se traduirait par un LCOE supérieur à 70 €/MWh pour la plupart des pays de l'UE ;
- Les données recueillies suggèrent une légère augmentation des coûts d'investissement globaux pour les CCGT sur la période 2008-2018 ;
- Les recettes diminuent à moyen et long terme en raison de la baisse des taux de remplissage ;
- Les IRRs sont sensiblement négatifs pour la plupart des pays de l'UE en raison des coûts élevés du CO_2 et des facteurs de charge plus faibles.

Charbon

- Dans le scénario de base, le prix du carbone devrait atteindre 350 €/tCO2 en 2050 et le prix du charbon devrait doubler, ce qui se traduirait par un LCOE supérieur à 80 €/MWh pour la plupart des pays de l'UE ;
- Aucune tendance spécifique des variations des CAPEX n'est observée sur la période historique, si ce n'est que, comme prévu, les grandes centrales électriques (1,5 GW+) se situent dans le bas du spectre ;
- Les régions/pays développés tels que l'UE et les États-Unis présentent des coûts d'investissement plus élevés pour cette technologie ;
- Les recettes sont en baisse en 2050 en raison de taux d'utilisation très faibles ;
- Une part importante des centrales au charbon mises en service entre 2008 et 2018 ne seraient pas économiquement viables dans certains pays de l'UE en raison des coûts élevés du CO_2 et des facteurs de charge plus faibles.

Nucléaire

- Dans les LCOE collectées auprès de sources internationales (par exemple, AIE, AEN-OCDE) et nationales (par exemple, Cour des comptes française, etc.), on observe une augmentation globale des coûts du nucléaire sur la période 2010-2018. Les projections pour 2020 et les LCOEs à long terme ne prévoient pas non plus de diminution des coûts, car les réacteurs de nouvelle génération IV pourraient nécessiter d'importants investissements ;
- Les prix réalisés prévus pour 2030-2050 (selon le scénario de base - METIS) pour l'Espagne, la France et le Royaume-Uni donnent une légère tendance à la hausse de la valeur du marché de l'énergie nucléaire, qui passerait de 100 % en 2018 à 105-110 % en 2030 et 2050. Les revenus projetés resteraient stables en France en 2030 et 2050. Au Royaume-Uni, on peut prévoir un niveau équivalent entre 2018 et 2030 avant une légère diminution des revenus pour 2050 (environ -10%) causée par une baisse similaire du prix moyen du marché en 2050. En Espagne, les revenus diminueraient en 2030 avant d'augmenter en 2050, mais resteraient inférieurs au niveau initial de 2018 ;
- Comme trop peu de centrales nucléaires ont été mises en service dans le monde sur la période 2008-2018 (par exemple aucune en Europe), la disponibilité des données sur les revenus du marché est un obstacle majeur empêchant de calculer les futurs flux de trésorerie actualisés, les IRRs, et donc de réaliser une analyse de rentabilité pour la branche nucléaire.

Hydro

- Sur les principaux marchés de l'électricité de l'UE, l'hydroélectricité (barrage) bénéficie d'un prix réalisé supérieur d'environ 5 à 15 % au prix moyen du marché ;
- Les petits projets hydroélectriques (barrages) montrent des LCOEs dans le spectre supérieur, au-dessus de 80 €/MWh ;
- Les projets à grande échelle en Chine et au Brésil présentent de faibles LCOEs d'environ 20 à 40 €/MWh.

1 Introduction

This final report of 5th October of 2020 presents the final results of all tasks.

1.1 The objectives of this study

The EC is committed to present an analysis of the prices and costs of energy every two years. This study represents a major input for the fourth energy prices and costs report in 2020 (along with other inputs prepared by the Commission Services, for example on household energy expenditure and energy poverty, energy price drivers for electricity and gas and bottom-up data on energy prices and costs paid by specific energy intensive industries). Compared to previous iterations of the costs and prices report in 2014, 2016 and 2018 the final report of this study aims inter alia to:

- Updates and extend the analysis of international comparisons on the evolution and drivers of energy prices;
- Update and extend the analysis on how energy costs influence industrial competitiveness, in particular of energy intensive industries as they are the most affected by higher energy costs;
- Provide insights on the impact of prices and the price formation framework in determining the 'captured' prices and additional support received by plants of different electricity generation technologies in the power market.

The specific objectives of the study were to:

- Analyse the evolution and drivers of wholesale and retail electricity, natural gas, petroleum products, biofuels and other alternative fuels (e.g. CNG, LPG, LNG[17], electricity prices for transport, including road transport) prices in major EU trading partners and compare it to EU prices;
- Analyse energy prices and costs as a component in production costs of industries in the EU and in major EU trading partners, and their impact on competitiveness;
- Analyse the historical 'captured' prices and support received by power generation technologies in the EU and major EU trading partners, compare it with the production costs and see how this affected profitability and investment across power technologies.

By gathering data to update or create these analyses for the EU27 countries and major trading partners, this study aims to increase transparency on energy prices and costs, to support market integration, and to identify factors that distort the internal market.

[17] LNG is not covered because the market is fragmented, not transparent and represent a small share of road transport alternative fuels. According to EAFO, CNG vehicle fleet in UE in hundreds of (around 350) times higher than LNG fleet.

1.2 The scope of this study

This study aims to build upon the work carried out in the third (2018) Energy Prices and Cost Report[18], the second (2016) Energy Prices and Cost Report[19], and Composition and Drivers of Energy Prices and Costs (2018)[20]. The table below provides an overview of the scope of the previous studies and the extended scope that shall be considered in this assignment. It mentions the countries to be covered, time period considered, and - depending on the task - the energy carriers or sectors to be included.

Table 1-1 Overview of the scope

Task	2016 energy prices & costs report	2018 energy prices & costs report	Composition and Drivers of Energy Prices and Costs (2018)	Current assignment
1.Energy prices	• Several G20 countries	• EU27 + selected non-EU G20 countries	• EU27 + selected non-EU G20 countries	• EU27 + major EU trading partners in G20 countries
	• 2008-2015	• 2008-2017	• 2008-2015	• 2008-2019
	• Electricity and gas	• Electricity, gas, biofuels and oil	• Electricity, gas and oil	• Electricity, gas, oil, biofuels and other alternative fuels
2.Industry energy costs	• EU27, China, USA, Japan	• EU27 + selected non-EU G20 countries	• EU27 + selected non-EU G20 countries	• EU27 + non-EU G20 countries, Norway, Iceland and Switzerland
	• 2008-2014	• 2008-2016	• 2008-2015	• 2008-2017
	• NACE 3: 15 energy intensive manufacturing sectors	• Manufacturing sectors including 10 NACE 2 and 20 NACE 3 sectors • Non-manufacturing sectors at NACE 1 and NACE 2 levels	• Steel, Aluminum, Wall and floor tiles, Bricks and roof tiles, Refineries	• 30 manufacturing sectors including 10 NACE 2 and 20 NACE 3 sectors, of which 15 are considered highly energy intensive • 13 non-manufacturing sectors at NACE 1 and NACE 2 levels (A-J) • Data centres, Flat glass, Refineries, Zinc, Ferro-alloys and silicon
3. .Impact of 'realised' prices and support interventions on profitability and investments on power generation technologies	Not covered	Not covered	Not covered	• EU27 + selected non-EU G20 countries, Norway, and Switzerland; and price-zones within countries
				• 2008-latest available year
				• Electricity • Granular: Per power generation technology and per fuel type

18 Energy prices and costs in Europe (2018) - Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. Brussels, 9 January 2019. COM (2019) 1
19 Energy prices and costs in Europe (2016) - Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. Brussels, 30 November 2016. COM(2016) 769 final
20 CEPS/Ecofys (2018) study on composition and drivers of energy prices and costs

2 Methodology

2.1 Overall approach

The overall approach to this work has been structured by three tasks, and an inception phase which was used to clarify the key definitions, scope, objectives and data to be used in the work. The three tasks each correspond to a specific and distinct aspect of energy prices and costs as requested in the original terms of reference of the work, namely:

- Task 1: Analysis of energy prices in EU major trading partners and comparison to the EU - the goal of this task was to gather and assess energy prices in both the EU27 and non-EU G20 countries, to compare levels and trends over time and provide analysis of the key movements and drivers of these. This constituted around 30% of the work;
- Task 2: Analysis of energy costs for industry in the EU and EU major trading partners - the goal of this task was to gather and assess the energy costs for industry in the EU27, Norway, Switzerland, Iceland and non-EU G20 countries, including energy costs, energy prices, energy consumption and energy efficiency as well as other production costs and parameters affecting costs and value added. This constituted around 40% of the work;
- Task 3 **- Analysis of impact of '**realised**' prices and support interventions on profitability** and investments across power generation technologies in the power market in the EU and EU major trading partners - the goal of this task was to assess the impact of realised prices and government interventions on profitability and investments across electricity generation technologies. This constituted around 30% of the work.

All tasks are structured in the same way and comprise three or four subtasks: 1) data collection, 2) database update/creation, 3) assessment and 4) communication material (only for Tasks 1 and 2). There was some interaction between the tasks, for example the international price data gathered in task 1 was used in task 2 for estimating energy costs of industry in other G20 countries.

2.2 Data collection

This work has been highly data intensive and has drawn upon a variety of approaches and sources to complete the work. Among the key sources have been the following:

- Previous Energy costs and prices work – the previous iterations of this study provided a starting point for many tasks in this work. These data were reviewed and discussed with the European Commission, in most cases being used to inform our specific approach, rather than being directly reused. For task 3, no data were available from previous versions of the Energy costs and prices series;
- Existing public databases – key national, EU and international data sources such as Eurostat, OECD and IEA have been major sources for this work;
- Private and commercial databases – working with the European Commission and other relevant administrations, agencies, associations and providers, it has been possible to access and use unpublished and/or commercially available data. One dataset was purchased from IHS Markit for use in Task 2 top-down analysis;
- Survey - a questionnaire was sent to Industry Associations to collect bottom-up data from plants of selected energy intensive industries;

- Stakeholder interaction - our work has included a stakeholder workshop, held as a webinar in May 2020, at which the approach of Task 3 was presented to an audience of highly relevant stakeholders. This provided an opportunity to improve our approach. A second stakeholder workshop was conducted on July 2020 to validate preliminary findings of the study.

Please see the task chapters to find the specific sources used.

2.3 Database update and creation

Our work on the creation or update of existing Excel databases has been based on the principles of:

- Traceability (of data);
- Simplicity & functionality;
- Consistency;
- Improvement (for updating of databases);
- Smart design (for creation of new database).

The databases that have been created for this work are supplied as accompanying deliverables to the work. These were developed in close cooperation with counterparts at the European Commission to ensure they provide relevant information and incorporate the (future) user perspective.

2.4 Analysis

This work has made use of a variety of analytical techniques, particularly statistical and trend analysis. Among the more complex techniques applied are:

- Regression analysis;
- Decomposition analysis.

A detailed description of the former and its specific application to this work can be found in the task chapters.

3 Task 1 - Analysis of energy prices in EU major trading partners and comparison to the EU

3.1 Methodology and data

3.1.1 Objective and scope

The aim of this task is to gather and assess annual energy price data of EU trading partners in G20 countries (including UK), Norway, Switzerland and Iceland and compare them to EU prices. Prices cover electricity, gas and various other fuels, such as biofuels and alternative fuels (e.g. CNG, LPG, electricity for transport)[21]. Based on the data collected in the sub task 1.1, the existing database on international prices has been updated, to analyse the evolution, levels and drivers of prices and compare the EU with its major trading partners.

The team collected data for the EU27 and non-EU G20 countries (including UK). Norway, Switzerland and Iceland were also included where relevant and depending on data availability. In terms of time coverage, data cover the period 2008-2019 with at least annual data, but data with higher granularity (quarterly, monthly) were collected and presented where relevant. There is substantial variability in terms of data availability for different countries.

Table 3-1 below presents the scope of the energy prices analysis, providing a comprehensive list of prices covered by the data-collection exercise. It should be noted that for some series, for example biofuels, CNG, and electricity for transport, availability of data is limited. Therefore, information was collected from a range of sources and it was necessary to develop estimation methodologies to complete the coverage of alternative fuels. Data availability for other fuels and specific price data are summarised in the following section.

Table 3-1 Scope of data collection - prices and source types.

	Electricity	Natural Gas	Petroleum products	Alternative fuels (new)
Wholesale	• EU27 and UK - using regional market or national prices • G20 - using national market prices	• EU27 and UK - using regional market average prices, hub prices or national prices • G20 - using national annual average day ahead or import prices	• Crude oil - based on main global price indices (Brent, WTI, Dubai, average)	• Biodiesel for large selected markets (Argentina, Brazil, USA, Indonesia, EU28). • Bioethanol for selected markets: USA, Argentina, Brazil, UK and EU27
Retail	• EU27 and UK: Industrial (split by	• EU27 and UK: Industrial (split	• Petrol (gasoline)	Upon availability, using estimation methodology

[21] Hydrogen could become an important fuel for transport (and possibly heating applications) but, given its very limited availability, it is not covered here

	Electricity	Natural Gas	Petroleum products	Alternative fuels (new)
	consumption bands as defined in Eurostat) • EU27 and UK: Household (split by consumption bands as defined in Eurostat) • G20: Average prices for industry and households	by consumption bands as defined in Eurostat) • EU27 and UK: Household (split by consumption bands as defined in Eurostat) • G20: Average prices for industry and households	• Diesel • LPG motor fuel • Heating oil • Heavy fuel oil • Light fuel oil	• Biofuels • CNG • Electricity in transport

3.1.2 Data gathering

The database on prices has been updated up to 2019 for different energy carriers with monthly, quarterly and annual historical data series. For electricity and gas across EU27 countries, we selected Eurostat biannual electricity and gas prices combined with monthly Harmonised Indices of Consumer Prices (HICP). For petroleum products, we used the Weekly Oil Bulletin to calculate monthly and annual retail prices. For alternative fuels, we used various national sources and specialised websites, such as CNGEurope, or carried out targeted research to gather prices in selected refuelling stations throughout Europe. For G20 countries, we used a mix of sources, such as IEA Energy Prices and Taxes report, and national sources. Where possible, public data sources were used instead of public ones, and the database now includes more prices series. Table 3-2 presents a summary of the data inventory, the sources and main changes that have been introduced compared to the previous version of the database.

Table 3-2 Summary of data inventory of Task 1

Energy Carrier	Markets	Sources	Changes compared to the previous database	Newly added into the database	Summary of data coverage, data gaps
Electricity	Households	• EU27 & UK from Eurostat • G20 - mix of IEA, national sources	• Added raw detailed prices using semi-annual prices and monthly HICP • ERRA 22sources replaced by national sources (Saudi Arabia)	Prices newly added for Argentina, India, South Africa, Norway, Switzerland, Iceland	• All countries available • Limited data for consumption bands out of EU countries
	Industry	• EU27 & UK from Eurostat • G20 - mix of IEA, national sources	• Added raw detailed prices using semi-annual prices and monthly HICP • ERRA sources replaced by national sources (Saudi Arabia, Russia)	Prices newly added for Argentina, Australia, India, South Africa, Norway, Switzerland, Iceland	• All countries available • Limited data for consumption bands out of EU countries
	Wholesale	• EU27 & UK - prices from main markets from spot hub • G20 - prices from main markets from spot hub and marker places.	• EU27 & UK: 16 EU countries with sources from key markets (Platts before); the others remain Platts.	Prices newly added for Croatia, India, Argentina, South Africa, South Korea, Norway, Switzerland	• For EU27 &UK: most data updated using information from main markets; Platts for the other ones. • No data for Saudi Arabia, Iceland
Natural gas	Households	• EU27 & UK from Eurostat • G20 - mix of IEA, national sources	• Added raw detailed prices using semi-annual prices and monthly HICP	Prices newly added for Australia, India, Switzerland	• Limited data for consumption bands out of EU countries • Missing data for Cyprus, Finland, Malta, Indonesia, South Africa, Norway, Iceland (no or few consumption)
	Industry	• EU27 & UK from Eurostat • G20 - mix of IEA, national sources	• Added raw detailed prices using semi-annual prices and monthly HICP	Prices newly added for Australia, India, Indonesia, Saudi Arabia, South Africa, Switzerland	• Limited data for consumption bands out of UE countries • Missing data for Cyprus, Malta, Saudi Arabia, South Africa, Norway, Iceland, Switzerland (no markets)

22 In the previous database, electricity and gas prices coming from ERRA (Energy Regulators regional Association) have been provided by the European Commission. When publicly available, such prices have been replaced by other national sources.

Source: Study on energy prices, costs and their impact on industry and households

Energy Carrier		Markets	Sources	Changes compared to the previous database	Newly added into the database	Summary of data coverage, data gaps
		Wholesale	• EU27 & UK - prices from major trading hubs Comext and Platts. • G20 - prices from major trading hubs		-	No data for Cyprus, Malta, Norway, Iceland (no or low consumption)
Petroleum Products	Crude oil	Wholesale	World Bank - Global Economic Monitor Commodities	Data update	-	• Brent, Dubai, WTI
	Heavy fuel oil	Industry	• EU27 & UK: Weekly Oil Bulletin • G20: IEA Energy prices and Taxes; GIZ International fuel prices; national data	Data update	-	• Some gaps remain for G20 countries (but not for petroleum and diesel) • Limited data for: heavy fuel oil, light fuel oil, heating oil, LPG
	Light fuel oil	Industry Households		Data update	-	
	Diesel	Transport		Data update. GIZ sources sometimes replaced by publicly available prices	-	
	Petrol	Transport		Data update. GIZ sources are planned to be replaced by national sources	-	
	LPG motor fuel	Transport		Data update	-	
	Heating oil	Households		Data update	-	
Alternative fuels	CNG	Transport	• National sources • Specialised website publishing CNG / NGV filling station prices (ex CNGEurope, Fuelo in Italy, etc).	CNGEurope data update	Prices newly added for Argentina, Brazil, India, USA	• Limited data for CNG (see methodology)
	Biofuels	Transport	National sources	-	Prices newly added for Argentina, Brazil, USA (Ethanol or Biodiesel)	• Limited markets for Biofuels as no retail markets for pure biofuels exist (except the 3 countries covered)
		Wholesale	• Platts - Biofuels Scan	Platts data update	-	

Methodology for CNG prices in transport

Natural gas vehicles (NGV) are alternative fuel vehicles that use compressed natural gas (CNG) or liquefied natural gas (LNG). CNG is mainly used by vehicles travelling moderate distances between refuelling (buses, passenger cars, minivans, delivery trucks, etc.), while LNG is better suited for high grossing vehicles travelling longer distances. LNG only represents a small part of transport consumption[23] and is well below CNG in terms of number of road vehicles[24], even if the gap is reducing slowly. Moreover, the market is fragmented and not transparent. So the price database is limited to CNG prices.

The main objective of this section is to determine CNG prices paid in refuelling stations of countries where NGVs are more widespread. Therefore, we first mapped the use of gas in transport, covering both private use and vehicle fleets.

a) Mapping of gas markets in transport

In 2018, across G20 countries, gas represented around 2% of the total final energy consumption in transport[25]. China is by far the largest consumer of gas for road transport (with 22 Mtoe in 2018) followed by Iran (7 Mtoe), India (2.5 Mtoe), and Argentina (2 Mtoe). Total consumption of natural gas fuels (CNG/LNG) in the EU was estimated at 1.6 Mtoe in 2018[26]. Within countries, the share of natural gas in total road consumption is around 13.6% for Argentina, followed by 8.4% for China and 3.5% for South Korea (see Table 3-3). Italy is the only EU country with a significant share (2.7%).

Table 3-3 Share of gas in road energy consumption

Countries	Share of natural gas in total road transportation energy consumption (2018)
Argentina	13.6%
China	8.4%
South Korea	3.5%
India	2.7%
Italy	2.7%
Brazil	2.4%

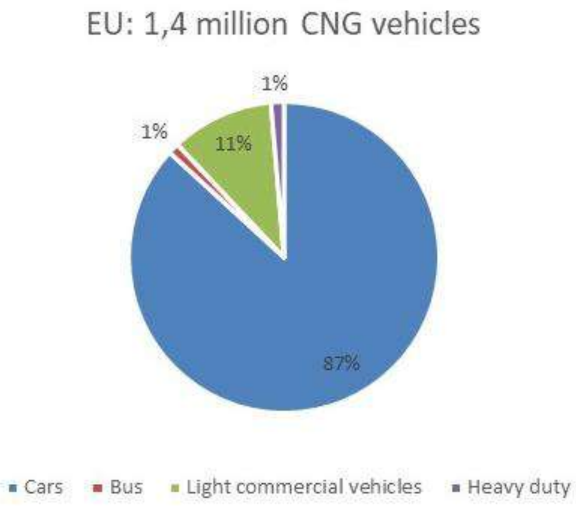
b) Mapping of CNG vehicle fleets

According to NGV Global, there are currently around 28 million natural gas vehicles and around 32 577 NG fuelling stations worldwide (July 2019). Asia leads with around 17 million vehicles, of which almost 6 million in China, followed by Latin America with 5.5 million and Europe with 1.4 million[27].

In Europe, detailed statistics are provided from the European Alternative Fuels Observatory (EAFO), which is supported by the European Structural and Investment Funds (ESI funds). Among the 1.4 million CNG vehicles, 87% are cars, 11% light commercial vehicles, 1% buses and 1% heavy duty vehicles.

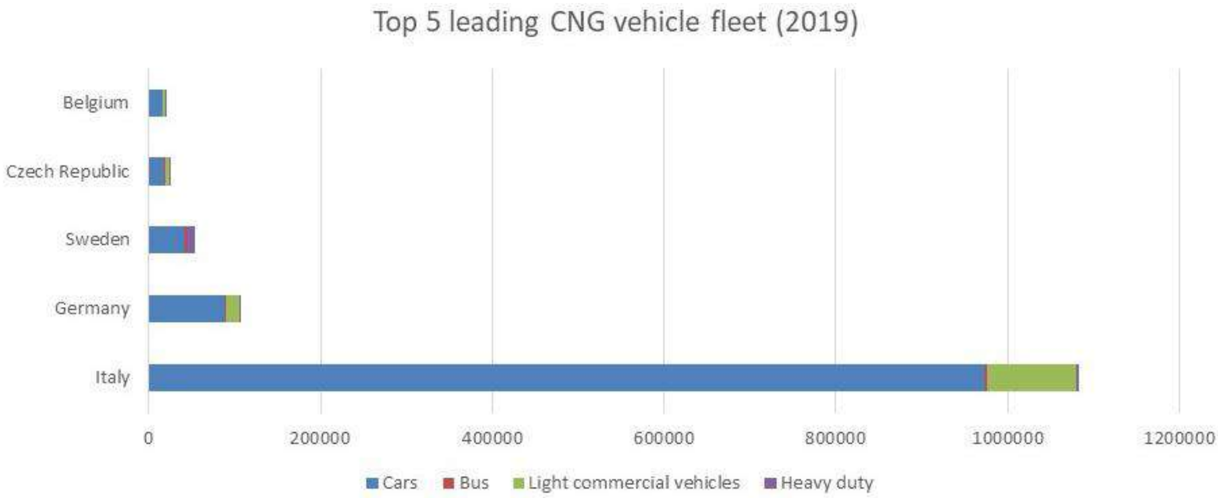
[23] LNG would represent around 1.6% of total transport consumption in 2020, (Source: Cedigas LNG potential demand and Enerdata Global Energy and CO2 database)
[24] About 4 thousand LNG vehicles in UE in 2019 versus 1.4 million CNG vehicles. And about 1.2 thousand LNG vehicles in UE newly registered in 2019 versus 79.3 thousand for CNG. Source EAFO
[25] Source: Enerdata, Global Energy and CO2 database
[26] https://www.eafo.eu/alternative-fuels/ng-natural-gas/consumption
[27] NGV Global is an International Association for Natural Gas (previously known as IANGV) (http://www.iangv.org/current-ngv-stats/); for Europe statistics from EAFO (https://www.eafo.eu)

Figure 3-1 Typology of CNG vehicles in Europe



The 5 countries with the largest fleet of CNG vehicles in Europe are Italy (80% of EU fleet), followed by Germany, Sweden, Czech Republic and Belgium (Figure 3-2).

Figure 3-2 CNG vehicle type in the top 5 leading countries



Based on this mapping and the sources previously identified, we have collected CNG prices for the following countries:

- For Argentina and Brazil CNG prices available since 2011 and 2008, respectively[28];
- For USA, quarterly prices since 2008;
- For India, CNG prices by region since October 2018; we used the New Delhi prices in order to estimate the national price;
- For China CNG prices are available from 2013 to 2019 based on prices for the Peking area for 2013 to 2015 and based on estimates thereafter based on the ratio gasoline/CNG provided by the NDRC government[29];
- For India, CNG prices corresponds to those of New Dehli;
- For European countries, we have covered the 5 leading countries plus 20 other countries covered by CNGEurope.

[28] ENARGAS (2011-2019) for Argentina; ANP for Brazil (2008-2019)
[29] http://tasri.org/upLoad/down/month_1902/201902191625266398.pdf

Methodology for electricity prices in transport

This analysis focuses on electricity prices for road vehicles (in particular cars) because the only other large market for transport electricity (rail transport) is not transparent enough to allow for comparisons. Price information concerning rail contracts is generally very difficult to obtain, as it is contained in commercially-sensitive agreements between private companies.

The objective of this section is to present the methodology used to collect electricity prices paid by electric vehicles (EVs) owners. We conducted a comprehensive literature search to identify different characteristics of vehicle charging (location, charger technology) available in different countries, and their relative importance. Due to the fact that electricity for transport is an emerging and rapidly changing market, we collected information from countries where EVs numbers are more widespread, and where available we provide data for different tariffs for EV users. The rest of this section presents our characterisation of the EV charging market and how we approached data collection, while the results concerning prices are detailed in section 3.2.4. More detailed information is available in Annex B, including further characterisation of the market and additional findings.

a) EV dynamics

In order to understand the market, we first identified the countries which have the highest numbers of EVs, using data on vehicle stocks. Then, to understand the market for EV charging, we looked at information on the number of charging stations, and when possible by type of charging mode. Data show that China is by far the largest market, followed by the EU, USA and Japan. In Europe, the Netherlands, Norway, Germany, France and UK are the countries with the highest number of EVs.

b) Charging technologies

We have identified three main charging technologies:

- Level 1, it could be as simple as a power outlet, and it is the slowest method (~10 hours to replenish daily usage);
- Level 2 (slow charging, between 2-5.5 hours to replenish daily usage), faster charging technology, becoming more popular across locations;
- Level 3 (fast or rapid charging, ~45 minutes to replenish daily usage), fastest method currently available, being developed more and more with the network.

EV owners are limited in their choice of charging technology by their car model. Not all batteries can use fast chargers, as they are not able to receive higher power inputs. Owners are also limited by plug types, as manufacturers have developed different ones, and EVs can generally only use those compatible with their car, even if adaptors exist. The main plug types are:

- Chademo, mainly used by Japanese and east Asiatic car manufacturers;
- Combo CCS, mainly used by German car manufacturers;
- Tesla Supercharger.

c) Charging locations

EV drivers have three main options for charging EVs:

- Charging at home: it is the most common method for charging privately owned EVs. Most drivers would plug in their vehicles in the evening, when coming when coming back home from work;

- Charging at work (or other private shared parking spaces): employers are beginning to install charging points in their workplace parking lot. This is a convenient option for drivers, notably for those not having the possibility to charge at home;
- Charging at public locations: this includes both spaces in public parking lots or roadside charging. There are a number of pricing options, with some local administration offering free charging, other requiring subscription or on a pay-per-charge basis.

EV users' preference for charging location depends on a range of factors, such as access to a driveway at home, availability of public charging infrastructure, the pricing applied by operators, and driving habits (for example, use of the car for short trips rather than longer distances). Charging at home is by far the more popular option. Most daily trips do not exceed a few tens of kilometres, and such distances can be covered with a few hours of charging even through a Level 1 charger. However, public charging infrastructure is a quite important complements to home charging, and it is an option that will gain more popularity in urban areas, given that drivers living in flats are unlikely to have access to a private driveway for home charging. For commuters, especially for those with no home charging option, workplace charging is an important option, while fast-charging stations will play a fundamental role in ensuring long distance travel.

d) Pricing systems

There are four main ways of pricing EV charging, the last three of which are relevant for public charging:

- When charging at home, drivers would pay according to their electricity contracts, so prices vary substantially. Some contracts, including those specifically targeted at EV owners, may have tariffs that vary with the time of use. This means the cost of a charge will vary according to when the user decides to plug in the EV;
- Energy consumption pricing, which means the users pay according to the amount of energy transferred into the battery;
- Time consumption pricing, commonly associated with parking, where the user is charged according to the time spent with the plug on, irrespectively of the amount of electricity transferred;
- Subscription based, where users pay a fixed monthly rate and may be entitled to charge for free, or at a reduced rate, at a network of charging points.

As the number of charging points and charging services providers increase, tariffs will also become more complex. For example, including a combination of energy, location and subscription charges, or different tariffs for home charging.

The work we carried out to understand EV charging prices aimed to cover the four methods. It included collecting data on customer tariffs from domestic energy suppliers and prices charged by public charging points. When necessary, we have converted a time-based pricing scheme into an energy pricing scheme, which is possible because the load curve is rather linear between 20% and 80% of charge. The subscription scheme generally includes a time or energy related part, which is more difficult to take into account. Some stations can also propose a price "per session", although we found these to be exception and not representative. Based on these considerations, we have selected some countries based on price availability and transparency and identified whether main electricity providers propose reduced tariffs at night, as off-peak tariffs could be considered amongst the proxies for the electricity prices used for charging EV's at home. In addition to these off-peak prices, we have tried to identify whether these electricity providers propose specific tariffs for EV owners.

At home, prices paid for charging EV are essentially regular electricity tariffs for private households. To collect this data, we have conducted internet searches covering existing off-peak electricity prices in selected countries in and outside Europe. As prices and tariffs are not always transparent in countries, we run a dedicated survey in 10 EU countries (Germany, The Netherlands, Sweden, Denmark, Belgium, Austria, Czech Republic, Finland, Spain and Italy) and two non-EU countries (Norway and Switzerland).

Prices reported in the next section must be considered with a number of caveats. For some countries, electricity prices differ from regions and municipalities. It means that even off-peak prices are proposed by utilities, this may not be representative of overall prices across the country (case of China). Another limitation is the uptake of off-peak or EV tariffs, which could be very low: for example, in Sweden only 2% of customers have opted for time of use rates[30]. Some countries may also propose time-of-use tariffs based on seasonal variations, such as summer rates in India (New Delhi) and South Korea.

3.2 Analysis of price data

Note: Within this section all prices are presented in constant 2018 Euros. Price data is typically only available until the end of 2019, this therefore precludes any COVID19 impacts being visible in the results.

3.2.1 Electricity prices

This section presents results for electricity price trends in the EU27 and G20. Full Member State data and figures are provided in the Excel tool annexed to this work.

Wholesale

Wholesale electricity prices have relatively complete datasets. The figures below present time series of available price data for the EU27 countries and G20 from 2008 to 2019 included.

There are a few caveats to bear in mind when considering this data:

- CY is excluded from the EU27 dataset because it does not have a wholesale market for electricity;
- In cases where electricity wholesale price data were not available, such as for LU and MT, we used proxy prices from DE and IT, respectively;
- In China, Brazil and Indonesia, in the absence of actual wholesale market prices, final consumer price data for large industrial customers have been used as a proxy for wholesale prices. For these countries, the results are presented as dotted lines to underline that these are not fully representative of wholesale prices (which are likely to be lower than the proxy levels) and therefore greater caution should be exercised in interpreting these prices.

[30] https://www.smart-energy.com/industry-sectors/electric-vehicles/as-energy-gets-smarter-time-of-use-tariffs-spread-globally/

Conclusions that can be drawn from this data include:

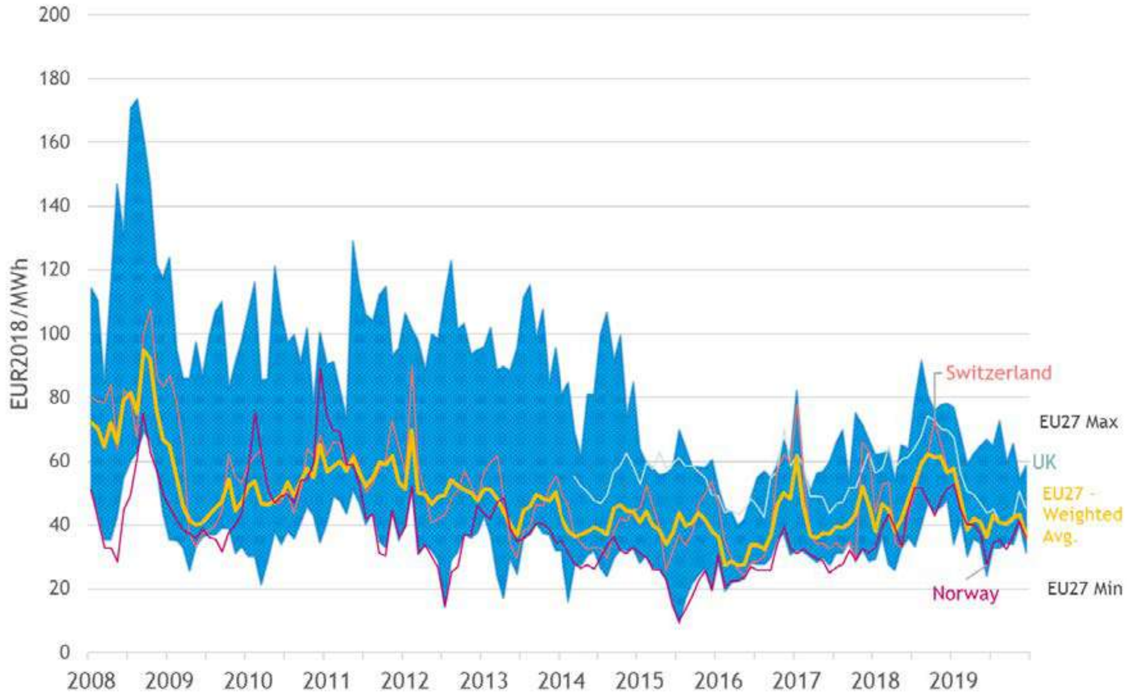
- Average wholesale electricity prices in EU27 have been relatively stable since 2009. Between 2009 and 2013 they have been moving within the 40 EUR/MWh to 60 EUR/MWh band, and between 2014 and 2016 within the 30 EUR/MWh and 50 EUR/MWh band. After 2017, wholesale prices have seen increased volatility, with a spike in 2017 and a protracted high in early 2019 (at around 60 EUR/MWh). Prices have stabilised at around 40 EUR/MWh since. This is in part due to low gas prices, because of abundant supply, and high LNG deliveries, combined with increasing output from renewables which tends to correlate with lower prices[31]. Balancing these downward price pressures is the cost of EU-ETS allowances (EUAs), which since around September 2017 have increased considerably from less than €6 tCO_2 to more than €20 tCO_2 for most of the period from September 2018 onwards. This has put upwards price pressure on fossil fuels, especially coal, whose emissions of around $1tCO_2$ per MWh are consistent with an increase in the production cost equal to the EU-ETS EUA price, the comparable emissions for natural gas are closer to 0.35-0.5 tCO_2/MWh. Naturally adding €20/MWh or more to the production cost of coal power, in a market with prices of €30-50/MWh, is very difficult to manage whilst remaining profitable, and consequently the share of coal in the energy mix has shrunk considerably in many countries;
- The UK price is slightly higher than the EU27 average price, but closely tracks its variation. The price for Norway is instead closer to the bottom of the EU27 range;
- Wholesale electricity prices in the USA have tended to fluctuate similarly to the EU27 weighted average price, albeit they are usually cheaper (€20-€50/MWh) and more variable within a year. On a few occasions US wholesale prices went above the EU27 price. Prices in Japan are higher than in the EU. They have decreased compared to the years post-Fukushima, but they have shown protracted upwards variability from a base price of 60 EUR/MWh in the last three years. The proxy for wholesale prices in China[32] continues its downwards trend, and at an accelerating pace since 2017. The proxy price level is relatively high, but in reality, the wholesale price is likely to be much lower, as suggested in other studies, but for which price data were not usable[33];
- Prices in other G20 countries (TR, IN, BR, MX, AU, RU, CA) have shown a variety of trends, but since 2016 they have started to converge and are now all between 10 EUR/MWh (CA) and 75 EUR MWh (ID). Extreme spikes seen before 2016 in BR are less pronounced, although the variability in BR is still quite high compared to other G20 countries. The EU27 average price sits at the middle of the range observed in the last two years, with some temporary upwards periods;
- Analysis of the evolution of price differentials between the EU27 average and G20 countries, in Euros (see Table A-1 in Annex A) in 2018 constant EUR prices, shows that price developments across 10 of the 14 non-EU G20 countries have been positive[34] compared to the EU average. In 2008, six countries (AU, CA, ID, RU, ZA and TK) had lower prices than the EU average, but this

[31]https://ec.europa.eu/energy/sites/ener/files/documents/quarterly_report_on_european_electricity_markets_q_2_2019_final.pdf
Also a simple correlation of the evolution of renewable energy shares and wholesale prices per EU Member State since 2008 shows a moderate-strong (correlation coefficient of 0.65) negative correlation (as renewable shares rise, average wholesale prices fall). The strength of the correlation varies per Member State, and only one exception (Bulgaria) shows a (very weak) positive price correlation with renewables shares.
[32] Used industrial price as proxy, this dataset from CEIC: CN: Purchasing Price Index: Fuel and Power (China).
[33] https://eta.lbl.gov/sites/all/files/publications/ced-9-2017-final.pdf
[34] Here and in the following sections we refer to positive and negative developments in price differentials for the EU. Positive developments refer to situations where EU prices become relatively more affordable due to price changes, i.e. price gaps with cheaper prices narrow, price gaps with more expensive prices widen; and vice-versa for negative developments.

had fallen to four countries by 2019 (CA, IN, RU, US), with Australia, Turkey and South Africa becoming more expensive than the EU and the US and IN becoming cheaper;

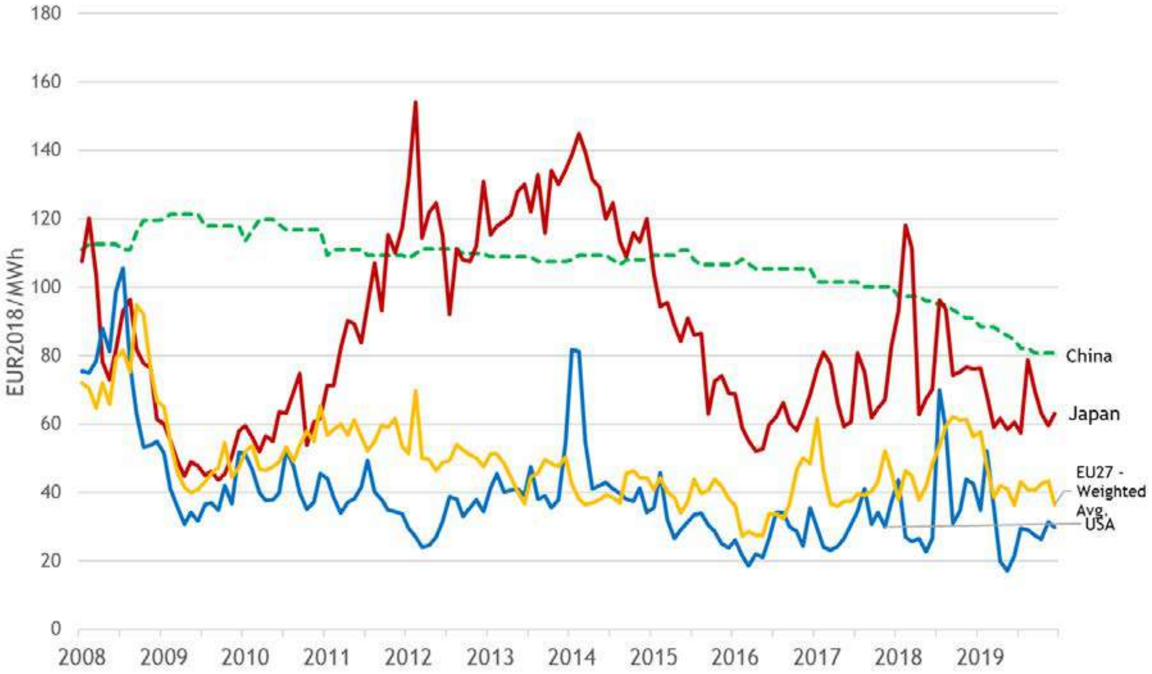
- In Table A-2 of Annex A we present a more detailed view of the observed (nominal) price changes with the breakdown of some of the key factors in these changes, namely inflation, national price and exchange effects. Looking at the national price effects we see that EU27 weighted average prices decreased almost 43% between 2008 and 2019. This change compares favourably with the other G20 countries, with only Canada, Brazil, and India experiencing greater price declines. Inflation had a significant effect on prices in Brazil and India.

Figure 3-3 Electricity prices, wholesale, EU27 (weighted) average, min and max, CH, IS, NO and UK, 2008-2019, EUR_{2018}/MWh



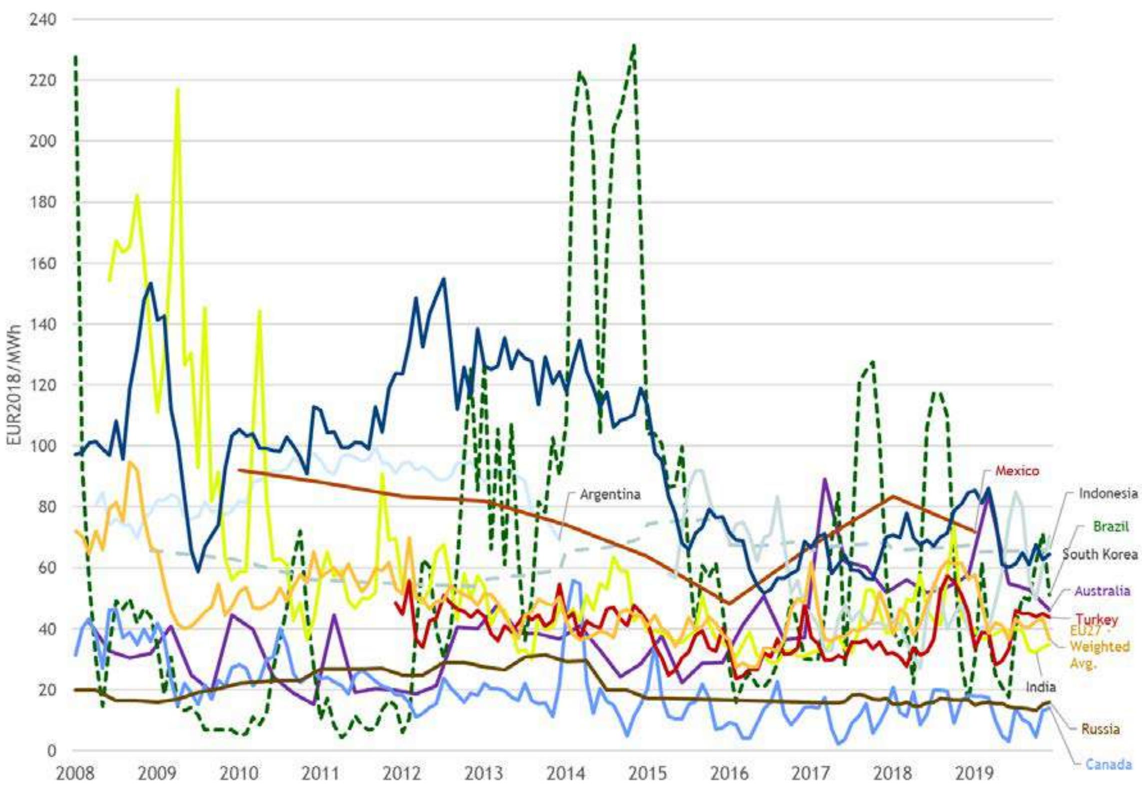
Sources: Own calculation, based on data from Eurostat, Platts, HUPX, Enexgroup, Gestore Mercati Energetici, Nordpool group

Figure 3-4 Electricity prices, wholesale, EU27, China, Japan, USA, 2008-2019, EUR_{2018}/MWh



Sources: Own calculation, based on data from Eurostat, US EIA, Japan Electric Power Exchange, CEIC, Nordpool group, EMOS
Note: the Chinese wholesale price is an assumed proxy price based on Usage Price: 36 City Avg: Electricity for Industry: 35 kV & Above (China). Actual wholesale prices, to the extent they exist in China, are likely to be lower.

Figure 3-5 Electricity prices, wholesale, EU27 and other G20, 2008-2019, EUR_{2018}/MWh



Sources: Own calculation, based on data from ERRA, AER, CEIC, IESO, Platts
Note: Price proxies are used for Brazil and Indonesia, these are based on prices for large industrial consumers. Further details can be found in the annexes.

Source: Study on energy prices, costs and their impact on industry and households

Retail - households

Retail electricity prices for households have relatively complete datasets. The figures below present time series of available price data for the EU27 and G20 countries from 2008-2019.

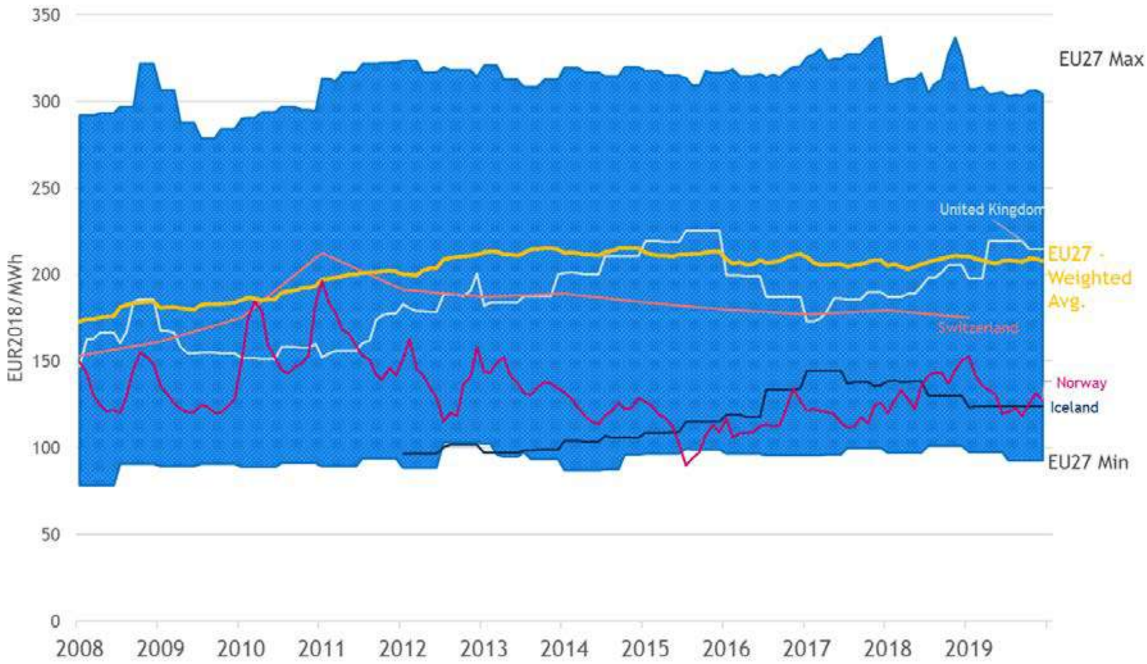
Conclusions that can be drawn from this data include:

- EU27 average prices have increased from around 156 EUR/MWh in 2008 to 208 EUR/MWh by the end of 2019, although prices have been quite stable around 210 EUR/MWh since 2013. Prices in Norway and Iceland are near the bottom of the EU range, while UK prices are closer to the average EU figure;
- Chinese prices are around 1/3 of the EU27 average, and US prices are just above 1/2 of the EU27 average. US prices have, subject to seasonal variations, remained at around the same level between 2008 and 2019. Chinese prices, which are subsidised, have been flat in nominal terms, therefore the observed decline is driven by inflation and exchange rate effects. Prices in Japan started higher than the EU average in 2008 and increased up to 2012 (likely linked to Fukushima), but since 2012 have declined significantly and were in line with the EU27 average up to the start of 2018;
- Amongst other G20 countries, prices in Saudi Arabia, Argentina, Russia, Mexico and Indonesia are lowest and have generally shown a flat trend between 2008 and 2019 (prices are subsidised in all four[35]). Prices in Canada (CA), South Africa (ZA) and Korea (KR) are typically less than 100 EUR/MWh, with prices in KO showing a significant seasonal variation. Prices in TR are also subject to seasonal variations, and were falling up to 2018, but are now following an upward trend. Prices in AU and BR, previously higher than the EU average, have declined below the EU average since 2014-15, with a depreciation in the value of the USD (in which Australian prices were listed) against the EUR among the main drivers of the observed fall in Australia. This effect is also visible to a lesser extent in some of the other price series;
- Since 2016, the EU27 average price for households is the highest of all G20 countries for which data are available (although AU was marginally higher in 2017-18). As one example of the driver of this, it is instructive to compare the USA and the EU. The similarity of EU27 and US wholesale prices (Figure 3-4) but large divergence in retail prices for households, highlights differences in other costs between the two. Network costs and, especially taxes and levies, drove prices higher for household electricity in the EU27 over the past decade. This difference is further analysed later in this section;
- The analysis of electricity prices in Purchasing Power Standards (PPS) gives a better measure of the relative effect of electricity prices on households' finances. The analysis in Error! Reference source not found. shows that, while the highest nominal prices are to be found in in Germany, once these are corrected for PPS the most expensive country is Spain. On the other hand, while Mexico has the lowest nominal price, the cost of electricity is the cheapest in Norway once prices are corrected for purchasing power. It is interesting to note that Germany ranks between the most expensive countries both in nominal and PPS terms, while Norway is among the lowest in both cases.
- On average, countries in the Euro area with income above EU average see their ranking decrease in PPS terms (so electricity is cheaper), while countries with income below EU average see their prices increase.

[35] IEA (2016) Mexico Energy Outlook: Special Report

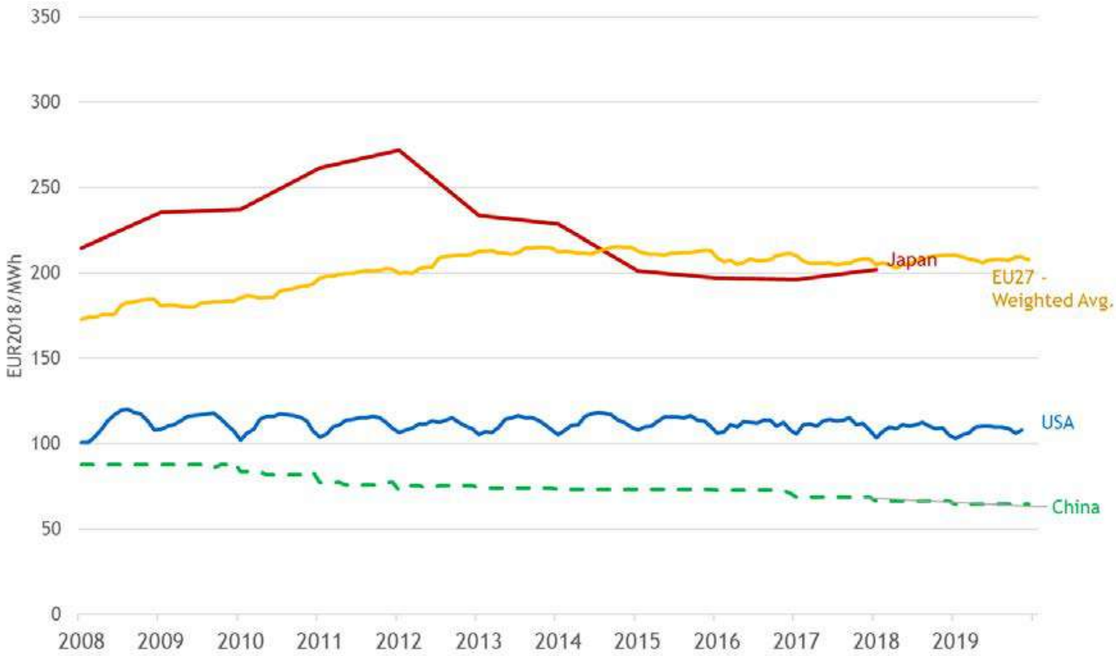
- Analysis of the evolution of prices (see Table A-3 in Annex A) in 2018 constant EUR prices shows that price developments across all countries have been relatively negative for the EU. Although this does not affect the competitiveness of the EU, it does signal a worsening of the relative price paid by the average EU household. The starting position was already that only 3 (AU, BR, JP) of the 13 countries had higher prices than the EU average in 2008, and in 2019 (Q2) none had, with the gap widening in all countries. This is unsurprising as the biggest price increase was recorded for the EU, whilst prices only increased in 3 of the other countries (CA, KR, US) in this period;
- In Table A-4 (in Annex A) we present a more detailed breakdown of the observed (nominal) price changes of some of the key factors, namely inflation, national price and exchange effects. It shows that EU prices increased by 36% in EUR and the majority of G20 countries showing a larger increase in local currency. In particular Argentina with a 360% increase. Exchange rate effects led to a relative decrease in the household retail prices for all countries excluding CN, JP, SA, KO and US.

Figure 3-6 Electricity prices, household retail, EU27 (weighted) average, min and max, CH, IS, NO and UK, 2008-2019, EUR_{2018}/MWh



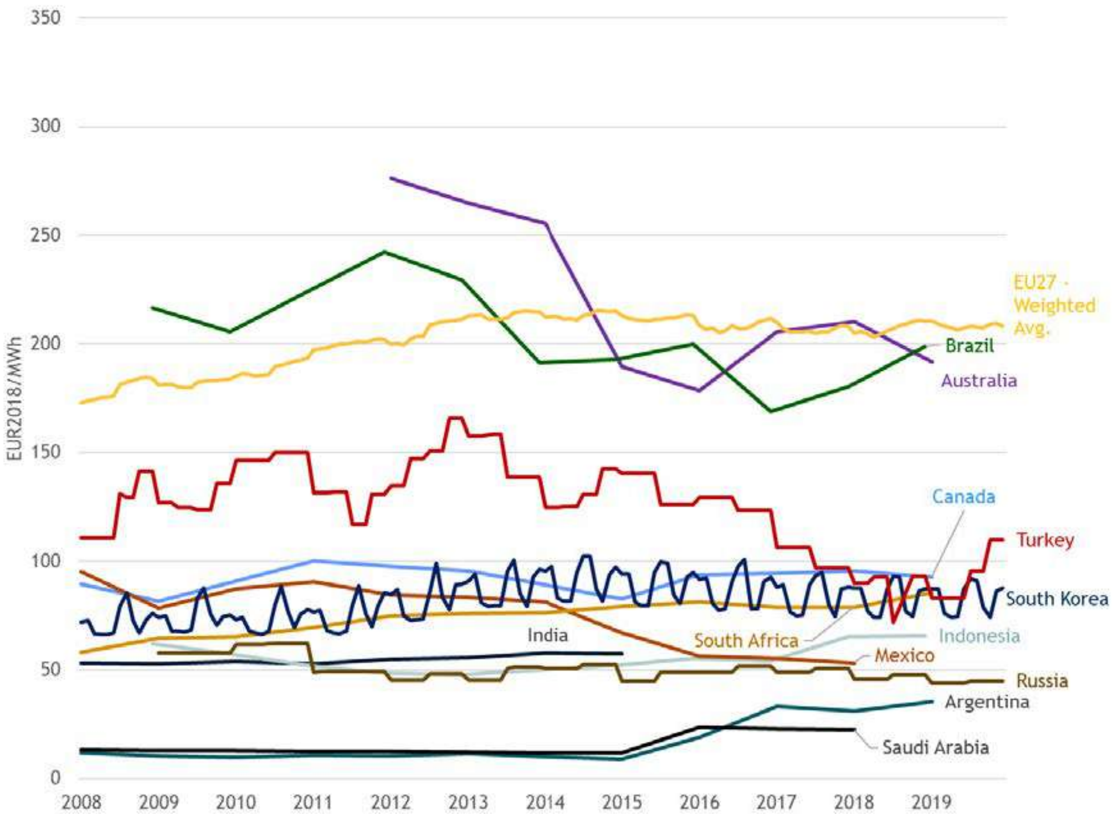
Sources: Own calculation, based on data from Eurostat

Figure 3-7 Electricity prices, household retail, EU27, Japan, USA, and China 2008-2019, EUR_{2018}/MWh



Sources: Own calculation, based on data from Eurostat, CEIC, IEA
Note: data for China is a proxy of the 36 largest cities

Figure 3-8 Electricity prices, household retail, EU27, other G20, 2008-2019, EUR_{2018}/MWh



Sources: Own calculation, based on data from Eurostat, CEIC, IEA, ERRA and national sources

Box 3-1 Household electricity prices and costs in context of income - Purchasing power standard (PPS) and on basis of consumption

The prices presented in the previous section are unadjusted for purchasing power differences, e.g. the differences in income and living costs between countries. It is interesting to look at these differences when considering the relative impact on households in each country to get a clearer understanding of the actual impact of the differences. In this text-box we provide a snapshot and analysis of the differences that result from using purchasing power standard (PPS) prices based on IEA data [36], and with the United States as the PPS reference point. We also calculate estimations of how the prices translate to costs and compare these to income.

Purchasing power standard comparison

As shown in Table 3-4, the lowest nominal prices are found in Mexico, Canada, South Korea and Norway, and the highest prices in Germany, Denmark and Belgium.

Table 3-4 Comparison of 2017 retail household electricity prices, nominal and PPS, EUR/MWh

Country	Nominal price (EUR/MWh) 2017	PPS price (EUR/MWh) 2017	Difference	Nominal Rank (highest to lowest price)	PPS Rank (highest to lowest price)	Rank change (nominal to PPS)
Austria	192.39	218.75	14%	9	16	-7
Belgium	277.27	314.81	14%	3	4	-1
Czech Republic	141.58	264.18	87%	22	10	12
Denmark	282.12	267.99	-5%	2	8	-6
Estonia	118.17	195.60	66%	23	20	3
Finland	158.32	160.14	1%	14	23	-9
France	162.39	185.71	14%	13	21	-8
Germany	297.90	350.44	18%	1	2	-1
Greece	173.75	262.88	51%	12	11	1
Hungary	111.76	225.33	102%	25	15	10
Ireland	208.17	231.84	11%	7	14	-7
Italy	228.20	290.79	27%	5	6	-1
Latvia	158.32	286.55	81%	14	7	7
Lithuania	110.11	217.79	98%	26	17	9
Luxembourg	150.34	154.76	3%	19	24	-5
Netherlands	153.98	172.79	12%	18	22	-4
Poland	142.19	307.09	116%	21	5	16
Portugal	220.57	337.18	53%	6	3	3
Slovak Republic	144.27	265.65	84%	20	9	11
Slovenia	154.50	238.17	54%	17	13	4
Spain	254.03	351.40	38%	4	1	3
Sweden	154.59	149.21	-3%	16	25	-9
United Kingdom	178.34	200.45	12%	10	19	-9
Norway	97.80	80.28	-18%	28	31	-3
Switzerland	176.96	146.09	-17%	11	26	-15
Canada	94.50	97.97	4%	30	30	0
Japan	196.46	215.02	9%	8	18	-10
South Korea	94.59	123.55	31%	29	27	2
Mexico	55.31	115.40	109%	31	28	3
Turkey	97.88	259.84	165%	27	12	15
United States	111.84	111.84	0%	24	29	-5

Source: Own calculation, based on data from IEA Energy Prices and Taxes 2017Q3 (2018)

When relative purchasing power is taken into account, these rankings change. Using PPS adjusts the prices in national currency to allow for a comparison on the basis of purchasing the same amount of goods and services, removing the price level effect. Table 3-4 is calculated using Purchasing parities in US Dollar converted to EU, so the country of reference is still the US. This means that countries with lower incomes than the US experience higher prices in PPS terms, and vice-versa for those with higher incomes, i.e. that the equivalent of €100 is more

[36] Note that IEA data is based on the OECD countries which means not all EU Member States are included (BG, CY, HR, MT, RO)

valuable (a higher share of income), for consumers in countries with lower income, and therefore equivalent to a higher price in PPS terms.

Once prices are expressed in PPS terms, the lowest prices are found in Norway, Canada and the US, and the highest prices in Spain, Germany and Portugal. The countries with the highest difference are Turkey, Poland and Mexico, which means that, even though their nominal prices appear low, once these are adjusted for local income, they become much more expensive. For example, Poland's prices are 117% more expensive once corrected for purchasing power, meaning Poland's ranking changes by 17 places (from the 22nd most expensive to the 5th most expensive). On the other hand, countries such as Norway, Switzerland and Denmark become less expensive.

Overall, this analysis shows that unit prices borne by consumers in half of the EU countries are higher in PPS adjusted terms than prices suggest, while in the other half they are lower. In general, countries whose GDP is above the EU average see the relative unit price of electricity lower than the nominal one and vice-versa (shown in red and green in Table 3-4). Of the non-EU countries considered, all except Switzerland have a PPS price higher than the nominal price.

It is important to remember that actual consumption is the other key determinant of the final cost to consumers, with a number of effects in play. Effects that can have an important influence on consumption and costs include the size of average households and houses, efficiency of appliances, fuels for heating, climate, behaviour and whether the household produces its own power (e.g. solar PV). As shown in the following section (see table 3-5) it is still the case that consumers in the US, despite low prices, have much higher total electricity costs than EU consumers due to very high consumption, although as also shown, higher household income means that the costs are lower than the EU average as a proportion of household income, although we treat the household income value with caution.

EU household electricity prices and costs in the context of income

An alternative comparison can be made, at least for the EU countries and UK on the basis of the price data and datasets from Eurostat on income and energy consumption. By taking the prices presented in this work, and using final energy consumption and households data it is possible to estimate both the average household electricity consumption and the cost of the same. Comparing this to income we can put the calculated cost in context for the average household in each country. The results are presented in Table 3-5 below.

The table shows that average household electricity consumption ranges from around 1 500 kWh to 3 500 kWh per year across the EU. Combining these consumption levels with prices (that vary depending on the consumption) we calculate average electricity bills of around EUR200 – 1 000 per year. Compared to income we see the highest relative electricity costs in Bulgaria, Portugal and Romania. This is notable as Bulgaria and Romania are the lowest income countries in the EU and despite low prices, the average household electricity costs remain high. For Portugal, median income is higher than in Bulgaria and Romania, but still below the EU average, whilst electricity prices are just above the EU average, leading to one of the highest calculated ratios of bills to income. This is consistent also with Portugal ranking relatively high in the PPS analysis.

The countries with the highest prices (Belgium, Denmark and Germany) have ratios close to the EU average as their incomes are higher. The lowest ratios are found in Luxembourg, Malta and the Netherlands, all with below average prices and either lower consumption (Malta) or higher income (Luxembourg, the Netherlands) than the EU average.

This analysis remains somewhat high level as it does not account for the differences in income levels across households in countries (low income level households, the most affected for energy costs, differ across countries depending of the income distribution of the countries). It does not account for all national variations in electricity use (e.g. share of electricity for heating, hot water or cooking). Finally, this analysis focuses on electricity bills which are a part of the household total energy bill (which includes the expenditure on other fuels like gas, heating oil, heating from distributed systems, liquids and solid fuels). Nevertheless, it provides a useful further insight that low prices may not necessarily mean that households in a country may be relatively better off than those in other countries.

Table 3-5 Comparing electricity prices, costs and income, with heatmap of (5) electricity bill as % of income

Country	(1) Retail electricity price (EUR/MWh) 2019	(2) Average household electricity consumption (kWh/yr)* 2018	(3) = (1)*(2) Calculated average electricity bill (EUR/yr)	(4) Median Household Income (EUR/yr)#	(5) = (3)/(4) Calculated bill as % of median income (%)
Austria	177.72	3 044	541	25 176	2.1%
Belgium	303.43	2 674	811	23 667	3.4%
Bulgaria	94.85	2 567	243	3 585	6.8%
Cyprus	218.16	2 830	617	15 336	4.0%
Czech Republic	172.90	1 870	323	9 088	3.6%
Germany	292.97	2 541	745	22 647	3.3%
Denmark	290.36	3 449	1002	30 097	3.3%
Estonia	128.62	2 239	288	10 521	2.7%
Greece	154.62	2 526	391	7 875	5.0%
Spain	235.76	3 323	783	14 785	5.3%
Finland	172.85	3 475	601	24 544	2.4%
France	164.50	3 139	516	22 261	2.3%
Croatia	129.99	2 828	368	6 659	5.5%
Hungary	108.96	1 806	197	5 444	3.6%
Ireland	209.91	3 411	716	24 920	2.9%
Italy	228.14	2 132	486	16 844	2.9%
Lithuania	125.47	2 044	256	6 895	3.7%
Luxembourg	176.78	2 753	487	40 270	1.2%
Latvia	160.66	1 467	236	7 322	3.2%
Malta	127.54	1 613	206	14 781	1.4%
Netherlands	202.58	2 583	523	24 033	2.2%
Poland	143.12	1 741	249	6 593	3.8%
Portugal	212.86	2 770	590	9 346	6.3%
Romania	136.73	1 617	221	3 284	6.7%
Sweden	203.17	5 071	1030	25 559	4.0%
Slovenia	140.46	2 602	365	13 244	2.8%
Slovakia	155.40	1 819	283	7 462	3.8%
EU27	**208.34**	**2 633**	**549**	**16 864**	**3.3%**
United Kingdom	212.91	2 793	595	21 464	2.8%
United States[1]	107.86	10 972	1183	52 423	2.3%

Source: Own calculations

** calculated from Eurostat datasets, Disaggregated final energy consumption in households -quantities [nrg_d_hhq] selecting only Final consumption - other sectors - households - energy use - cooking / lighting and electrical appliances / other end use, for electricity only. Dividing by total number of private households from [lfst_hhnhwhtc].*

 # Median equivalised net income from Eurostat Mean and median income by household type - EU-SILC and ECHP surveys [ilc_di04]

1 Data for the United States sourced from Household avg consumption from EIA (https://www.eia.gov/tools/faqs/faq.php?id=97&t=3), Household income from (https://www.census.gov/library/stories/2019/09/us-median-household-income-up-in-2018-from-2017.html). It is unclear if median household income is prepared on a comparable basis to Eurostat data, so should be treated with caution.

Source: Study on energy prices, costs and their impact on industry and households

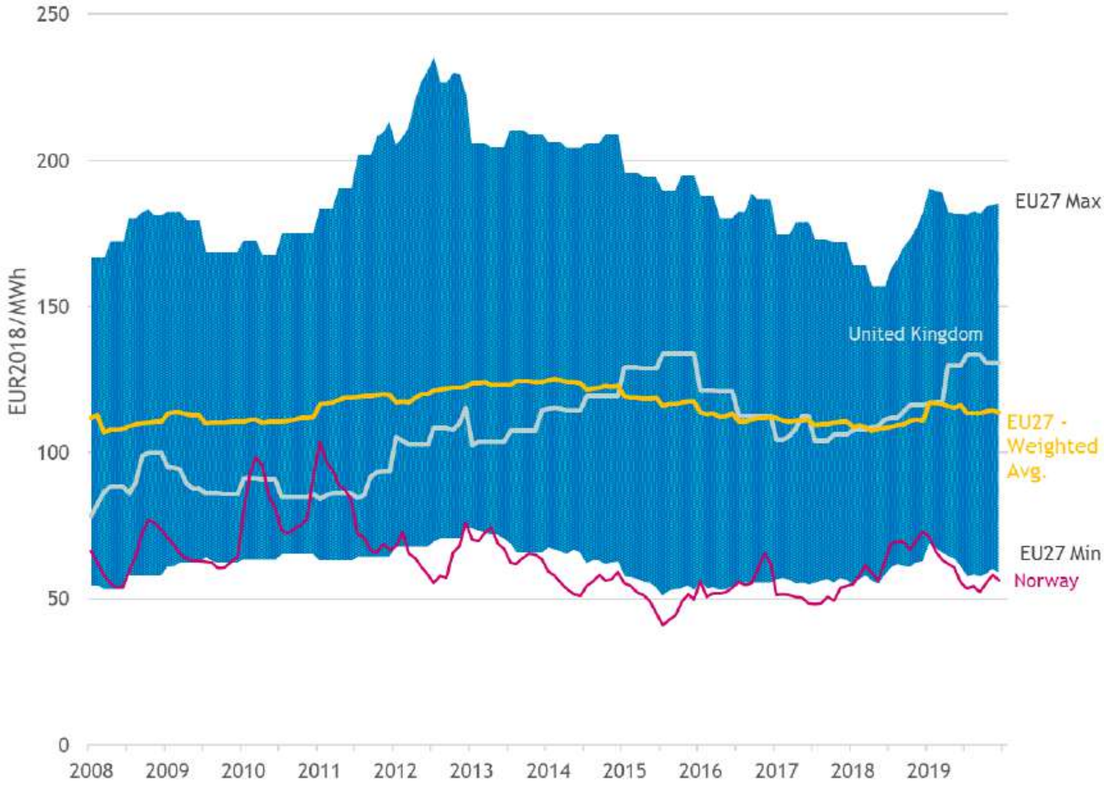
Retail - industry

Retail electricity prices for industry have relatively complete datasets. The following figures present time series of available price data for the EU27 and G20 countries from 2008-2019. Prices in this section are exclusive of VAT and recoverable taxes and levies, but include relevant (non-recoverable) excise taxes and levies. From 2017 onwards, EU prices are for non-household consumers, not only industry.

Conclusions that can be drawn from this data include:

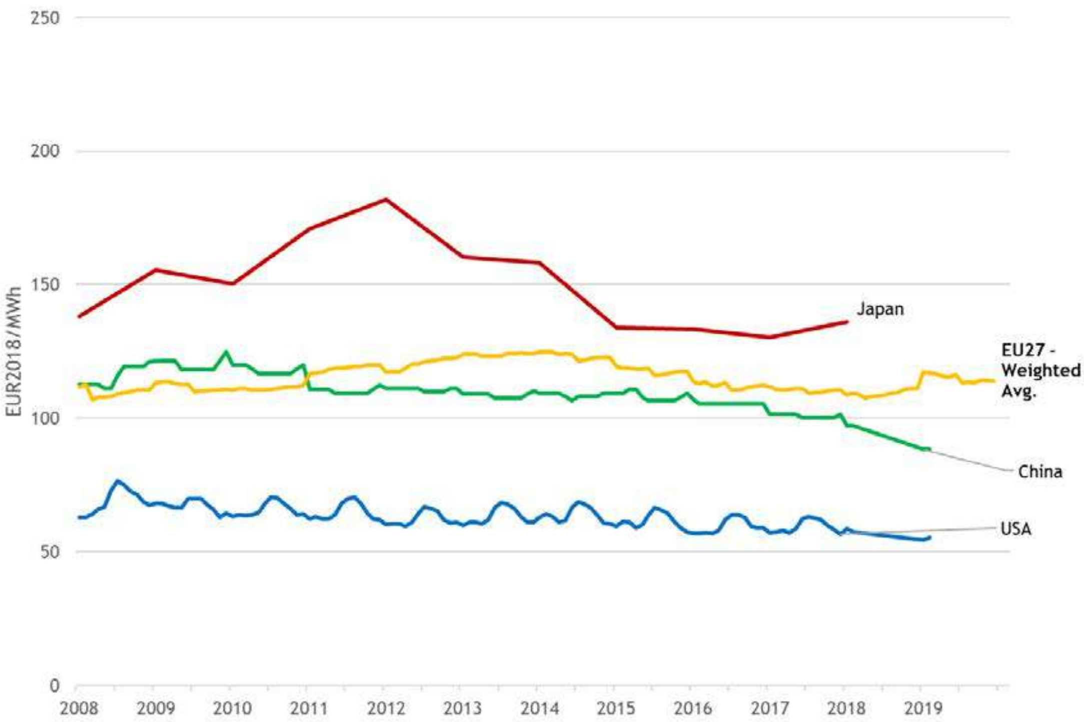
- The EU27 industrial electricity prices have spanned a range of 50-220 EUR/MWh between 2008 and 2019. EU27 average prices increased from around 95 EUR/MWh in 2008 to 115 EUR/MWh by the end of 2019, although they declined from a 125 EUR/MWh peak in 2013. UK prices are closer to the EU average, while Norwegian prices are towards the bottom, or sometimes even lower, then the EU minimum;
- EU27 prices are based on consumption band assumptions, which for the majority, but not all, correspond to consumption band ID (annual consumption of 2 000 – 20 000 MWh). No consumption band data is available for international countries;
- US prices are around half the EU average levels and have been slowly drifting lower between 2008 and 2019. Prices in CN were at a comparable level to EU in 2015 but have diverged since 2011 and continued declining until 2019. Prices in Japan were higher than the EU27 average but converged in 2015-2016 to a level around 10-20% higher than the EU27 average;
- Most other G20 countries (AR, CA, ID, IN, RU, MX, KR, SA, TR) also have lower prices than the EU average. Only in AU and BR they are higher, the former increasing over the period, consistent with the observed increase in wholesale prices. Prices in Turkey have increased since 2018 and have begun converging with EU levels;
- Analysis of the evolution of prices (see Table A-5 in Annex A) in 2018 constant EUR prices shows that price developments in G20 countries have largely been negative for EU competitiveness, with positive price developments for the EU only seen for AU and ZA. In 2008, the EU weighted average price was higher than prices in 11 countries, while in 2019 it was higher than 13 countries;
- In Table A-6 (in Annex A) we present a more detailed breakdown of the observed (nominal) price changes of some of the key factors, namely inflation, national price and exchange effects.

Figure 3-9 Electricity prices, industry retail (exc. VAT and recoverable taxes and levies), EU27 (weighted) average, min and max, NO and UK 2008-2019, EUR_{2018}/MWh



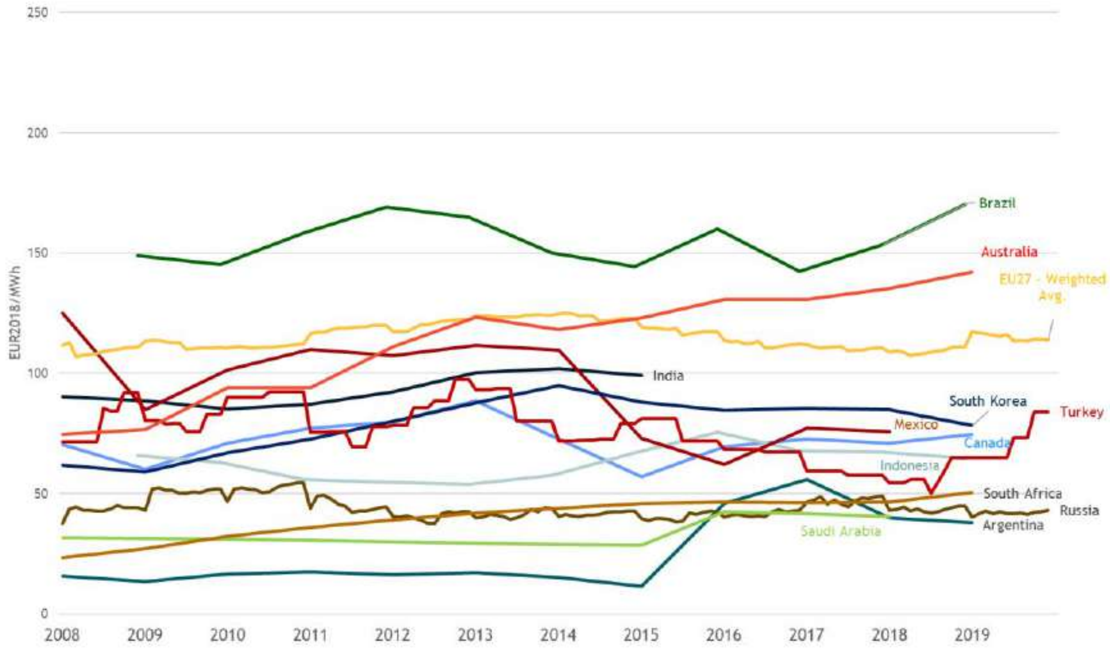
Sources: Own calculation, based on data from Eurostat

Figure 3-10 Electricity prices, industry retail, EU27, USA, China, and Japan 2008-2019, EUR_{2018}/MWh



Sources: Own calculation, based on data from Eurostat, CEIC, IEA

Figure 3-11 Electricity prices, industry retail, EU27, other G20, 2008-2019, EUR_{2018}/MWh



Sources: Own calculation, based on data from Eurostat, CEIC, IEA, ERRA and national sources

Households - comparing retail prices to wholesale prices

For the international comparison it is interesting to reflect on the role that different price components play in the retail prices paid by consumers and how these differ across countries. The main components of the electricity price are: wholesale energy cost; network costs; VAT; other taxes and levies, such as charges used to pay for renewable schemes. As part of these costs, utility companies will also earn their mark-up. This includes suppliers costs, such as admin costs, and the profit margin[37]. Within the EU[38]:

- Over the period 2012-2018 mark-ups have remained stable, with EU average at 15€/MWh, and with suppliers in Germany and Ireland having the highest markups over the whole period, typically above 40€/MWh and 35€/MWh, respectively;
- In 2018, suppliers in Belgium and Italy recorded the highest mark-up levels (above 40€/MWh and 30€/MWh, respectively), while Romania and Latvia were the lowest, around -5€/MWh.
- The share of regulatory components in prices has increased from 59% to 63% between 2012 and 2018, mostly due to increases in the cost of renewable electricity schemes. Across Member States, the regulatory component varies substantially, ranging from 24% of the price in Malta to 81% of the price in Denmark, although for the majority of countries this is in the 35-55% band.

Unfortunately, corresponding price data (energy and supply, network charges, taxes and levies) is not available for non-EU countries. There are a number of limitations sourcing the information to compare regulatory costs of other major economies: in some countries, networks are owned by the State, which means there is no obligation to operate commercially and price levels are not closely linked to costs; some countries have vertically integrated operators, or are in the process of separating production,

[37] On the basis that the consumer price = energy costs + supplier mark-up = wholesale energy price + regulatory components.

[38] Data from ACER, *annual report on the results of monitoring the internal electricity and natural gas markets in 2018*, and Eurostat.

transportation and supply of electricity; countries may have more than one electricity grid, which operate under different terms. As general points, we can observe that:

- In the US, distribution and transmission costs amount to 42% of electricity costs;[39]
- China is embarking on a process to liberalise the market, but elements such as price levels and generators' remunerations are regulated. As part of vertical disintegration, China is now taking steps to identify network costs[40];
- Japan, similarly to China, has recently started the process of liberalising the market.[41]

In order to present a wider coverage of this assessment, the rest of this section presents a proxy for this analysis: a comparison of the difference between the retail prices paid by consumers and the observed wholesale prices. Wholesale prices representing a proxy for the energy and supply component, and the difference between wholesale and retail prices illustrating the other components in the price such as network charges, mark-ups and non-recoverable taxes and levies. This can also illustrate where price regulation and/or tariff deficits exist in other countries.

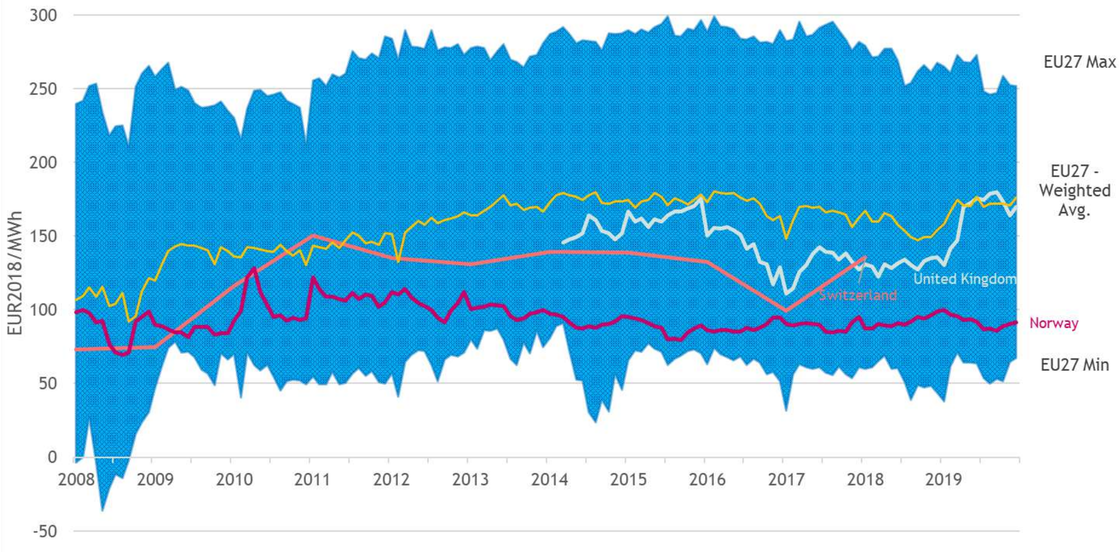
Analyses of the difference between retail electricity prices for households and electricity wholesale prices are presented in the figures below (they show time series of this difference for the EU27 and G20 countries from 2008-2019).

Conclusions that can be drawn from this data include:

- The EU27 average difference between household retail prices and wholesale prices has increased from around 100 EUR/MWh in 2008 to almost 180 EUR/MWh by June 2019, although having mostly remained at around the same level since 2013. It is also notable that with wholesale prices averaging around 30-60 EUR/MWh over this period the difference between the two, equating broadly to network charges, taxes and levies, and mark-ups is by far the most important component in, and driver of, retail price increases in the EU27;
- The same analysis using the wholesale proxy for China shows a negative outcome of -15 to 25 EUR/MWh, which highlights that household consumers in China are not paying the full cost of their electricity use. Since 2018, the proxy used for CN is increasing, which suggest the support for household consumption is being reduced. The difference in the US is lower than in the EU27 at around 80-90 EUR/MWh but has increased since 2008. The difference in Japan has varied considerably over the period, with the Fukushima effect on wholesale prices likely to have played an important role in the 2011 peak. UK's trend mirrors closely the EU27's;
- For the other G20 countries, the difference is also much lower than the EU27 average. In Mexico (MX), Indonesia (ID) and Russia (RU), there is only a small difference between the two prices, highlighting also that retail prices are held low in these countries. In Canada (CA) and Turkey (TR), the difference is greater, but still significantly smaller than in the EU27, while Brazil (BR) appears to have caught up with the EU and now has a greater differential.

[39] US EIA, Annual Energy Outlook 2020, January 2020, Reference case, Table 8: Electrical supply, disposition, prices and emissions
[40] EPRG, Reforming the Chinese Electricity Supply Sector: Lessons from International Experience, 2017
[41] JEPIC, *The electric power industry in Japan*, 2019

Figure 3-12 Difference between household retail electricity prices and electricity wholesale prices, EU27 (weighted) average, min and max, CH, NO, and UK, 2008-2019, EUR2018/MWh

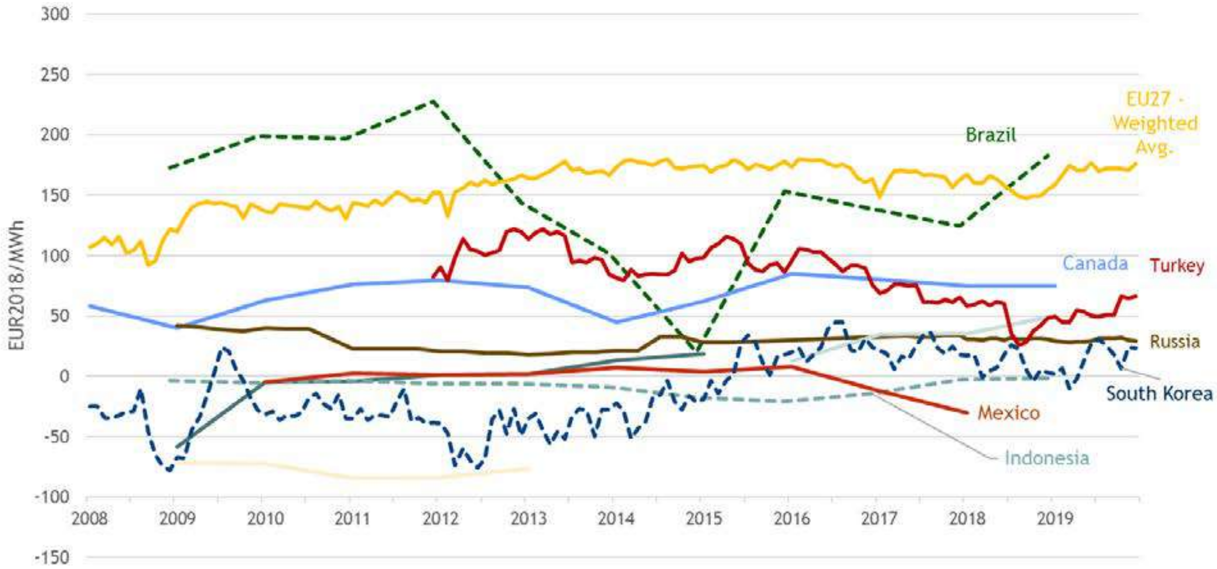


Sources: Own calculation, based on data from Eurostat

Figure 3-13 Difference between household retail electricity prices and electricity wholesale prices, EU27, US, CN, JP 2008-2019, EUR2018/MWh

Sources: Own calculation, based on data from Eurostat, CEIC, EIA
Note: the Chinese wholesale price is an assumed proxy price based on Usage Price: 36 City Avg: Pipe Natural Gas: for Resident (China).

Figure 3-14 Difference between household retail electricity prices and electricity wholesale prices, EU27 and other G20 countries, 2008-2019, EUR2018/MWh



Sources: Own calculation, based on data from Eurostat, CEIC
Note: Price proxies are used for wholesale prices Brazil and Indonesia, these are based on prices for large industrial consumers.

Industry - comparing retail prices to wholesale prices

Carrying out a similar international comparison of the difference for retail industrial electricity and wholesale prices brings the results presented in the figures below (Figure 3-15 , Figure 3-16 and Figure 3-17).

For industrial prices[42] the same considerations apply concerning the uncertainty of regulatory and other non-wholesale costs as presented in the previous section. It is not possible to identify to what extent distribution and transmission costs, profit margins, and non-VAT taxes and levies affect the final prices for non-EU countries. This is because most countries do not require operators at different points in the value chain to report these costs, and because most countries have not fully implemented market reforms that would increase price transparency by allowing competition.

Conclusions that can be drawn from this data include:

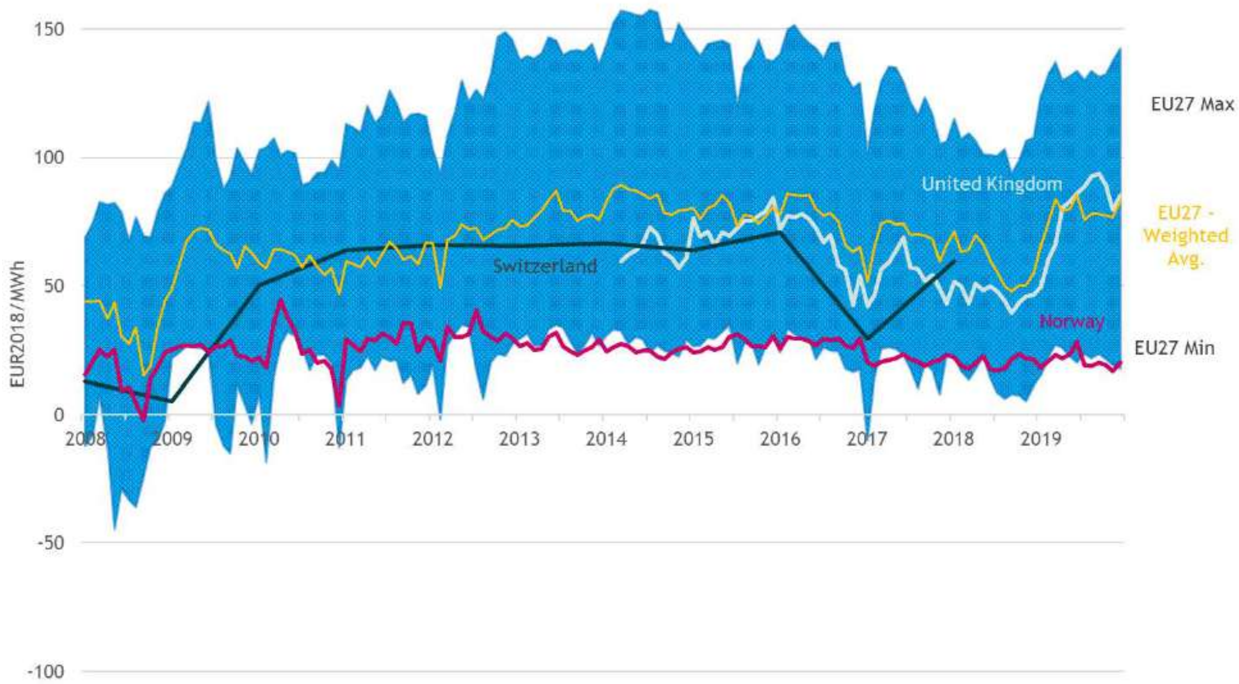
- The EU27 average difference between industrial retail prices for the average consumption band (ID) and wholesale prices has increased from around 30 EUR/MWh in 2008, peaking in 2014, then declining to around 85 EUR/MWh in Q2 2019, almost tripling. Although the weighted average always stays above zero, it is notable from the minimum of the range that in some EU member states (EL, FI, FR, HU, RO, SE, SI), there has been a negative difference between the two at specific points in time, particularly when the wholesale price has spiked, as for example in January 2017 (in HU, RO and SI). These short-lived spikes in wholesale prices highlight that day-to-day or month-to-month volatility in day ahead wholesale prices is not matched by corresponding short-term volatility in industrial retail prices, at least in some Member States. This can lead to (so far only) short-term negative differences. The relative effect of the two factors, wholesale prices and other cost components in the retail price, has been relatively

[42] As in the earlier section, the industrial retail electricity prices used are those that exclude VAT and recoverable taxes and levies

constant over time. Although with a slowly declining wholesale price and slowly increasing difference, the role of these other (network and tax) costs is becoming more influential as a component in, and driver of, retail prices in the EU27. It should be noted that retail prices paid by consumers in higher consumption bands are lower, and therefore also the difference with wholesale prices would be lower. It is also important to note that industrial retail prices are only indicative of actual prices paid by industry, with a variety of different pricing arrangements and contracts in place;

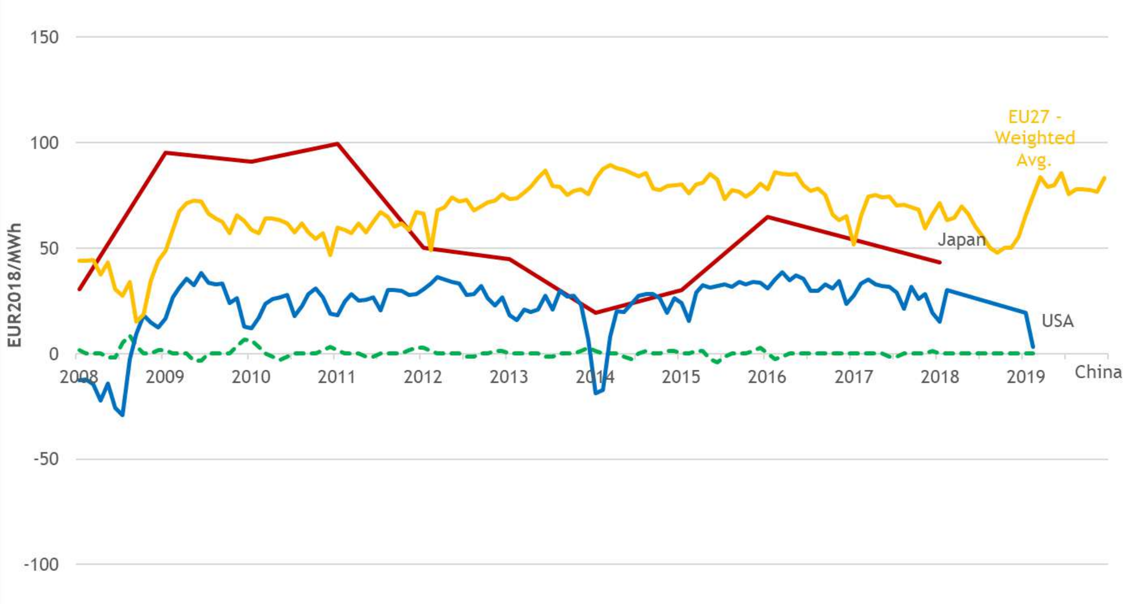
- The difference in the US is lower than in the EU27 at around 15-40 EUR/MWh, over the period, ending in a downward curve in 2019. In the US the difference turned negative at 3 points in time when the wholesale price spiked. At least part of the reason for these spikes is that wholesale prices tend to vary on a much shorter timeframe than retail prices, which are often fixed annually. Usually the retail price is set by suppliers at a level high enough to cover the wholesale price plus a mark-up, but shocks to supply or other factors can lead to temporary jumps in wholesale prices, and negative differences such as those observed. The difference in Japan is in the same order of magnitude as the EU27 average and US levels, but has varied considerably over the period. The same analysis using the wholesale proxy for China shows virtually no difference, likely due to the proxy being similar to the industrial price. It is an interesting contrast to household prices, pointing towards energy policy priorities and price interventions in favour of households rather than industry. The difference for the UK closely mirrors the EU27 average;
- For the other G20 countries the difference with the EU27 average is typically lower, although the difference in Canada (CA) has generally been similar to the difference in the EU.

Figure 3-15 Difference between industrial retail electricity prices and electricity wholesale prices, EU27 (weighted) average, min and max, NO, CH and UK, 2008-2019, EUR_{2018}/MWh



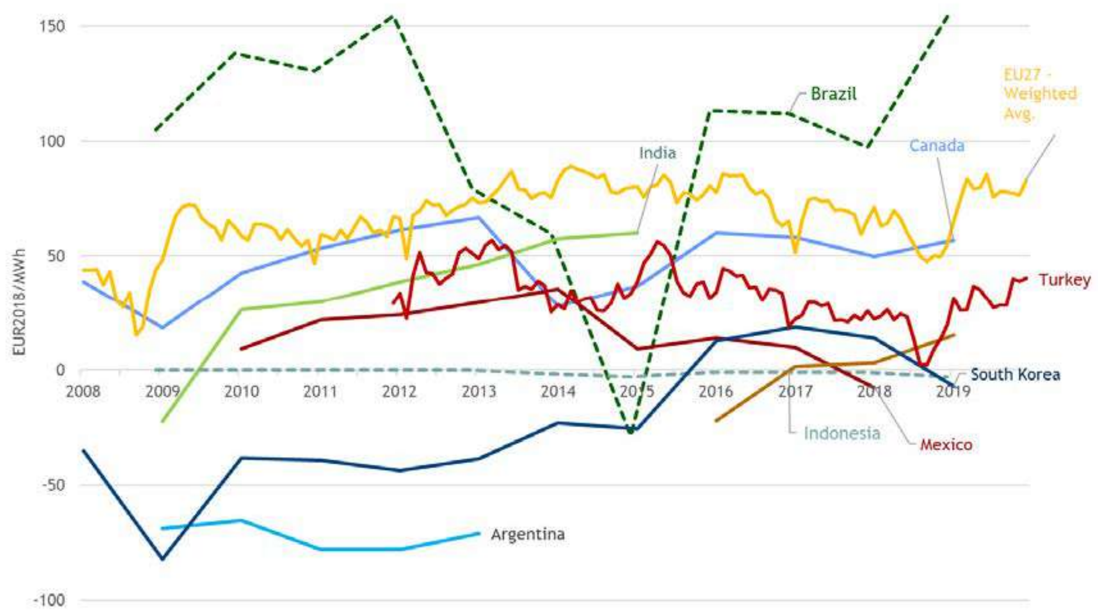
Sources: Own calculation

Figure 3-16 Difference between industrial retail electricity prices and electricity wholesale prices, EU27, US, CN, JP, 2008-2019, EUR2018/MWh



Sources: Own calculation
Note: the Chinese wholesale price is an assumed proxy price based on Usage Price: 36 City Avg.

Figure 3-17 Difference between industrial retail electricity prices and electricity wholesale prices, EU27 and other G20 countries, 2008-2019, EUR2018/MWh



Sources: Own calculation
Note: Price proxies are used for wholesale prices Brazil and Indonesia, these are based on prices for large industrial consumers.

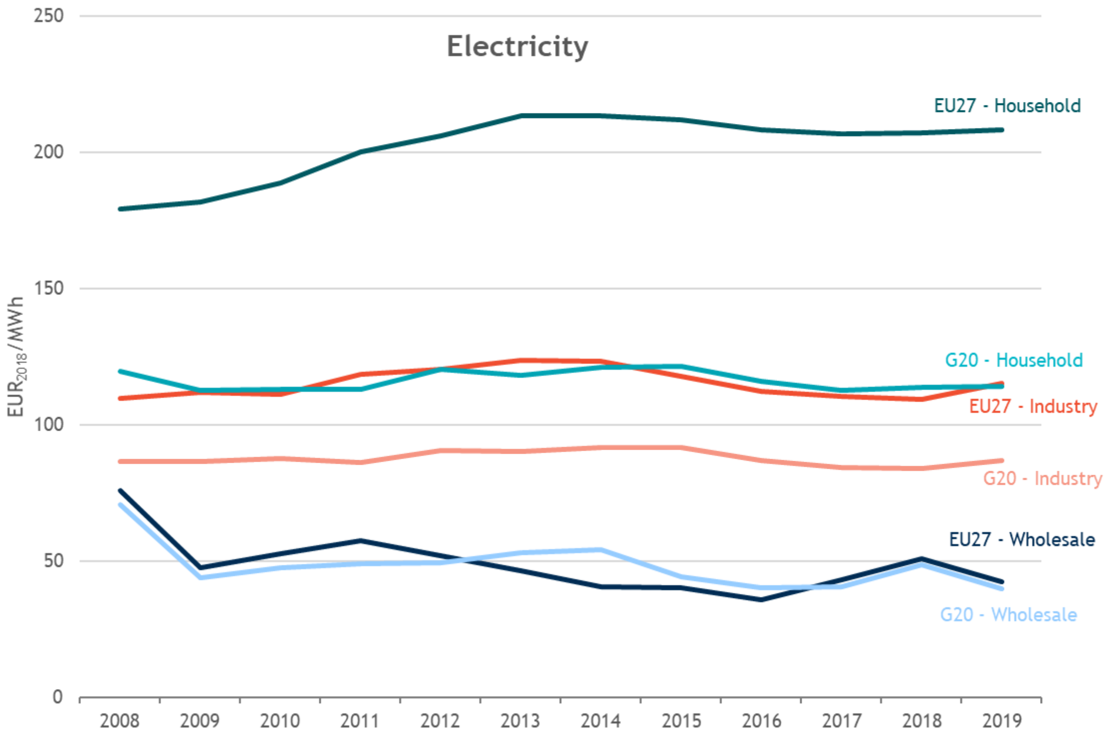
Summary of electricity price analysis

Our analysis of electricity prices in the EU27 and main trading partners in the G20 is summarised in Figure 3-18, and the analysis as a whole found that:

- Wholesale prices – EU27 average wholesale prices are comparable to most G20 countries but lower than some (Japan, Australia, Mexico, Turkey), and have seen favourable developments relative to most G20 countries between 2008-2019;

- Household prices - EU27 average retail prices have increased over time, but relatively stable since 2013, while G20 prices are mainly stable or decreasing; EU27 prices are higher than most G20 countries and similar to some. Relatively high consumer taxes in the EU and price regulation/subsidies in the G20 are amongst the main reasons for this. Relatively high network costs may also play a role although data on these in the G20 are very limited:
  - Analysis of prices at Purchasing Power Standard (PPS) and in the context of average household income shows that prices in countries remain relatively high compared to other G20 OECD countries, and that for countries with relatively low GDP per capita, low nominal prices become much higher in PPP terms. When considering household consumption and income, this is further apparent, with electricity costs representing 3.3% of average household income on average but shares above 6% in Bulgaria, Romania and Portugal. Much higher average electricity consumption in the US does not translate to a similar burden on households as household income is much higher.
- Industrial prices - EU27 average retail prices in the consumption band covered here increased by around 5% between 2008 and 2019, although have declined since a 2013 peak. Prices are comparable to China and lower than Japan, but almost double US levels. EU prices remain higher than for most other G20 countries. Relatively high non-recoverable taxes in the EU and price regulation/subsidies in the G20 play an important role in this difference;
- As to the role of taxes and levies, network costs and mark-ups - by comparing wholesale and retail prices we find that the difference between the two is by far the highest in the EU for households, with only a handful of G20 countries (US, CA, JP) having a significant difference. This highlights that most G20 countries still regulate household prices. The same issue also exists for industry, but is less pronounced than for households.

Figure 3-18 Comparison of EU27 weighted average with G20 (trade) weighted average



Sources: Own calculation,
Note: the G20 weighted averages are calculated on the basis of all available price data for a particular year, weighted in the total price by the share a country had in EU imports+exports 2017-2019. Coverage ratios of total trade range from 84-99% (household prices), 76-99% (industrial prices) and 36-74% (wholesale prices).

3.2.2 Natural gas prices

This section presents results for natural gas prices in the EU27 and G20. Natural gas-based fuels such as CNG and LPG are addressed in the petroleum products section along with other transport fuels. Full Member State data and figures are provided in the Excel tool annexed to this work.

Wholesale

Wholesale natural gas prices have relatively complete datasets. The following figures, present time series of available price data for the EU27 and G20 countries from 2008 to 2019.

Specific assumptions relating to this dataset include:

- There is no wholesale market for natural gas in CY or MT and therefore they are excluded from the EU27 dataset;
- For EU27 member states, multiple sets of data were often gathered, particularly in the area of wholesale gas. We selected data in the following order of preference if multiple sources were available:
    - Hub prices – were used as first preference in almost every case for which a hub price was available. In the cases of ES and LT an Estimated Border Price was used as the hub price only had a very limited time series available[43]. Whilst these type of prices are often similar i.e. within +/- 10% of each other, there can sometimes be more significant differences;
    - Estimated Border Prices – as second preference, were used for BG, EE, EL, HU, IE, LV, PT, RO, SE, SI, SK;
    - LNG prices – were available for a handful of member states, but in the two cases (EL, PT) with no hub prices, estimated border prices were also available and used. It is useful to note that global LNG markets have their own price dynamics, different from those to piped gas, and that the comparison with hub prices includes this difference;
    - Proxy prices – were used for LU: prices were calculated using a proxy average of neighbouring countries (BE and DE) prices.

The following conclusions are drawn from the data:

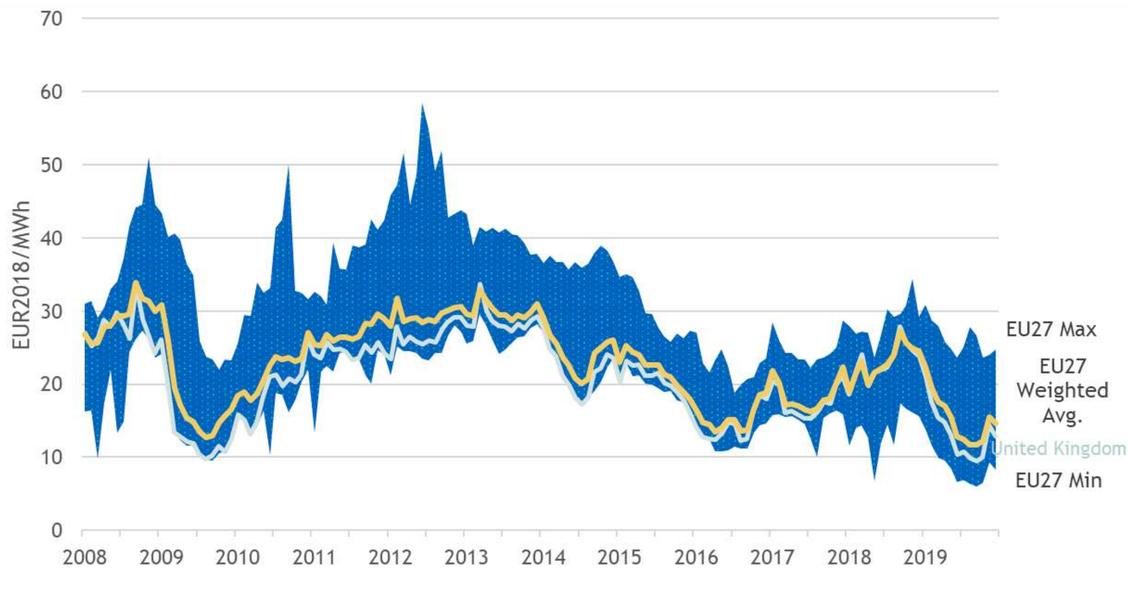
- It is important to note the significant link between gas and crude oil prices, as part of the gas prices are indexed on crude oil prices. Crude oil prices can be found in Figure 3-35, later in this chapter. This link is particularly true for long-term contracts, not therefore for hub prices, but nevertheless the oil price remains a powerful (though declining) influence on gas wholesale prices;
- EU27 average wholesale prices have moved between 10 and 27 EUR/MWh in the last four years, averaging around 18 EUR/MWh but decreasing to around 10 EUR/MWh since late 2018 and standing at 13 EUR/MWh in 2019. The EU weighted average price is close to the lower end of the full range; HR, LT and SI are among the outliers at the maximum of the range. UK prices closely mirror the EU average;
- From 2010 onwards, US prices have diverged from around the same level as EU average prices to around half of EU average levels, at less than 10 EUR/MWh, although in 2019 the gap significantly narrowed based on a significant price drop in EU27. US price decline was primarily driven by shale gas exploitation and low exports in the US, the narrowing in 2019 is at least partially driven by growing gas exports from the US to EU27 (i.e. imports from the US increased

[43] Hub prices in Spain only available from Oct 2015, and in Lithuania from April 2017

from 2.2 bcm in 2017 to 13.6 bcm in 2019, compared to total inland consumption of 407 bcm in 2019);

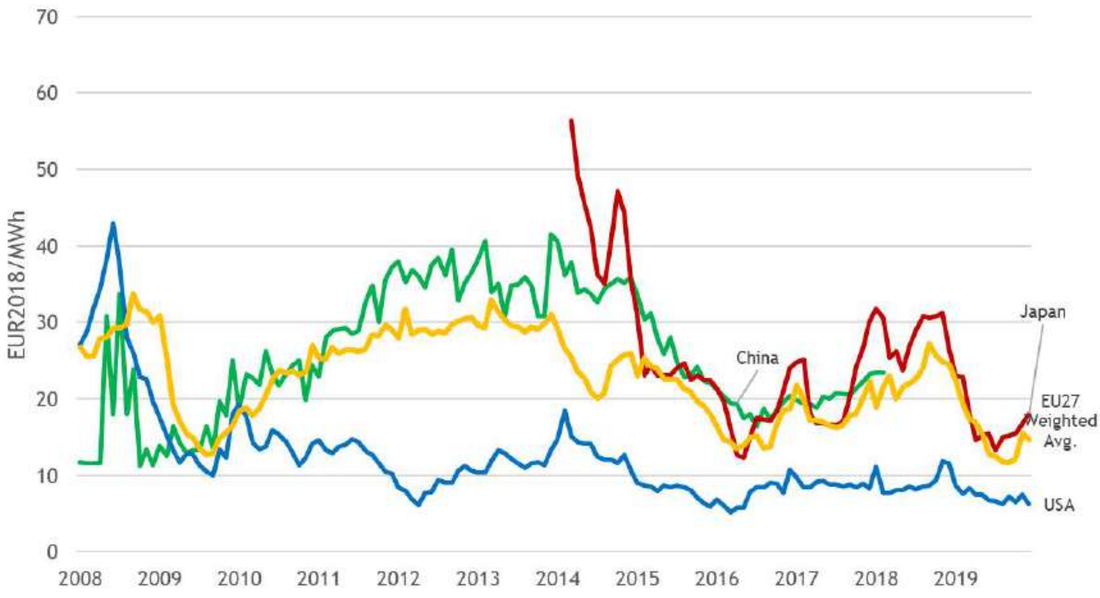
- EU average, JP and CN prices have tended to follow similar trends. Since 2015, prices are very similar and primarily driven by global LNG prices, this is consistent with hub prices being more closely linked to LNG prices than border (pipeline) prices;
- For other G20 countries, prices in major producers (CA and RU) are significantly lower than the EU average. In AU, also a major producer, prices were consistently lower than the EU average until 2016-2017 where prices rose above the EU average, as domestic supply shortages were experienced due to high exports to Asia. AU prices fell back below EU average levels in late 2017 but are now again just above EU27 average. Other prices (TR, ID, KR) all tend to be higher than the EU average, and with significantly higher price peaks and volatility. KR and ID prices move similarly to JP and CN prices;
- Analysis of the evolution of price differentials across countries in Euros (see Table A-7 in Annex A) in 2018 constant EUR prices shows that price developments across 7 (AU, BR, CN, ID, MX, RU, KR) of the 13 countries have been positive compared to the EU average. EU prices, previously higher, are now lower in five of these countries (CN, JP, MX and KR). Negative (unfavourable to the EU) price developments are observed for AR, CA, IN, JP, TR and the US, with higher price declines than the EU. Nevertheless, wholesale prices are only lower in AR, CA, MX, RU and the US;
- In Table A-8 (in Annex A) we show a more detailed presentation of the observed (nominal) price changes with the breakdown of some of the key factors in these changes, namely inflation, national price and exchange effects.

Figure 3-19 Natural gas: Wholesale prices, EU27, min and max, UK, 2008-2019, EUR_{2018}/MWh



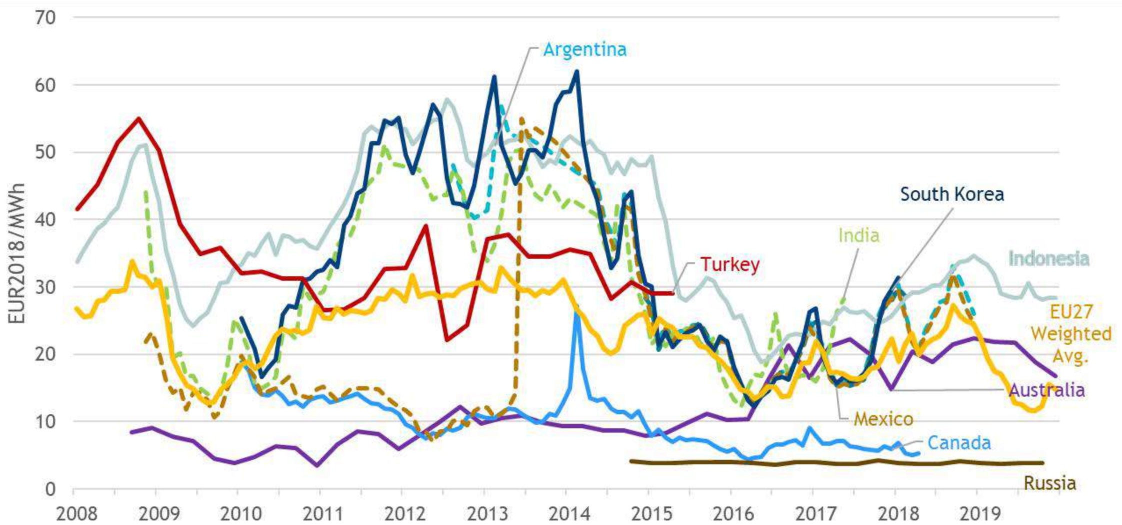
Sources: Own calculations based on data from Platts, Comext, OTE, Finnish gas exchange, POLPX, Enerdata

Figure 3-20 Natural gas: Wholesale prices, EU27, CN, JP, US, 2008-2019, EUR_{2018}/MWh



Sources: Own calculation based on data from Platts, Comext, OTE, Finnish gas exchange, POLPX, Enerdata, EIA, METI, CEIC.

Figure 3-21 Natural gas: Wholesale prices, EU27, other G20, 2008-2020, EUR_{2018}/MWh



Sources: Own calculation based on data from Platts, Comext, OTE, Gaspool, Finnish gas exchange, Eurostat data provided by the European Commission, value of pipeline gas import - WSP, value in EURs, Enerdata, ERRA, Knoema (World Gas Intelligence; World Bank), Australian Energy Regulator (AER), Bluegold research, Bloomberg, CEIC, Index mundi (World Gas Intelligence; World Bank), METI, Thomson-Reuters + Waterborne, EIA.
Note: The dotted lines indicate the use of proxy data. Data for IN, MX and AR represents LNG prices.

Retail - households

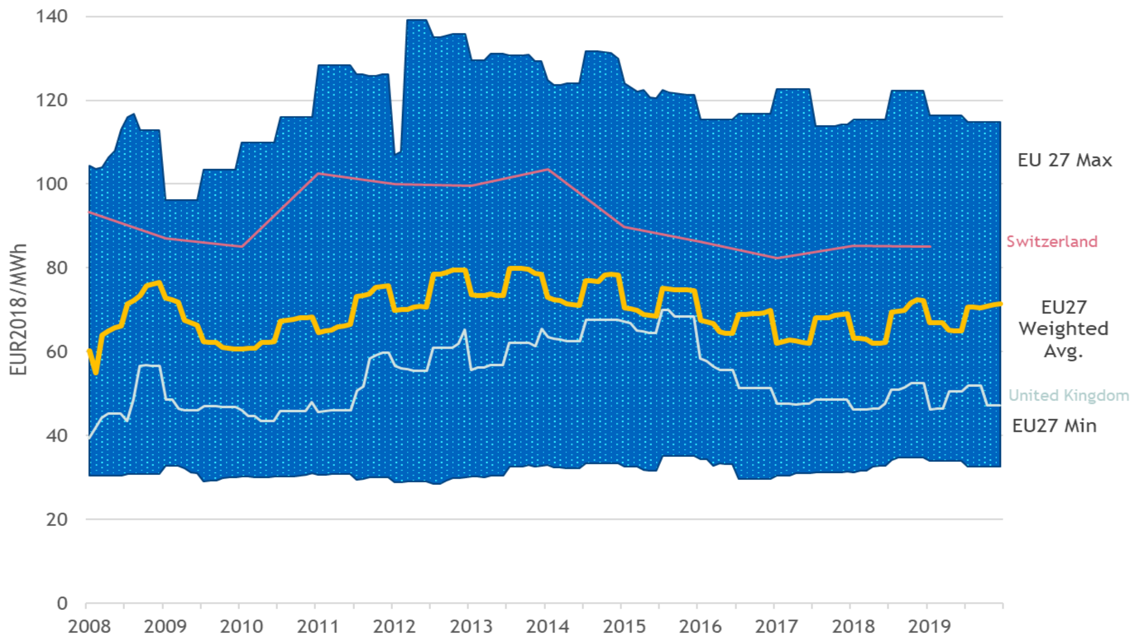
Retail gas prices for households have relatively complete datasets, the following figures, present the time series of available price data for the EU27 and G20 countries from 2008-2019.

Source: Study on energy prices, costs and their impact on industry and households

Conclusions that can be drawn from this data include:

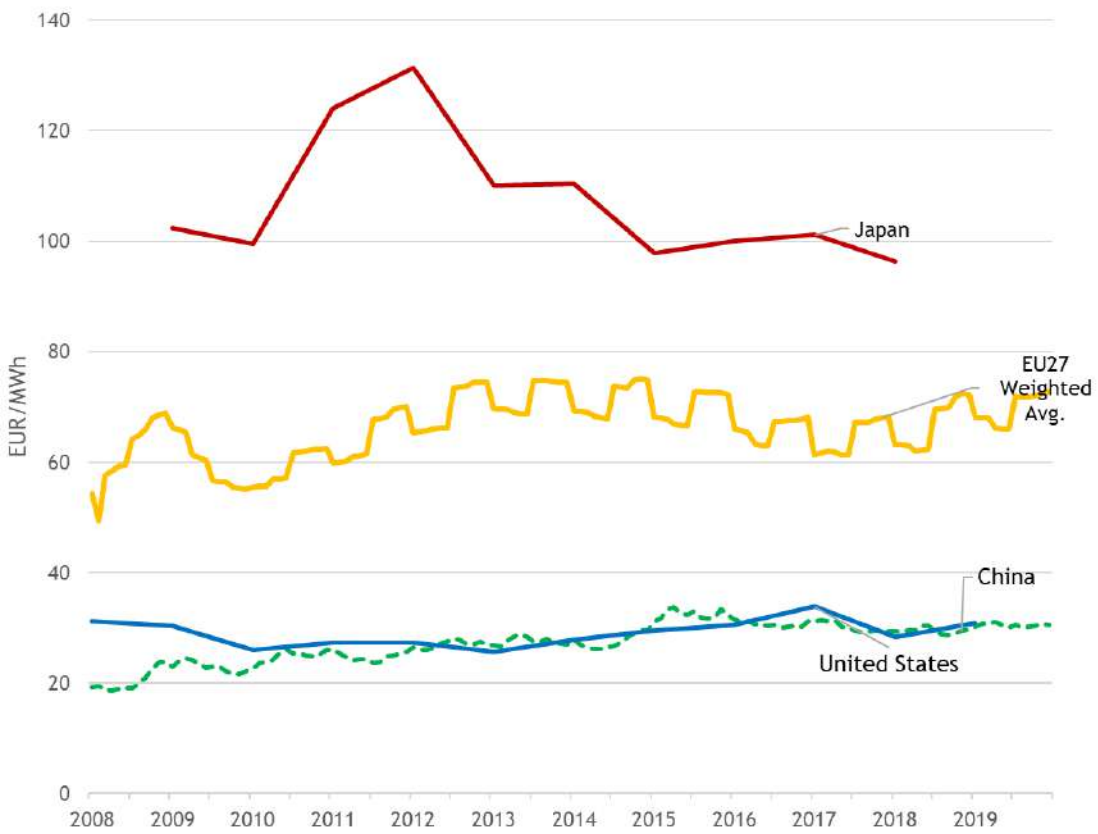
- EU27 average household prices have remained around 60 EUR/MWh between 2008-2019, moving only around 15 EUR/MWh higher or lower. Seasonal variations are noticeable since 2011. UK prices roughly mirror EU27 prices, but are on average 10-15 EUR/MWh lower since 2016;
- Prices for the USA and CN are almost identical and trend along the 30 EUR/MWh level, about half the EU27 average level. US prices show a decline from around 50 EUR/MWh in 2008 as a result of lower wholesale prices due to shale gas exploitation. The low Chinese prices relative to wholesale prices reflect price caps for household consumers. Japanese (JP) prices are considerably higher than EU prices, but since peaking in 2012 have been converging towards the EU27 average prices, which is consistent with the wholesale price movements;
- Prices in other G20 countries all tend to be lower than the EU27 average, although prices in Australia were broadly comparable. The lowest prices can be found in the major oil and gas producing countries, namely Saudi Arabia (SA), Canada (CA), Russia (RU) and Mexico (MX). Prices are also low in India, Brazil (BR) and Turkey (TR), this is notable particularly for TR which has higher wholesale prices than the EU, reflecting price subsidies for household gas use. Prices in Argentina (AR) were lowest of all, but subsidies were scaled back in 2017-2018 and prices more than doubled, although remaining relatively low;
- Analysis of prices in PPS terms (see Box 3-7) shows that EU prices remain amongst the highest amongst the countries considered, and that when adjusting for income the prices experienced in some lower-income MS are not as low for households as first indicated by the nominal price levels. These types of effects, and high income adjusted (PPS) prices, are particularly an issue for EL, ES, PT, PL and CZ;
- Analysis of the evolution of prices (see Table A-9 in Annex A) in 2018 constant EUR prices shows that price developments across all countries except Argentina, Australian, Brazil and India have been relatively negative (unfavourable) for the EU. Although this does not affect the competitiveness of the EU, it does signal a worsening of the relative price paid by the average EU household;
- In Table A-10 (in Annex A) we present a more detailed presentation of the observed (nominal) price changes with the breakdown of some of the key factors in these changes, namely inflation, national price and exchange effects.

Figure 3-22 Natural gas: household retail prices - EU27, min and max, CH, UK, 2008-2019, EUR2018/MWh



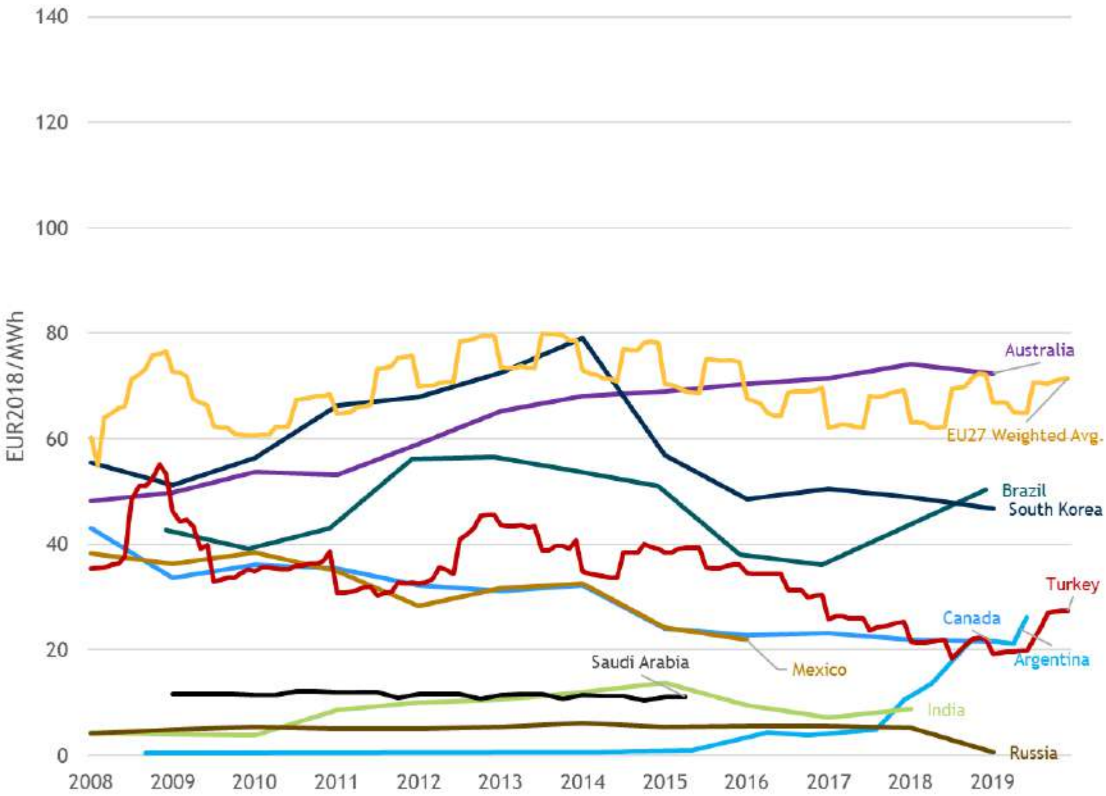
Sources: Own calculations based on data from Eurostat

Figure 3-23 Natural gas: household retail prices, EU, CN, JP, US 2008-2019, EUR2018/MWh



Sources: Own calculations based on data from Eurostat, CEIC, IEA
Note: the Chinese wholesale price is an assumed proxy price based on Usage Price: 36 City Avg: Pipe Natural Gas: for Resident (China). Actual wholesale prices, to the extent they exist in China, are likely to be lower.

Figure 3-24 Natural gas: household retail prices for natural gas, EU, other G20, 2008-2019, EUR_{2018}/MWh



Sources: Own calculations based on data from Eurostat, CEIC, IEA, ERRA, Ministry of Petroleum and Natural Gas - India.

Box 3-2 Household natural gas prices - Purchasing power standard (PPS)

The prices presented in the previous section are unadjusted for purchasing power differences, e.g. the differences in income and living costs between countries. As presented for electricity in Box 3-4 it is interesting to look at these differences when considering the relative impact on households in each country to get a clearer understanding of the actual impact of the differences. In this text-box we provide a snapshot and analysis of the differences that result from using purchasing power standard (PPS) prices based on IEA data[44], and with the United States as the PPS reference point.

Purchasing power standard comparison

As shown in Table 3-6, the lowest nominal prices are found in Mexico, Canada, Turkey and the United States, and the highest prices in Sweden, Japan and Greece. When relative purchasing power is taken into account these rankings change a little (see box 3-4 for more detail on PPS prices). The lowest prices in PPS terms include many of the same countries, Mexico, Canada and the United States, and Luxembourg also joins this grouping. Prices in Turkey, once adjusted for income increase. The highest prices are found in Greece, Portugal and Spain, the latter two jumping into the top 3 due to the income effect. The countries with the highest difference due to income effects remain the same as those in Box 3-5 as the PPS conversion remains the same, these are Turkey, Poland and Mexico.

[44] Note that IEA data is based on the OECD countries which means not all EU Member States are included (BG, CY, HR, MT, RO)

Table 3-6 Comparison of 2017 retail household natural gas prices, nominal and PPS, EUR/MWh

Country	Nominal price (EUR/MWh) 2017	PPS price (EUR/MWh) 2017	Difference	Nominal Rank (highest to lowest price)	PPS Rank (highest to lowest price)	Rank change (nominal to PPS)
Austria	68.06	77.34	14%	10	14	-4
Belgium	53.23	60.43	14%	15	24	-9
Czech Republic	56.70	105.86	87%	14	5	9
Denmark	82.11	78.03	-5%	5	12	-7
Estonia	40.14	66.41	65%	22	22	0
Finland	No data	No data				
France	68.06	77.86	14%	10	13	-3
Germany	64.85	76.30	18%	13	15	-2
Greece	86.70	130.57	51%	3	1	2
Hungary	35.37	71.35	102%	25	19	6
Ireland	67.89	75.60	11%	12	16	-4
Italy	75.00	95.63	28%	8	7	1
Latvia	41.18	74.48	81%	21	17	4
Lithuania	37.11	73.44	98%	24	18	6
Luxembourg	39.62	40.84	3%	23	27	-4
Netherlands	73.78	82.80	12%	9	9	0
Poland	43.96	94.85	116%	20	8	12
Portugal	76.82	117.39	53%	7	2	5
Slovak Republic	44.04	81.06	84%	19	11	8
Slovenia	52.63	81.15	54%	16	10	6
Spain	81.24	112.36	38%	6	3	3
Sweden	114.27	110.28	-3%	1	4	-3
United Kingdom	47.95	53.93	12%	18	25	-7
Norway	No data	No data				
Switzerland	82.28	67.89	-17%	4	21	-17
Canada	25.40	26.36	4%	28	29	-1
Japan	93.12	101.96	9%	2	6	-4
South Korea	50.46	65.81	30%	17	23	-6
Mexico	21.50	46.04	114%	29	26	3
Turkey	26.01	69.01	165%	27	20	7
United States	31.30	31.30	0%	26	28	-2

Source: Own calculation, based on data from IEA Energy Prices and Taxes 2017Q3 (2018)

Retail - industry

Retail gas prices for industry have relatively complete datasets, the following figures, present the time series of available price data for the EU27 and G20 countries from 2008-2019. Prices exclude VAT and all recoverable taxes and levies. From 2017 onwards, EU prices are for non-household consumers, not just industry. EU prices are typically for consumption band I4 or 100 000 - 1 000 000 GJ per year, the selection per country was based upon reported consumption data[45].

Conclusions that can be drawn from this data include:

- EU27 average industry prices have tended to move in a range of 25-40 EUR/MWh, but since 2016 have established at a level of around 24 EUR/MWh (a strong decline of around 25% over the 2008-2019 period). Industrial prices are significantly higher than the EU maximum in Switzerland, whilst UK prices have been slightly below the EU average throughout the period;
- Industry gas prices in the US are considerably lower than the EU27 average. Prices were roughly at the same level in 2008 (near 30 EUR/MWh) but they have since diverged considerably. Since 2016, US prices have declined to around 10 EUR/MWh. Prices in CN have stayed around the 40 EUR/MWh level until 2016, but have since started declining. Prices in JP increased strongly above the EU average between 2009-2014; in 2015-16 have started to converge to close to EU27 average prices, but have subsequently risen again.;

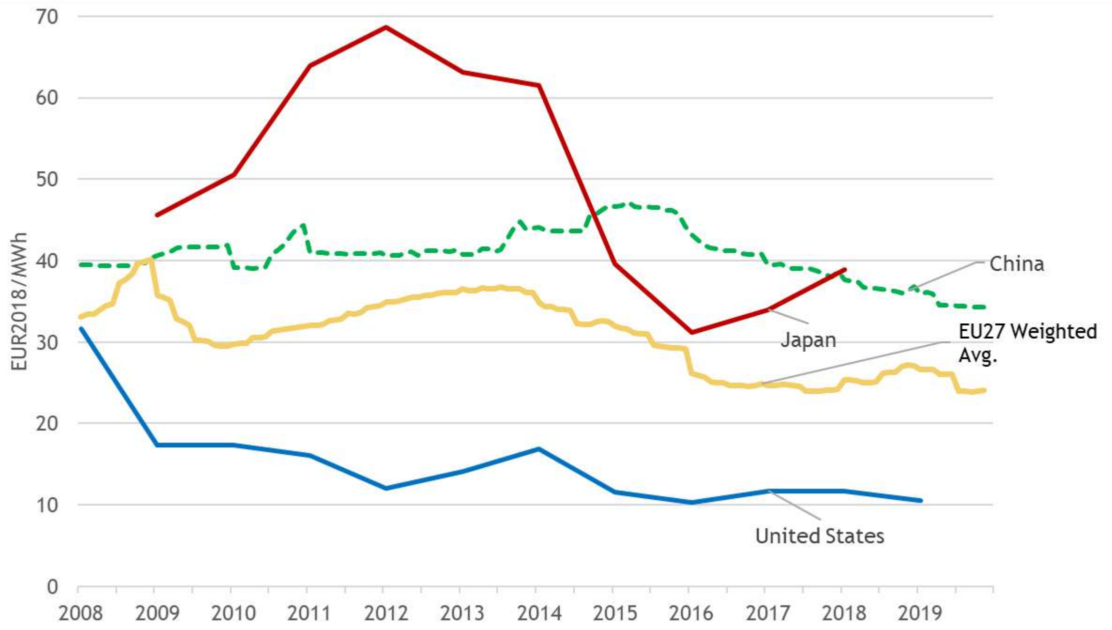
[45] Eurostat (2015) Gas prices: price systems 2014

- Prices in TR display similar, but slightly lower, levels and trends to the EU27 average. Prices in KR more closely mirror the observed trends for Japan, diverging between 2009-2014, then converging since 2015-16, following movements in the wholesale LNG markets on which these countries depend. Prices in BR, CA and RU are around half the EU levels, comparable to prices in the US. The CA trend, unsurprisingly given the close market links, very closely follows the US trend. Prices in Argentina (AR) are the lowest of all, held artificially low by policy, although starting to increase in the most recent years;
- Analysis of the evolution of prices (see Table A-11 in Annex A) in 2018 constant EUR prices shows that price developments in 5 (BR, CA, JP, KO, US) of the 14 G20 countries were of relatively negative for the EU, whilst 9 of the 14 were positive (AR, AU, CN, IN, JP, RU, SA, ZA). These trends can have potentially important implications for the competitiveness of EU industry. The starting position in 2008 found prices higher than the EU in CN, JP, MX, KR and the US. The US experienced the biggest single change, with the shale gas expansion driving prices significantly lower; Canada also experienced similar benefits. Prices in Japan and South Korea have come closer to EU prices, but remain higher;
- In Table A-12 (in Annex A) we present a more detailed analysis of the observed (nominal) price changes with the breakdown of some of the key factors in these changes, namely inflation, national price and exchange effects.

Figure 3-25 Natural gas: industrial retail prices, EU27, 2008-2019, EUR_{2018}/MWh

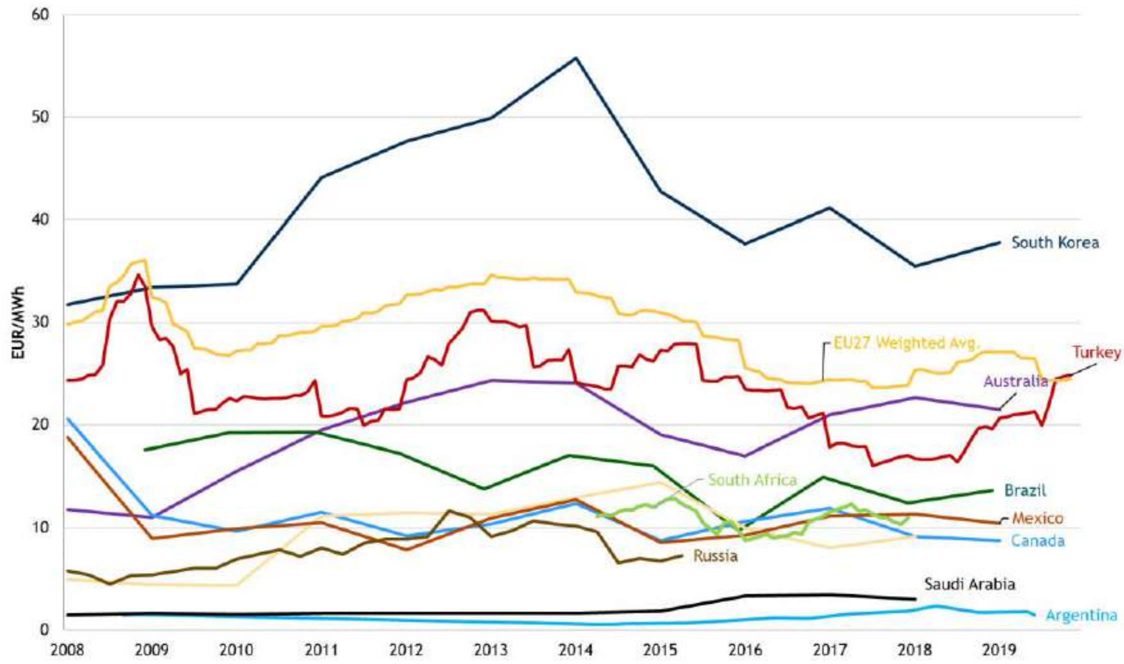
Sources: Own calculations based on data from Eurostat

Figure 3-26 Natural gas: industrial retail prices, EU, CN, JP, US, UK 2008-2020, EUR_{2018}/MWh



Sources: Own calculations based on data from Eurostat, CEIC
Note: the Chinese wholesale price is an assumed proxy price based on Usage Price: 36 City Avg: gas for Industrial users. Actual wholesale prices, to the extent they exist in China, are likely to be lower.

Figure 3-27 Natural gas: industrial retail prices, EU27, other G20, 2008-2019, EUR_{2018}/MWh



Sources: Own calculations based on data from Eurostat, CEIC, ERRA, IEA and national sources

Households – comparing retail prices to wholesale prices

For the international comparison it is interesting to reflect on the role that different price components play in the retail prices paid by consumers and how these differ across countries. The main components of the gas price are: wholesale energy cost; network costs; VAT; other taxes and levies. As part of these costs, utility companies will also earn their profit margin (mark-up). This includes suppliers' costs, such as admin costs, and the profit margin[46]. Within the EU[47]:

- On average, mark-ups have remained stable in the period 2012-2018, with EU average at around 10€/MWh, with suppliers in Greece and Germany reporting the highest mark-ups, averaging 20€/MWh and 15€/MWh, respectively, over the whole period;
- In 2018, the average EU mark-up was around 6€/MWh, suppliers in Sweden and the Czech Republic recorded the highest mark-up levels (at around 15€/MWh and 20€/MWh, respectively), while Latvia and Hungary were the lowest below 0€/MWh, potentially implying losses to suppliers or other measures being in place, although it can also be within the margin of error of the estimation method;
- The share of the regulatory component in prices[48] has increased from 42% to 50% between 2012 and 2018, mostly due to increases in network costs. Across Member States, the regulatory component varies substantially, ranging from 30% of the price in Malta to 74% of the price in Denmark.

Unfortunately, corresponding price data (energy and supply, network charges, taxes and levies) is not available for non-EU countries. As a proxy for a component level analysis we provide in this section a comparison of the difference between the retail prices paid by consumers and the observed wholesale prices. Wholesale prices representing a proxy for the energy and supply component, and the difference between wholesale and retail prices illustrating the other components in the price such as network charges, mark-ups and non-recoverable taxes and levies. This can also illustrate where price regulation and/or tariff deficits exist.

Analysis of the difference between retail natural gas prices for households and natural gas wholesale prices are presented in the figures below (they show time series of this difference for the EU27 and G20 countries from 2008-2019).

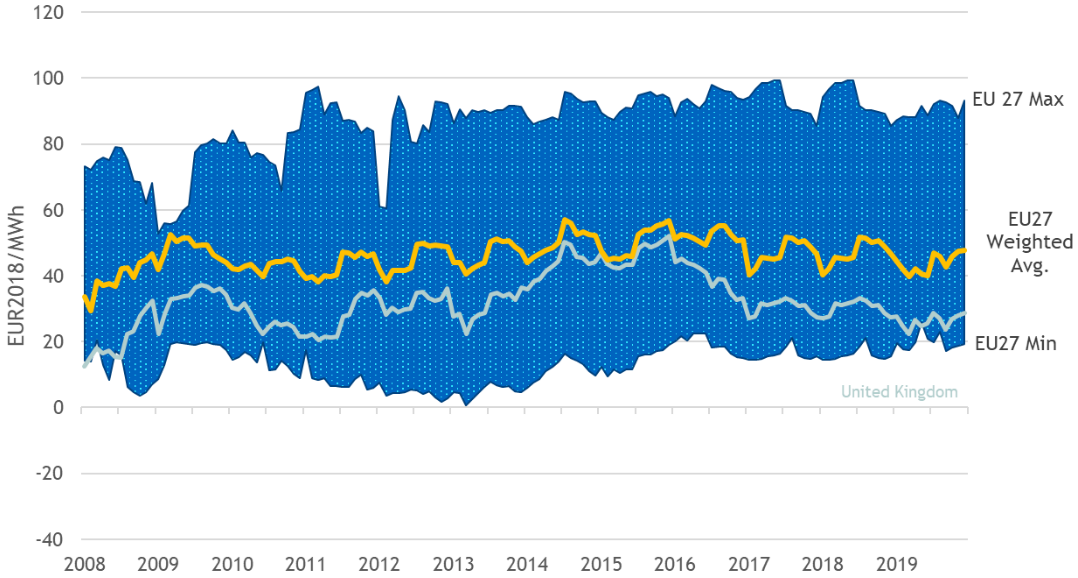
Conclusions that can be drawn from this data include:

- The EU27 average difference between household retail prices and wholesale prices (see Figure 3-28) has remained stable at around 50 EUR/MWh since 2009. With wholesale prices averaging around 20-30 EUR/MWh and being relatively stable over this period, the difference between the two, equating broadly in other price components such as network charges and taxes and levies, has also remained stable. In UK, the difference is now lower, which suggests the non-wholesale costs are decreasing;
- Internationally, we see (Figure 3-29) that the price difference in China is low, starting at around 20 EUR/MWh in 2008, before declining to around -10 EUR/MWh for much of 2012-2015, before increasing to 10 EUR/MWh in 2016 and remaining stable since then. These low and sometimes negative differences highlight that, as with electricity, household consumers in China are not paying the full cost of their natural gas use. The difference in the US is lower than in the EU27 at around 20 EUR/MWh and has only increased a little since 2008. This is noteworthy as US wholesale prices have declined significantly, signalling that the other price components have increased;

[46] On the basis that the consumer price = energy costs + supplier mark-up = wholesale energy price + regulatory components.
[47] Data from ACER, *annual report on the results of monitoring the internal electricity and natural gas markets in 2018*, and Eurostat.
[48] For incumbent suppliers

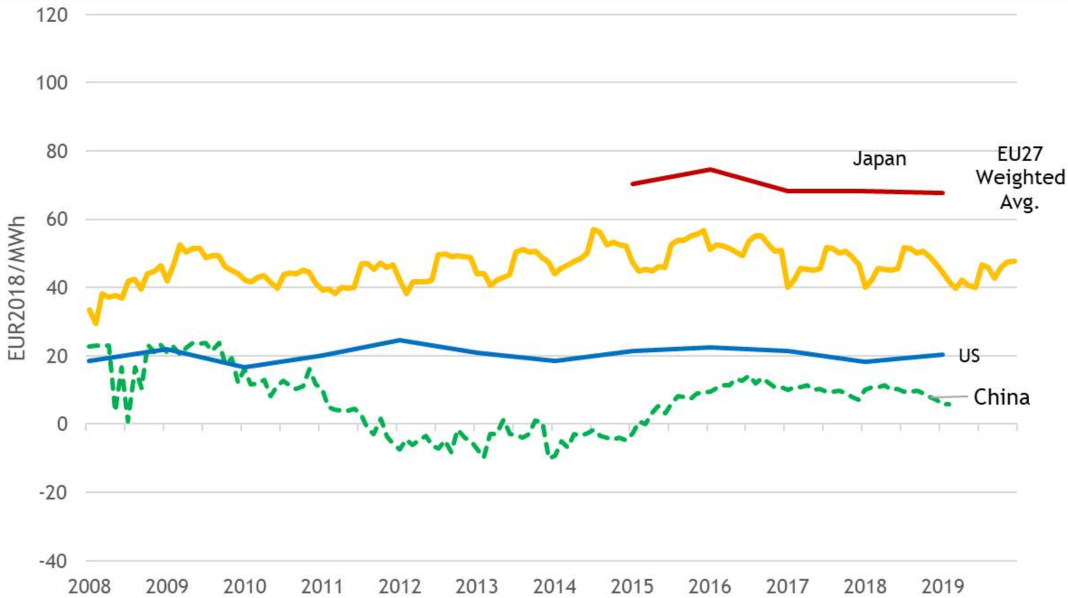
- For the other G20 countries (see Figure 3-30) the difference is lower than the EU27 average. In Mexico (MX), Turkey (TR), Russia, Canada and Brazil, the difference is around the 20 EUR/MWh level. In Argentina and India, the prices difference is negative, highlighting that households pay less than wholesale prices, although the gap in both has narrowed as household retail prices have increased;
- Overall, whilst EU27 average wholesale prices are comparable to a number of other G20 countries this does not translate into comparable household prices. The price difference analysis highlights how this is driven by factors unrelated to the wholesale price. It is notable that some countries with higher wholesale prices than the EU, such as Turkey and South Korea, have lower household retail prices.

Figure 3-28 Difference between household retail natural gas prices and wholesale prices, EU27 (weighted) average, min and max, UK, 2008-2019, EUR_{2018}/MWh



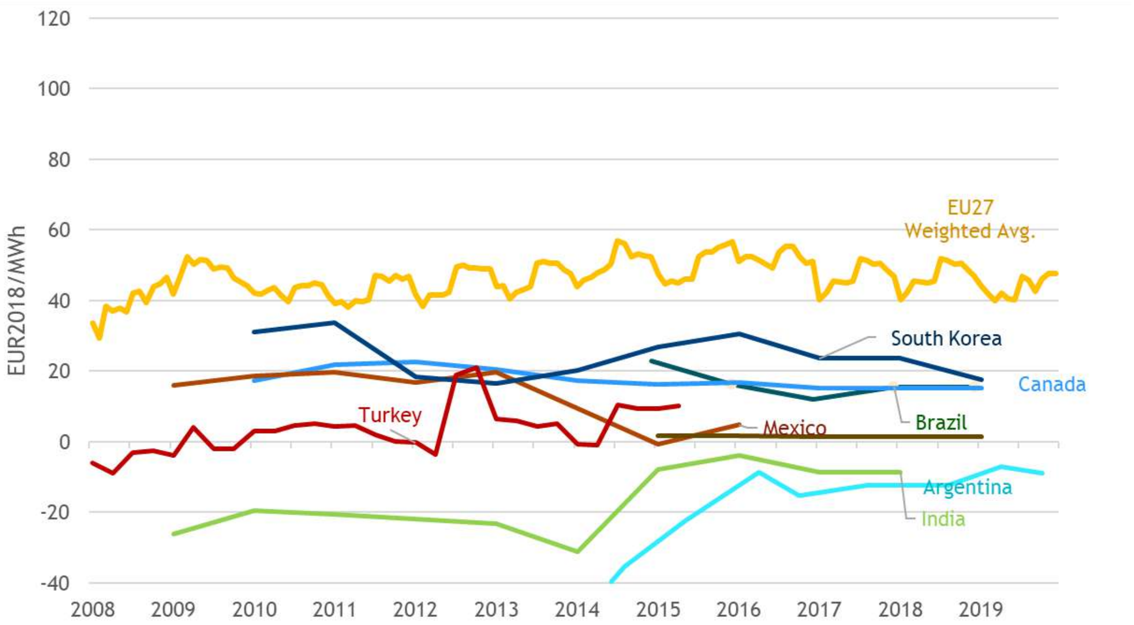
Source: Own calculations

Figure 3-29 Difference between household retail natural gas prices and wholesale prices, EU27, US, CN, JP 2008-2019, EUR_{2018}/MWh



Source: Own calculations

Figure 3-30 Difference between household retail natural gas prices and wholesale prices, EU27 and other G20 countries, 2008-2019, EUR_{2018}/MWh



Source: Own calculations

Industry - comparing retail prices to wholesale prices

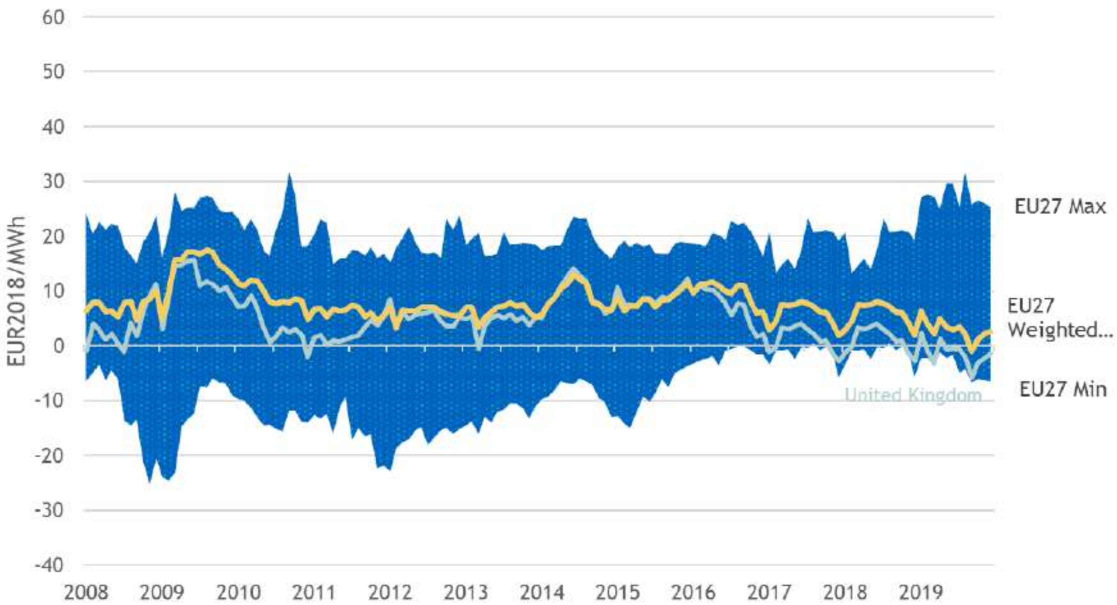
Carrying out a similar international comparison of the difference for retail industrial natural gas and wholesale prices provides the results presented in Figure 3-31, Figure 3-32 and Figure 3-33, which present time series of this difference for the EU27 and G20 countries from 2008-2019.

Conclusions that can be drawn from this data include:

- The EU28 average difference between industrial retail prices and wholesale prices (see Figure 3-31) has remained around 5 EUR/MWh between 2008 and 2017 but it has slightly decreased into 2019, which suggests industry is paying no, or very little for the, other cost components, such as network charges, and taxes and levies. In some Member States (especially Romania, but also Bulgaria) the difference between the two is often negative, highlighting effectively low or negative impacts from other price components. Wholesale prices in these Member States are relatively high or around the EU average, whilst retail prices are amongst the lowest. It should be noted that the retail price excludes recoverable taxes and levies so the focus is on any mark-up, network charges or non-recoverable taxes;
- Looking at Figure 3-32 the difference in the US has been a little lower than in the EU27 at around 0-5 EUR/MWh over the period. The price difference in China has been greater than in the EU and finished the period at around 15 EUR/MWh. In both Japan and China, this reflects both wholesale and retail prices that are similar or higher than in the EU;
- For the other G20 countries (Figure 3-33), the difference is typically lower than the EU27 average difference, although the difference in South Korea has become higher than the EU since 2014, but now is realigning again. In Turkey, Mexico and Brazil, the difference is negative in most years highlighting that industry in these countries typically pays prices lower than the wholesale prices. In Canada and Russia, price differences are close to zero, signalling that companies are paying close to cost prices in these countries;
- Overall, we find that the non-wholesale price component in the EU and in G20 countries is similar, with the EU having often lower figures than Asian countries, which have both higher

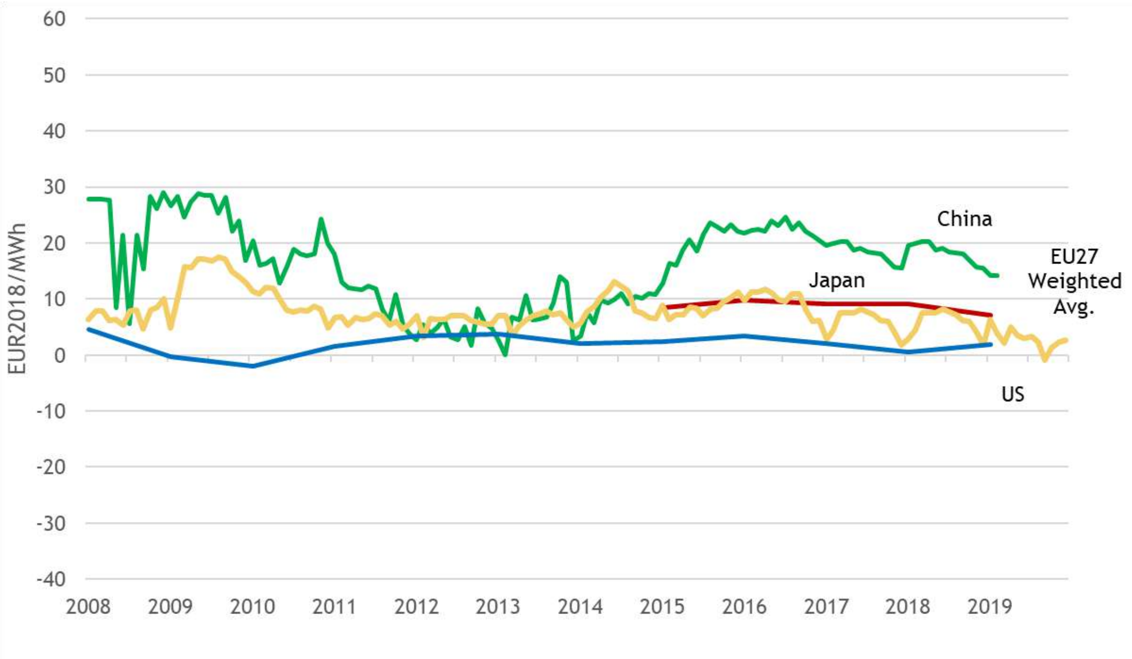
wholesale and retail prices in any case. At the same time the US and Canada have lower differences and a number of countries (Mexico, Turkey, Brazil) have negative prices differences, highlighting the low prices that industry pays in these countries.

Figure 3-31 Difference between industrial retail natural gas prices and wholesale prices, EU27 (weighted) average, min and max, UK 2008-2019, EUR_{2018}/MWh



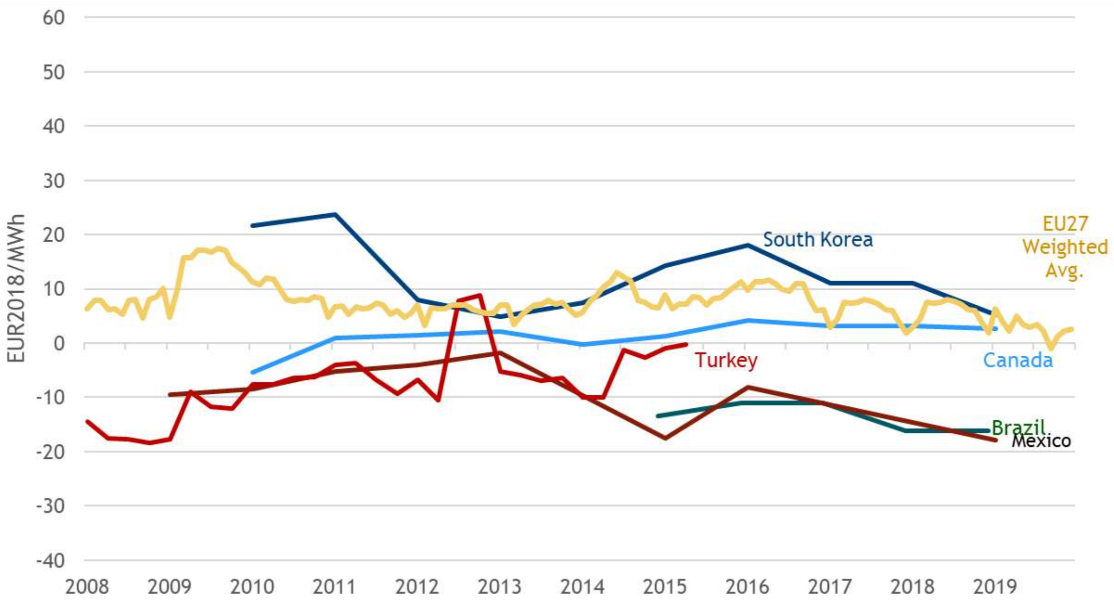
Source: Own calculations

Figure 3-32 Difference between industrial retail natural gas prices and electricity wholesale prices, EU27, US, CN, JP, 2008-2019, EUR_{2018}/MWh



Source: Own calculations

Figure 3-33 Difference between industrial retail natural gas prices and electricity wholesale prices, EU27 and other G20 countries, 2008-2019, EUR_{2018}/MWh



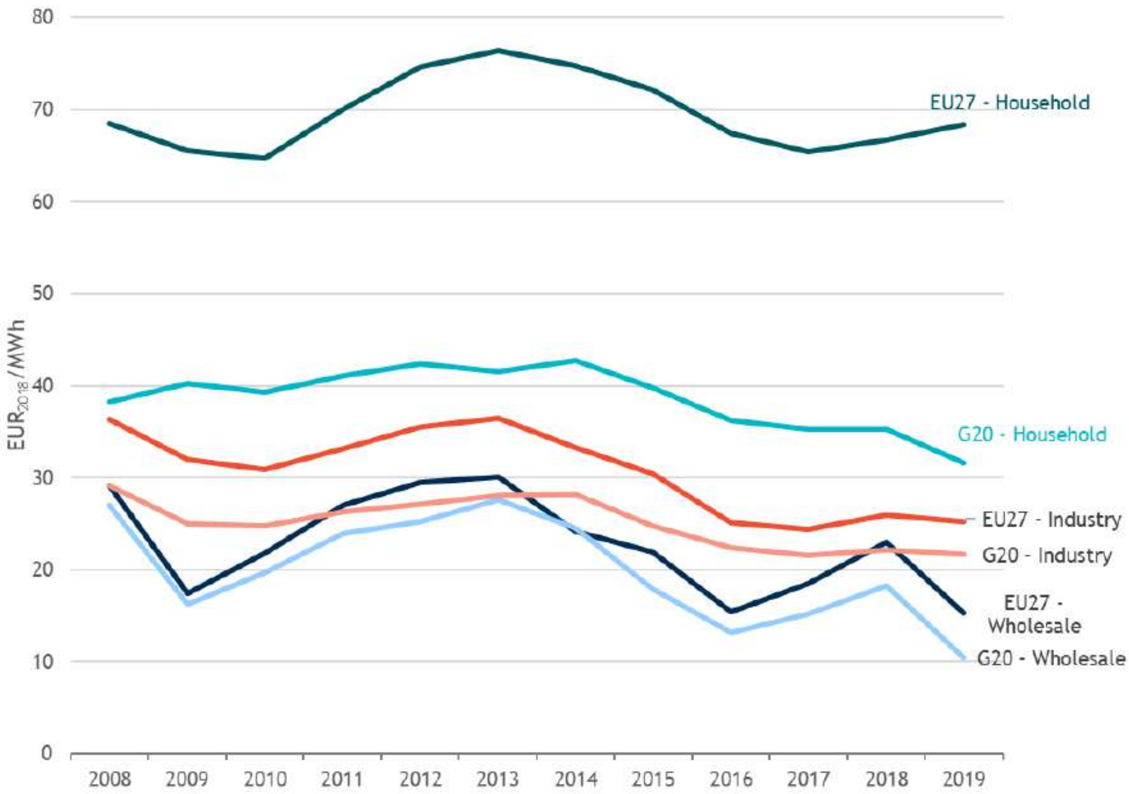
Source: Own calculations

Summary of natural gas price analysis

Our analysis of energy prices in the EU28 and main trading partners in the G20 is summarised in Figure 3-34, and the analysis as a whole found that:

- Wholesale prices – in the EU are similar to most other G20 countries, with the exceptions of the US, which has benefitted from the onset of shale gas around 2010, and other major producers (Russia, Canada and (until recently) Australia) which have lower prices. Price developments have been relatively positive compared to East Asia (CN, JP, KO) but negative compared to the producers;
- Household prices - average EU27 prices are considerably higher than in most other G20 countries (except JP and KO), although at the same level in 2018 as in 2008. Relatively high consumer taxes in the EU and price regulation/subsidies in the G20 play an important role in the differences;
- Industrial prices – average EU27 prices are lower than in East Asian countries (Japan, South Korea, China), but higher than in most other G20 countries, including the US. Prices have declined since 2008 in the EU, but apart from East Asia and Mexico prices have declined faster elsewhere in the G20. As before, non-recoverable taxes in the EU and price regulation/subsidies in the G20 play an important role in the observed difference;
- As to the role of taxes and levies, network costs and mark-ups - by comparing wholesale and retail prices we find that the difference (for households) between the two is the highest in Japan, and second highest in the EU. In most G20 countries the difference is less than half compared to EU average levels, and in some G20 countries (AR, MX, TR) less than, or near, zero. For industry, there is a difference of around 5 EUR/MWh between the weighted averages of both, representing around 20% of the total price. The difference compares relatively favourably for the EU with JP, CN, US and CA, but other G20 countries (TR, BR, AR, RU) have near zero or negative differences, highlighting likely price regulation/subsidies.

Figure 3-34 Comparison of EU27 weighted average with G20 (trade) weighted average



Source: Own calculations
Note: the G20 weighted averages are calculated on the basis of all available price data for a particular year, weighted in the total price by the share a country had in EU imports+exports 2017-2019. Coverage ratios of total trade range from 84-98% (household prices), 77-99% (industrial prices) and 60-97% (wholesale prices).

3.2.3 Petroleum product prices

The following section presents results for petroleum products, including crude oil, as a proxy for wholesale prices, and examining various transport, heating and industrial fuels. In the following data the EU average represents a weighted average of the EU composition at that moment in time, this is provided by the EU Oil Bulletin data[49]. Full Member State data and figures are provided in the Excel tool annexed to this work.

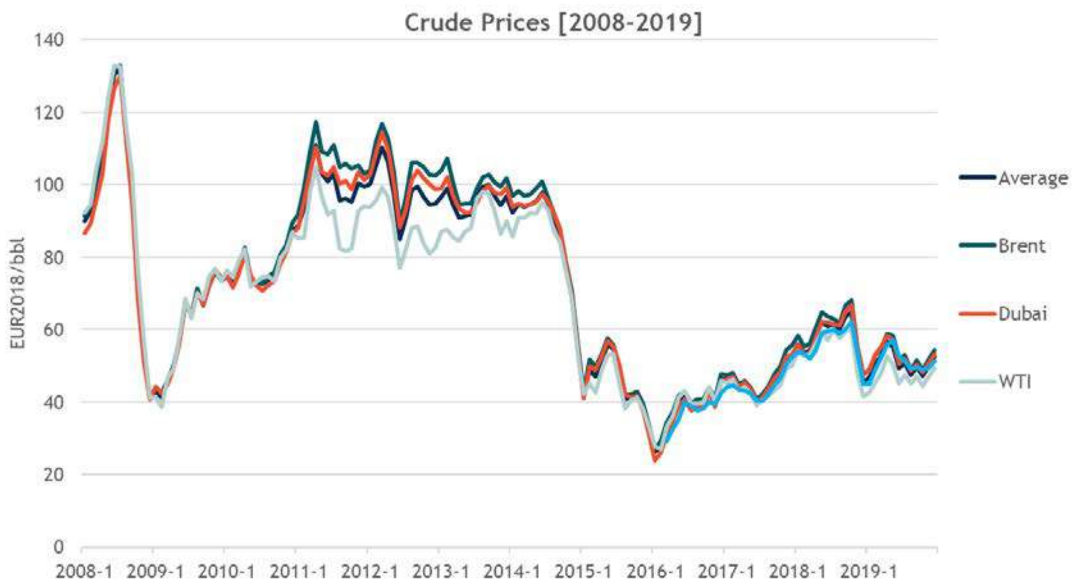
Wholesale - crude oil

Prices from the major crude oil indices (Brent, Dubai, West Texas Intermediate) all track each other very closely over time as shown in Figure 3-35, with prices rarely varying by more than 10 EUR/bbl from each other. Only between 2011-2014 did a divergence start to emerge with rapidly increasing US shale oil production starting to lead to lower prices for West Texas Intermediate oil compared to the other major benchmarks. The response of Saudi Arabia and other OPEC countries to increase production led to a sharp decline in crude prices, which led to financial difficulties and cutbacks in the US shale oil sector (and a deterioration in public finances in OPEC countries) and to WTI prices converging again with the other benchmark indices. Latest price data from the IEA and the World Bank, up to the end of 2019, indicates an increasing price trend, although the COVID19 crisis has resulted in oil prices falling significantly in 2020, which is, however, not yet included in the data here.

[49] This means that until July 2013 the EU averages do not include Croatia and that the averages since then include the UK, as it is only removed from the average on leaving the EU at the end of January 2020.

Crude oil prices are highly influential in the pricing of wholesale petroleum products and to some extent also in wholesale natural gas products, as noted previously in the Natural Gas wholesale prices, therefore it will be normal to observe similar price trends for prices in the following sections as shown in Figure 3-35 below.

Figure 3-35: Crude oil prices, main benchmarks, 2008-2019, EUR_{2018}/barrel (bbl)



Source: Own calculations based on data from World Bank, IEA

Retail - petrol

Retail petrol prices are available for all countries although for some countries only partial data could be found. The following figures, Figure 3-36, Figure 3-37 and Figure 3-38, present the time series of available price data for the EU and G20 countries from 2008-2019. Retail prices for petrol (gasoline) are strongly driven by taxation, particularly in the EU. We provide a comparison both including and excluding taxes to isolate this component.

Specific assumptions relating to this dataset include:

- The EU average is a consumption weighted average calculated by the EC in the Weekly Oil Bulletin (see also the introductory text to section 3.2.3).

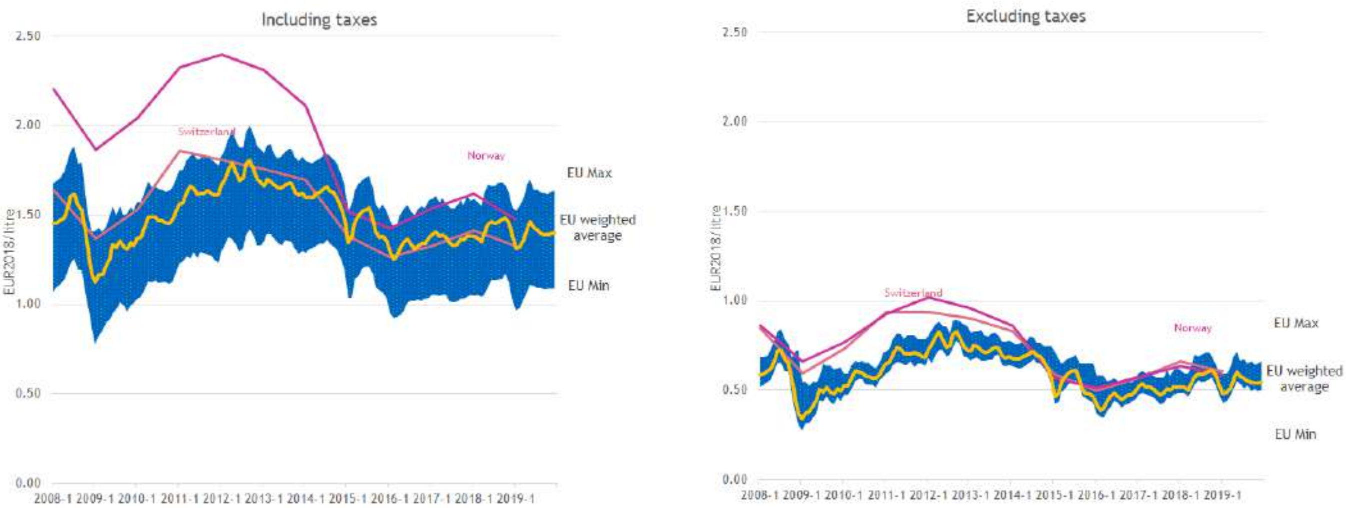
Conclusions that can be drawn from this data include:

- EU average prices including taxes have remained around the 1.40 EUR/litre level since 2008, varying by up to 0.35 EUR/litre higher or lower broadly in line with crude oil price trends. Excluding taxes, we find that price levels are considerably lower but show similar trend in volatility to prices with taxes. These varied between the low in 2009 of 0.31 EUR/litre, peaks at 0.77 EUR/litre in 2012 and fluctuating within this range, often around 0.50 EUR/litre, until 2019. Taxes constitute on average around 60% of the total retail price in the EU. The range of maximum and minimum prices is much larger for the prices including taxes, highlighting the differences in tax regimes between EU Member States;
- US prices including taxes follow similar trends to the EU28 average, although prices are less than half of EU average levels. US tax rates are closer to 15-25% of the total price, this being the major explanatory driver of price differences. Prices including taxes in CN are also lower

than EU levels, while in Japan they were higher before 2013 but have since being around 30% lower than EU. Excluding taxes, we find that EU28 average and US prices are very closely comparable. We do not have reliable tax exclusive prices for CN to make a similar comparison;

- Retail prices including taxes in TR and KO were notable for being higher than the EU average until around 2013, but prices have converged to the EU average level over the period and are now below the EU28 average. Prices including taxes are lower than the EU average in all other G20 countries. Prices in CA and MX are a little higher than their US neighbour;
- Prices excluding taxes are more difficult to compare. With no reliable price data excluding taxes for some of the other G20 (see dotted lines in Figure 3-38), it is impossible to conclude if taxes are present or at which level, although indications are that taxes of around 40% are present in Argentina[50]. Looking at those countries with more reliable data we see that EU price levels correspond closely to other G20 countries and are in fact among the lowest;
- Trends in all countries (except AR) quite closely match movements in crude oil prices, the extent of this effect on prices including taxes is higher in countries with lower taxes;
- In summary, the main differences in final retail prices can be largely explained by differences in tax levels, and in this area the EU taxes are among the highest of the countries considered.

Figure 3-36 Petrol (unleaded 95): EU retail prices 2008-2019, EUR_{2018}/litre



[50] https://www.afip.gob.ar/genericos/guiavirtual/consultas_detalle.aspx?id=3000746

Figure 3-37 Petrol: retail prices EU, US, JP and CN, 2008-2019, EUR2018/litre

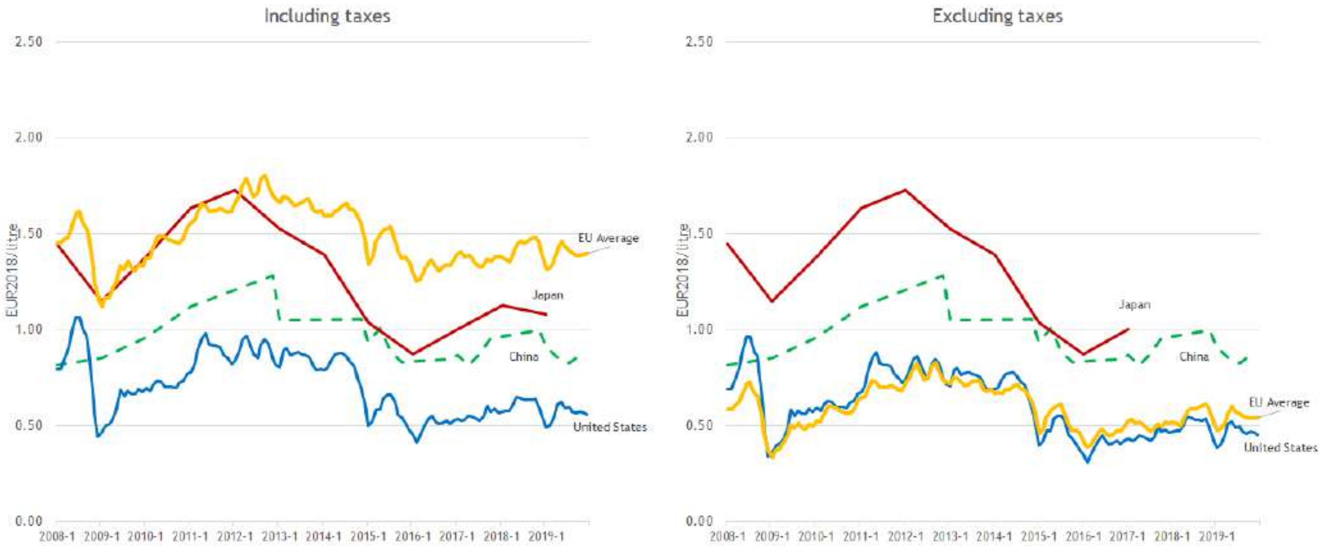
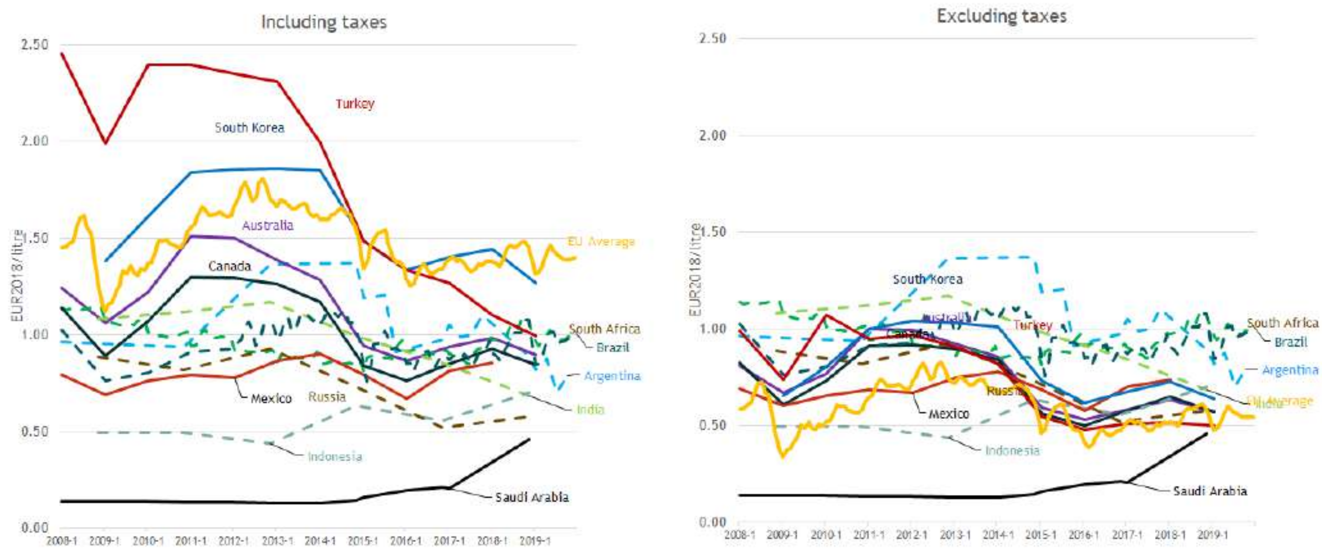


Figure 3-38 Petrol: retail prices, EU and other G20 countries, 2008-2019, EUR2018/litre



Source: Own calculations based on data from EU Oil Bulletin, EC, IEA, GIZ, EIA.
Note: dotted line highlights that it is unclear if the excluding taxes price actually excludes relevant taxes as no detailed tax information was available. Indications from other sources are that fuel taxes represent around 50% of the fuel price in Japan. In most cases little or no fuel taxes are levied - see main text for note on AR.

Retail - diesel

The following figures, present the time series of available price data for the EU and G20 countries from 2008-2019. Conclusions that can be drawn from this data are similar to those for petrol and include:

- EU average retail prices including taxes have remained around the 1.30 EUR/litre level since 2008, varying by up to 0.30 EUR/litre higher or lower. Prices have peaked in 2012, reached a low in 2016 and have increased since. Excluding taxes, we find that price levels follow a similar volatility trend, but are considerably lower at around 0.65 EUR/litre in 2008, and around 0.55 EUR/litre by 2019. Taxes constitute on average around 55% of the total retail price in the EU, 5 percentage points lower than for petrol. The range of maximum and minimum prices is much larger for the including taxes price, highlighting the differences in tax regimes between EU Member States;

- Retail prices including taxes in CN, JP and the US follow similar trends to the EU average as well as to crude oil prices, although prices in all countries are lower than the EU average, and significantly so in the US with prices less than half of EU average levels. US tax rates are around 15-25% of the total price, compared to the 55% on average in the EU, this being the major explanatory driver of price differences. We do not have reliable tax exclusive prices for CN and JP to make a similar comparison;
- For the other G20 prices including taxes, TR was notable for having higher prices than the EU average until 2014, but prices have converged to the EU average level in 2015 and are now lower. Prices are lower than the EU average in all other G20 countries. A similar trend to petrol can be observed for prices in AR. Prices in CA and MX are a little higher than their US neighbours';
- Prices excluding taxes are more difficult to compare, with no reliable price data excluding taxes for some of the other G20 (see dotted lines in Figure 3-41); it is not possible to conclude whether taxes are present or at which level, although indications are that taxes of around 40% are present in Argentina[51]. Looking at those with more reliable data (AU, CA, KR, MX) we see that EU price levels correspond closely to other G20 countries. The lowest prices are found in Saudi Arabia (SA);
- Trends in all countries (except AR) quite closely match movements in crude oil prices, the extent of this effect on prices including taxes is higher in countries with lower taxes;
- Using other sources to compare, such as OECD tax data[52], we find that in 2015 fuel taxes in the EU were typically constituted by around 60-75% excise taxes, the remainder being VAT. In other G20 countries, excise taxes typically constitute >75% of all taxes as VAT or sales taxes on fuel are either much lower or entirely absent;
- It is also notable that in almost all countries the price of automotive diesel is lower than that of petrol. There are many reasons for this, including the different energy content per fuel, but most often relating to policy choices to favour diesel on the basis of its typically lower CO_2 emissions per km than petrol.

Figure 3-39 Automotive diesel: retail prices, EU weighted average, 2008-2019, EUR_{2018}/litre

51 https://www.afip.gob.ar/genericos/guiavirtual/consultas_detalle.aspx?id=3000746
52 http://www.oecd.org/ctp/consumption/Table-4.A4.7-Taxation-of-automotive-diesel-(per%20litre)-2015.xls

Source: Study on energy prices, costs and their impact on industry and households

Figure 3-40 Automotive diesel : retail prices EU, US, JP and CN, 2008-2019, EUR_{2018}/litre

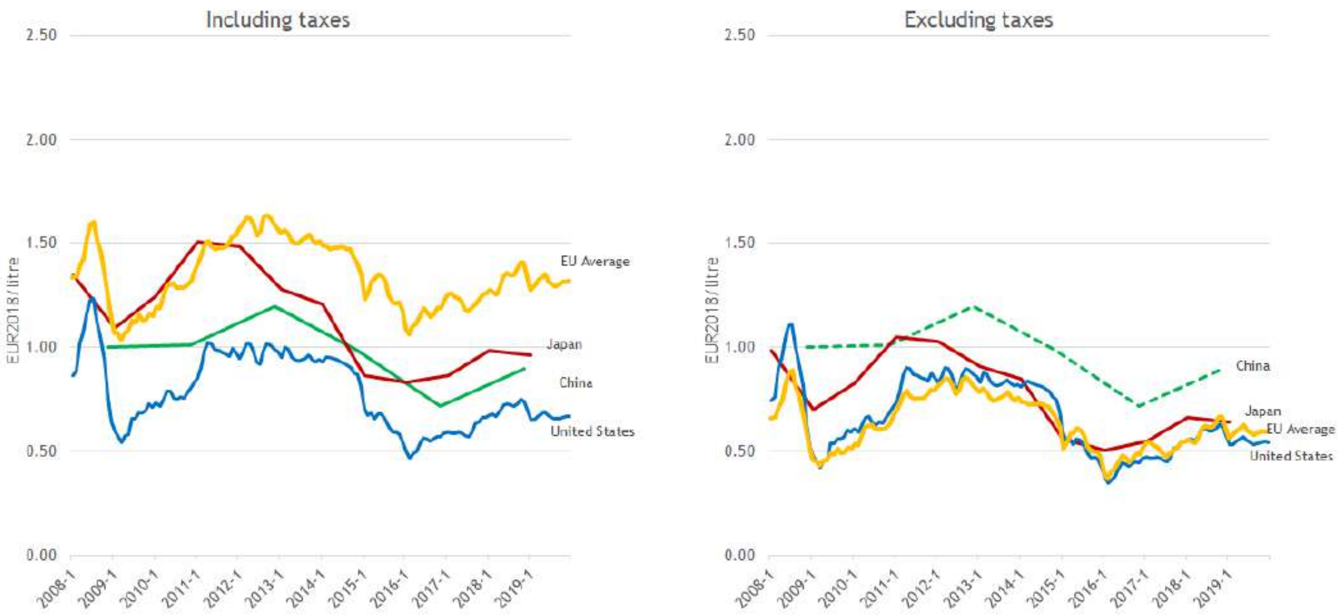
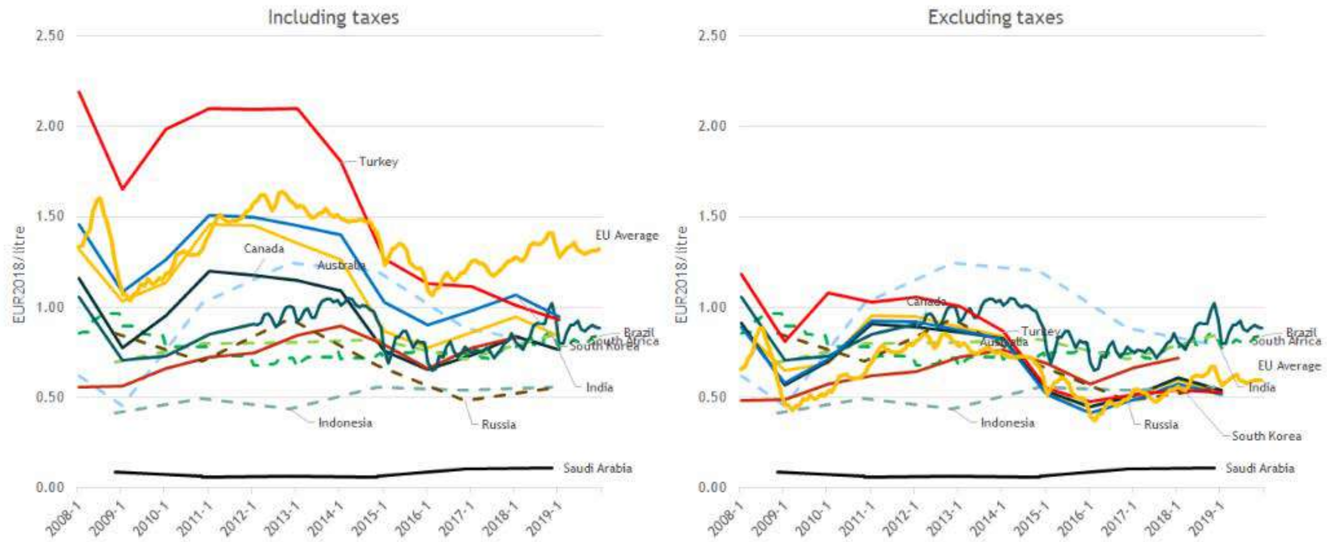


Figure 3-41 Automotive diesel: retail prices, EU and other G20 countries, 2008-2019, EUR_{2018}/litre



Sources: Own calculations based on data from EU Oil Bulletin, EC, IEA, GIZ.
Note: dotted line highlights that it is unclear whether the excluding taxes price actually excludes relevant taxes as no detailed tax information was available. In most cases little or no fuel taxes are levied - see main text for note on AR.

Retail - Fuel oil (high sulphur)[53]

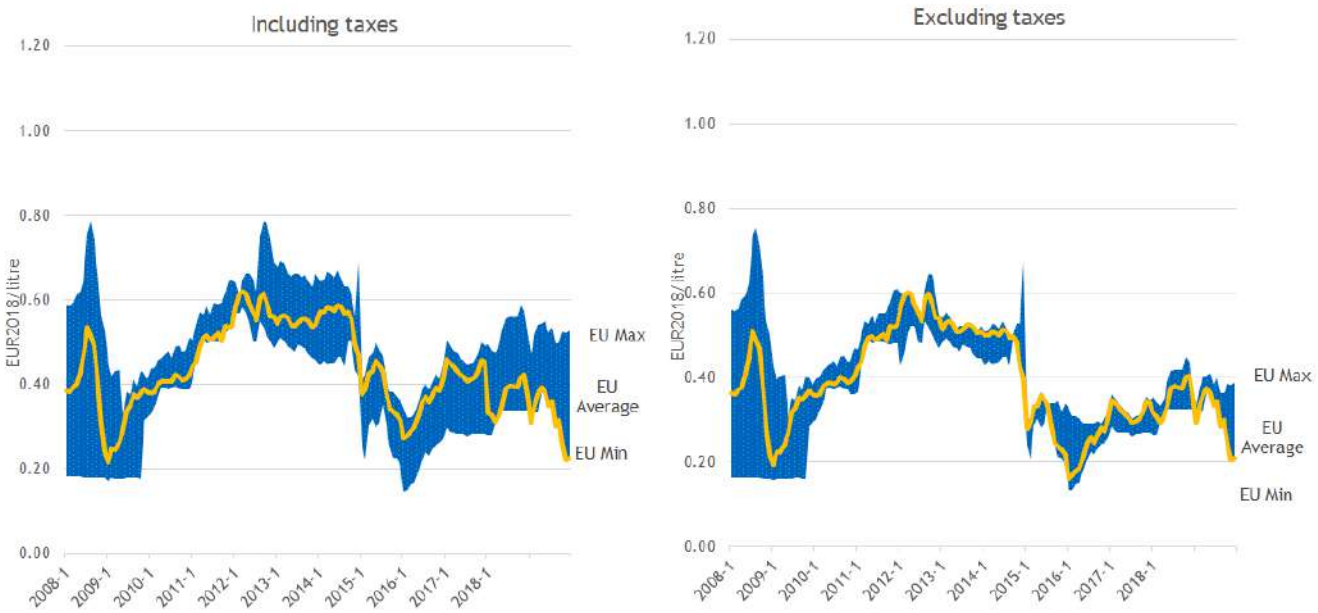
Fuel oil, both high and low sulphur (see following sub-section), is primarily used for maritime transport although it also has other uses as a fuel for backup diesel power generators and steam locomotives. There is relatively comprehensive information in the EU oil bulletin for the EU countries covering fuel oil. However, prices data is scarce outside the EU, with the exception of countries covered by the IEA (CA, JP, KO, MX, TR, USA). The following figures, present the time series of available price data for the EU average and G20 countries from 2008-2019.

Conclusions that can be drawn from this data include:

[53] High sulphur refers to a >1% sulphur content

- Since the low prices recorded in 2009, EU average prices including taxes have fluctuated around 0.55 EUR/litre until 2014, reached a new low in 2016, and fluctuated reaching a new low of 0.23 EUR/litre in 2019, roughly the same level as in 2009. Global restrictions from 2020 and existing EC legislation (EC 2016/802) on the usage of high sulphur maritime fuel oil is likely to have an impact on demand for high sulphur fuels, and in turn on prices i.e. reducing demand and lower prices as supply adjusts – this may become evident in a future update of this work taking into account prices in 2020. Observed short-term volatility corresponds quite closely to movements in global crude oil prices. Prices excluding taxes are only a little lower than tax inclusive prices, signalling that the tax rates on this fuel are relatively low compared to petrol and diesel, with tax forming 10% or less of the price[54]. Taxes in the EU are similar to international taxes, this is consistent with tax competition amongst countries and the ease with which ships can cover large distances on a single tank of fuel;
- Prices in other G20 countries (CA, MX, TR, KR, US) show similar trends, and prices both including and excluding taxes are close to EU average levels, although in 2014-2015 many of these prices switched from being higher than the EU average to lower than the EU average. Prices in TR are somewhat higher than the EU average levels (although they have converged since 2012), with higher taxes being one of the major factors in this.

Figure 3-42 Fuel oil (>1% [high] sulphur content): retail prices EU 2008-2019, EUR_{2018}/litre



Source: Own calculations based on data from EU Oil Bulletin

[54] Maritime fuels, including international bunkers, are exempt from certain taxes, and prices are excluding VAT, and therefore the taxes represent country level excise duties and indirect duties.

Figure 3-43 Fuel oil (>1% [high] sulphur content): retail prices EU and G20 countries 2008-2019, EUR_{2018}/lt

Source: Own calculations based on data from EU Oil Bulletin, IEA

Retail - Fuel oil (low sulphur)[55]

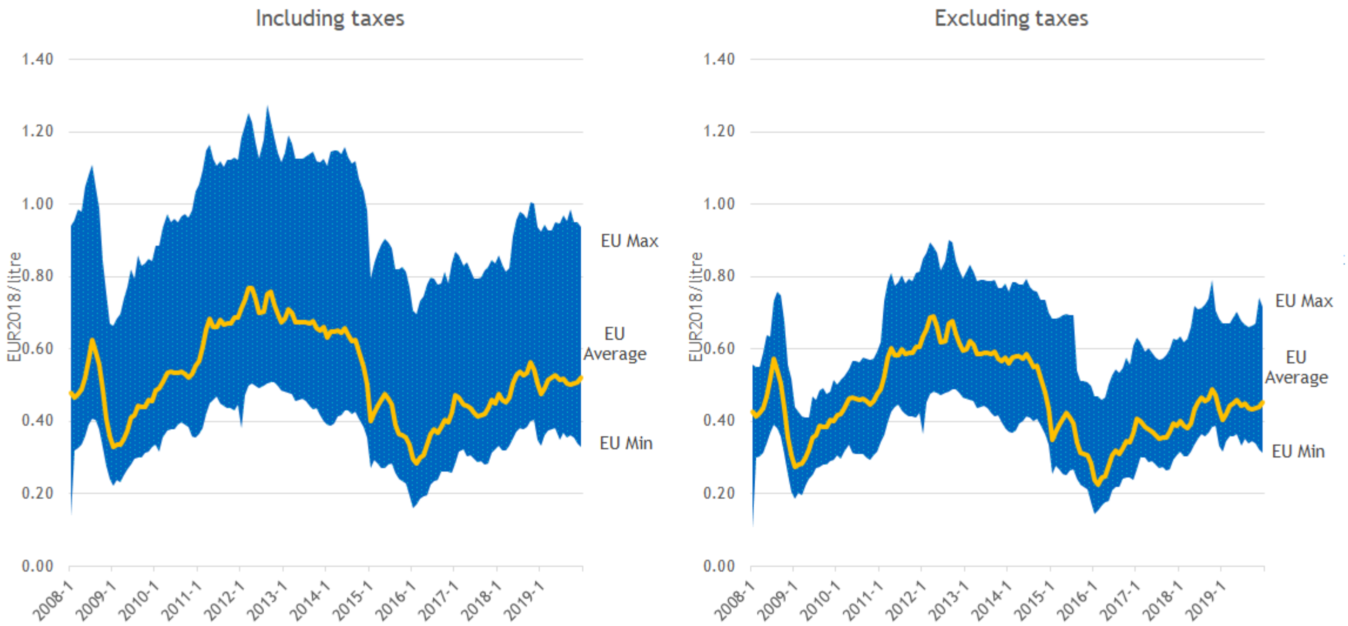
There is relatively comprehensive information in the EU oil bulletin for the EU countries, however prices are scarce outside the EU28, with the exception of countries covered by the IEA (JP and KO). The following figures, present the time series of available price data for the EU average and G20 countries from 2008-2019.

Conclusions that can be drawn from this data include:

- Similar to high sulphur fuel oil, EU average prices including taxes for low sulphur fuel oil are at a similar level in 2018 as in 2009 at around 0.45 EUR/litre. However, they have not decreased as much as for high sulphur fuel oil in 2019. The observed trend corresponds quite closely to movements in global crude oil prices. Prices excluding taxes are a little lower, again signalling the relatively low tax levels compared to fuels such as petrol and diesel;
- Prices in other G20 countries (JP, KR) are very close to EU average levels and mirror the price trends.

[55] Low sulphur fuel oil has less than 1% sulphur content

Figure 3-44 Fuel oil (<1% [low] sulphur): retail prices 2008-2019, EUR_{2018}/t



Source: Own calculations based on data from EU Oil Bulletin

Figure 3-45 Fuel oil (<1% [low] sulphur): retail prices EU and G20 countries 2008-2020, EUR_{2018}/t

Source: Own calculations based on data from EU Oil Bulletin, IEA

Retail - Heating oil

Retail heating oil prices are relatively comprehensive for the EU, from the information in the EU Oil Bulletin. Price data for heating oil was found for G20 countries covered by the IEA (CA, JP, KR, TR, USA). The following figures, present the time series of available price data for the EU average, minimum and maximum from 2008-2020 as well as for the G20 countries.

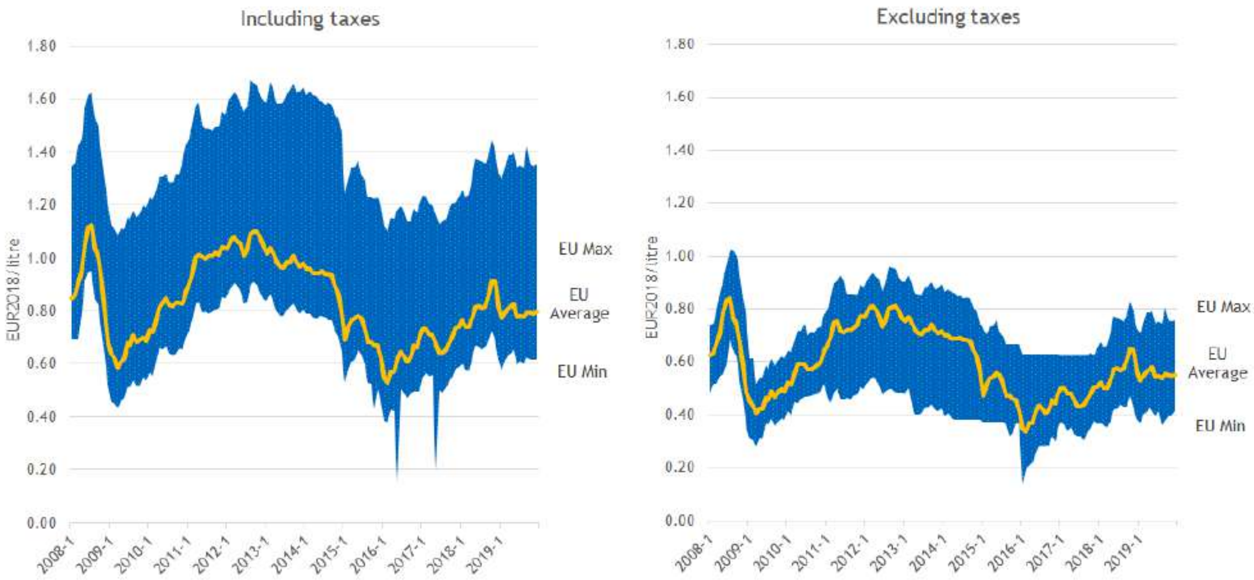
Specific assumptions relating to this dataset include:

- In the IEA dataset light fuel oil for residential use is equivalent to heating oil in the EU Oil Bulletin.

Conclusions that can be drawn from this data include:

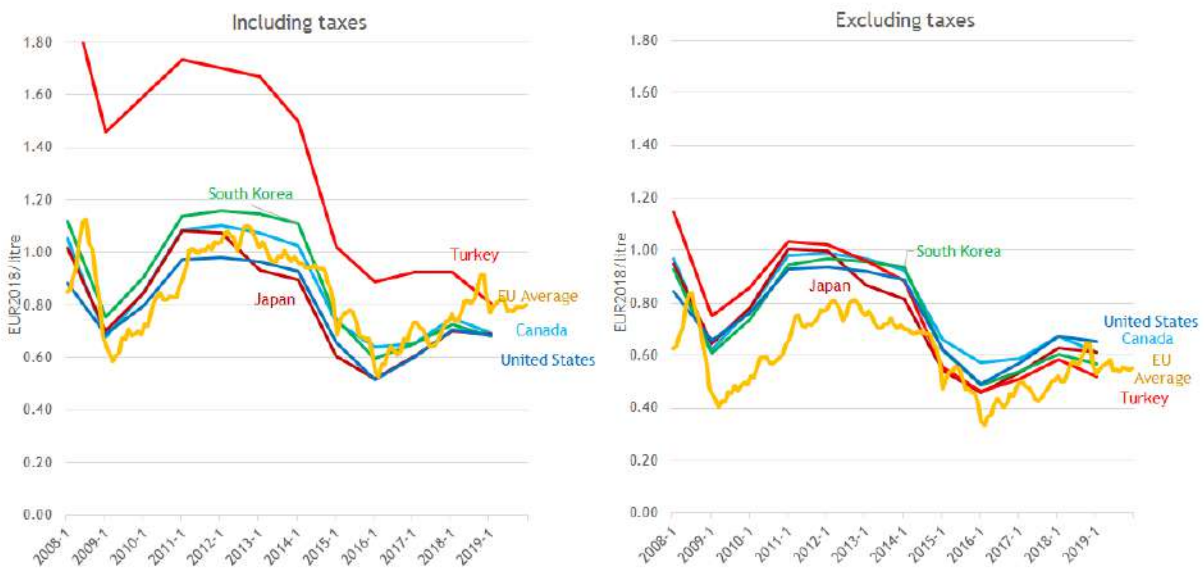
- EU average prices for heating oil including taxes have increased since 2016 to come back at the level they were in 2008. The observed short-term volatility corresponds quite closely to movements in global crude oil prices. Prices excluding taxes are around 0.20 EUR/litre lower than prices including taxes, highlighting tax rates of 20-30% in most EU countries. The graphs highlight relatively high levels of taxed prices in some EU countries (namely DK, IT, SE, PT);
- Prices levels and movements in CA, JP, KR and the US very closely match those of the EU average both including and excluding taxes. Prices in TR including taxes are by far the highest of all countries, although these have been decreasing since 2011 and particularly from 2014, the prices are converging with those of the EU average prices and other G20 countries. Excluding taxes, the EU average price is the lowest of all countries for which there is data.

Figure 3-46 Heating oil: retail prices EU, 2008-2020, EUR_{2018}/litre



Source: Own calculations based on data from EU Oil Bulletin

Figure 3-47 Heating oil: retail prices, EU and G20 countries 2008-2020, EUR_{2018}/litre



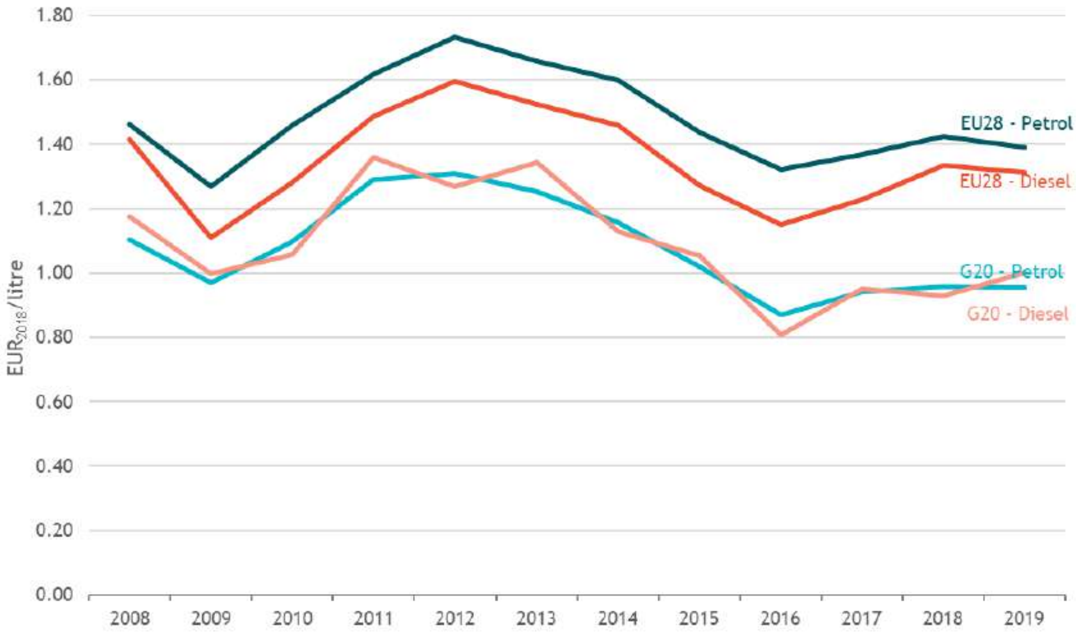
Source: Own calculations based on data from EU Oil Bulletin, IEA

Summary of petroleum product price analysis

Our analysis of petroleum product prices in the EU and main trading partners in the G20, is summarised in Figure 3-48, and the analysis as a whole found that:

- EU prices for conventional automotive fuels (petrol, diesel), tend to be higher than in other G20 countries, highly driven by differences in taxes. Excluding taxes, EU average prices are comparable or lower than most G20 countries for petrol and diesel;
- For high and low sulphur fuel oils (primarily for marine transport), EU prices are comparable to international prices, both with and without taxes, as, in contrast to petrol and diesel, EU taxes are also similar to international taxes. Taxes on these fuels are relatively low globally due to the relative ease with which shipping can refuel in lower cost jurisdictions resulting in tax competition. Increased international restrictions on the use of high sulphur fuels from 2020 onwards could have an impact on prices although this is not yet clear;
- For heating oil EU average prices are amongst the lowest in the G20 both including and excluding taxes, EU taxes on this product are relatively low compared to EU taxation of other fuels, although in a handful of EU countries (DK, SE, IT, PT) high taxes lead to relatively high prices;
- Prices in all countries for oil-derived fuels tend to follow the crude oil price trend.

Figure 3-48 Comparison of EU weighted average prices with G20 (trade) weighted average prices



Source: Own calculations
Note: the G20 weighted averages are calculated on the basis of all available price data for a particular year, weighted in the total price by the share a country had in EU imports+exports 2017-2019

3.2.4 *Alternative fuels prices*

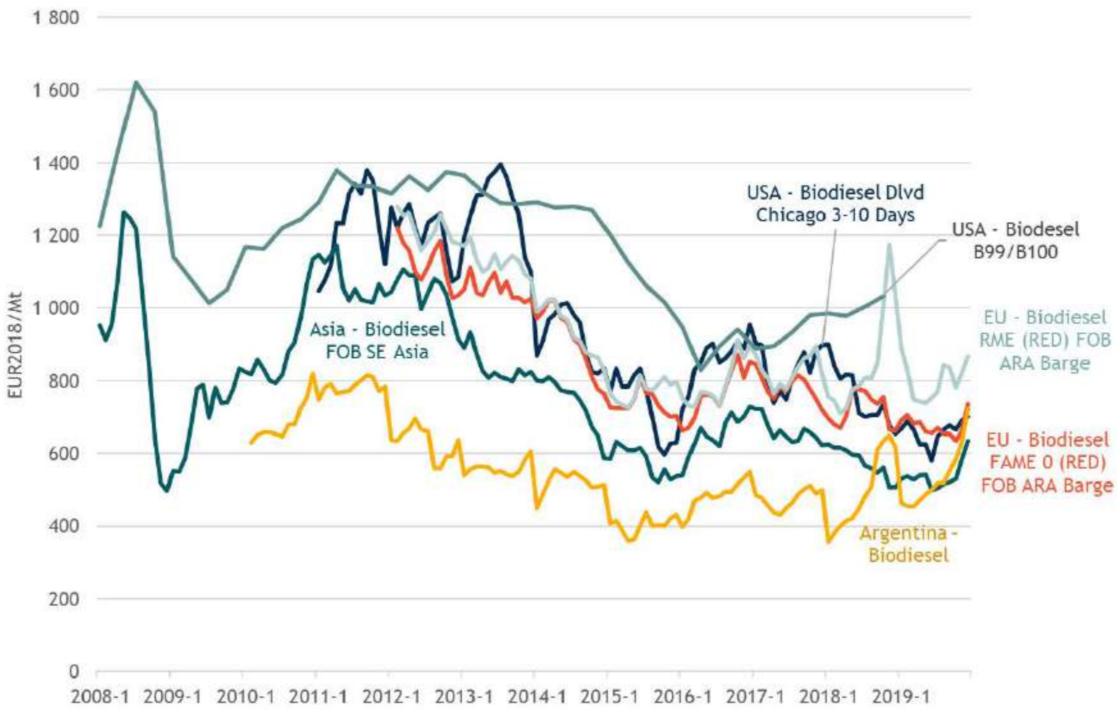
Wholesale - Biofuel

Wholesale biofuels data has proved limited, with access to international and EU price indicators available through the Platts Biofuelscan dataset. The price data provided through this source provides a split between biodiesel and ethanol and series for the EU, Asian and US markets. In addition three other country specific data sources for the US, Brazil and Argentina are used to show retail prices (see also the box text following the figures for comment on EU data).

Conclusions that can be drawn from this data include:

- Wholesale prices for biodiesel (Figure 3-49) are lowest in the Asian market, whilst EU and US price levels are similar. The price trends are similar across all markets, signalling the links between the three, although EU RME (as opposed to FAME)[56] has seen a noticeable spike in late 2018. US prices show greater volatility than the other series. It is notable that since 2011 prices have significantly declined from around 1 200 EUR/Mt to around 800 EUR/Mt in 2018 as supply has increased. Retail prices, available only for the US (B99/B100) and Argentina, show prices in Argentina are similar to the wholesale prices in Asia and the EU, whilst US prices are around 1000 EUR/Mt in 2018;
- Wholesale prices for ethanol (see Figure 3-50) were available for two price series in the US market (Chicago swap and Chicago pipe) and one EU price series, the Rotterdam benchmark. The US series show almost identical trends and notably, a halving of prices between 2011 and 2018. The EU price series also displays a similar significant price decline over the period, but EU prices remain higher than US prices and the difference has been increasing since 2018. This difference is most likely explained by higher transport costs to bring ethanol to EU markets from major global producers (US and Brazil). Retail prices for Argentina, Brazil and the US (E85) were also available and these show that prices in Argentina and Brazil are higher than US wholesale prices, whilst US retail prices are typically around 200 EUR/Mt higher than the wholesale prices.

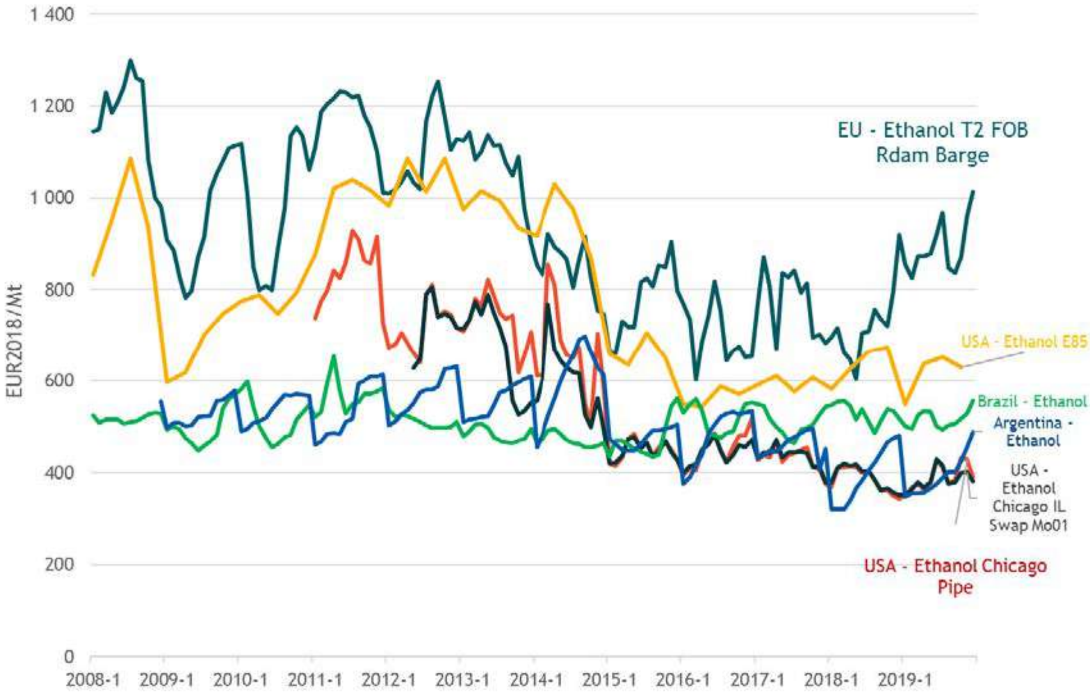
Figure 3-49 Biodiesel: wholesale prices, 2008-2019, EUR_{2018}/Mt



Source: Own calculations based on data from Platts

[56] Biodiesel, which is produced from rapeseed oil, is called rapeseed methyl ester, or RME. Biodiesel produced by esterification, is FAME and stands for Fatty Acid Mehtyl Ester. FAME can be made from most vegetable oils, of which rapeseed oil has the least proportion of saturated fatty acids and is therefore most suitable for cold climates.

Figure 3-50 Ethanol, wholesale prices, 2008-2019, EUR_{2018}/Mt



Source: Own calculations based on data from Platts

Box 3-3 Retail biofuel prices

The data presented above provide relatively few data points for retail markets for biofuels, and none in the EU. Whilst the team searched various sources we were not successful in finding such data. The main reason being that retail markets for biofuels do not really exist in the EU. Whilst biofuels are used, their use is characterised either by localised specific contracts and exchanges between companies, or in the blending of large volumes at relatively low percentages into standard petrol or diesel. Neither use provides for a market with public retail prices. Therefore we only present retail prices for the markets in the US, Brazil and Argentina for which very high percentage blends, i.e. E85 exist and for which recognisable retail prices and markets exist.

Retail - LPG

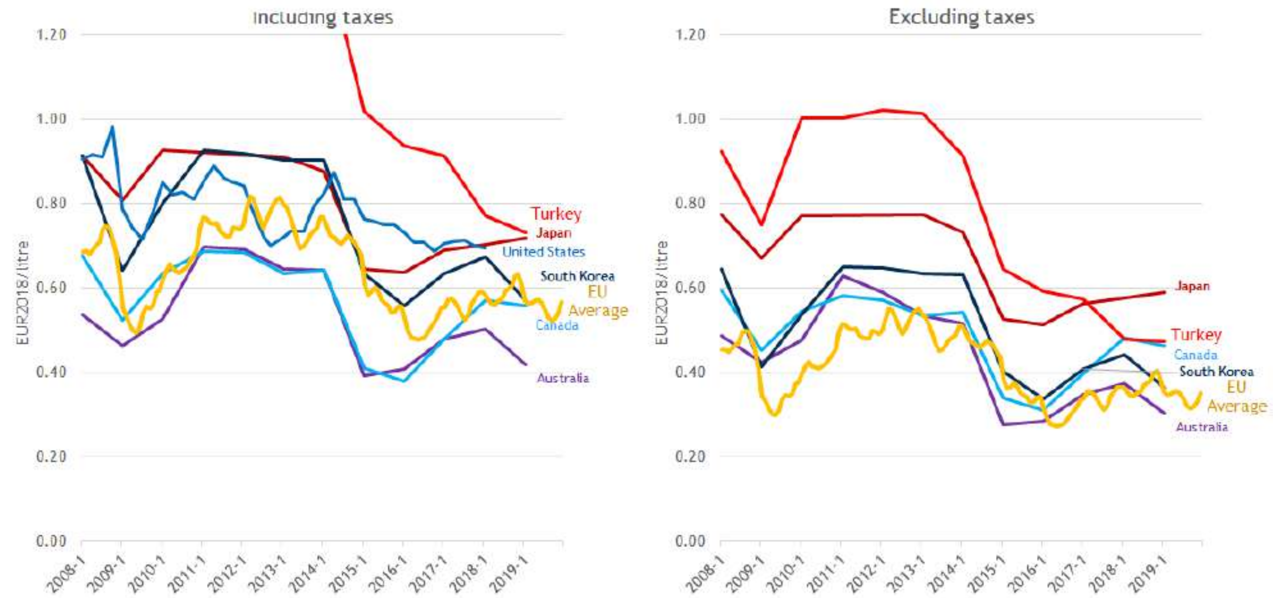
The following figures, present the time series of available price data for the EU and G20 countries from 2008-2019. Conclusions that can be drawn from this data include:

- EU average retail prices including taxes have moved up and down within a relatively small range since 2008, and finished below 0.60 EUR/litre in 2019. Excluding taxes, we find price trends mirror this price decline, moving from 0.53 EUR/litre in 2012 to around 0.35 EUR/litre at the end of 2019. Taxes on LPG form around 35% of the total price on average, a lower rate than for petrol or diesel;
- Prices including and excluding taxes in the other G20 countries (AU, CA, JP, KR, TR, US) follow similar overall trends to the EU average;
- For prices including taxes it is notable that prices in TR are significantly higher than the EU average, although these have been converging since 2012. Prices in the US are slightly higher than the EU average. Whilst prices in JP and KO are very similar to EU average levels, prices in AU and CA are generally lower than the EU28 average;
- Excluding taxes, we find EU prices very similar to those in South Korea, Canada and Australia. Prices in Turkey and Japan are higher than the EU. It was not possible to find US LPG tax data, but based on other fuels it is estimated that tax rates are around 25% and therefore also comparable to EU levels, when taxes are excluded.

Figure 3-51 LPG: retail prices EU, 2008-2019, EUR_{2018}/litre

Source: Own calculations based on data from EU Oil Bulletin

Figure 3-52 LPG: retail prices EU and other G20 countries, 2008-2018, EUR_{2018}/litre



Source: Own calculations based on data from EU Oil Bulletin, IEA, US AFDA

Retail - CNG

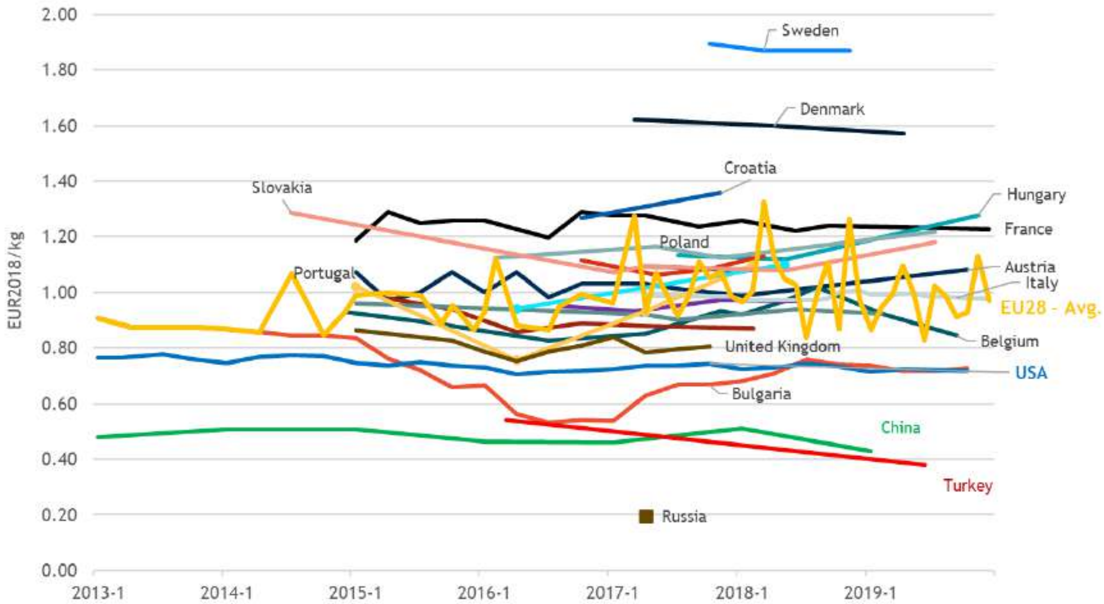
Retail CNG prices are available to some extent within the EU although only unofficial sources are available and therefore the quality of the price data cannot be guaranteed. Amongst G20 countries only data for the UK, US and Turkey were found as time series, with a single data point for Russia. The available price data are presented in Figure 3-53.

Conclusions that can be drawn from this data include:

- EU (simple) average prices have trended slowly upwards over time, but the volatility that is visible is related to the availability of prices from a particular country in a period rather than real volatility in price movements, as CNG prices tend to be rather stable;

- CNG prices in the UK and US tend to be lower than EU prices but relatively stable over time. Lower prices are likely to be driven by lower US wholesale natural gas prices resulting from higher domestic natural gas production (shale gas), tax differences may also play a role;
- The price point data from Turkey and Russia suggests very low CNG prices, in Russia this is consistent with low prices for energy and fuels in general.

Figure 3-53 CNG: retail prices EU28 Member States, USA, Turkey, China, Russia, 2013-2019, EUR_{2018}/kg



Source: Own calculations based on data from CNG Europe, US AFDA

Retail - Electricity for road transport

Charging at home

The prices paid by EV owners to charge their vehicles at home correspond to their electricity tariffs. Our survey of 12 European countries found that off-peak tariffs are available in all countries surveyed excluding Norway, although in some countries availability is limited and in others the uptake is poor. On the other hand, dedicated EV tariffs are a novelty available only in France, the UK and Spain. Table 3-7 presents the result of our survey, where we identify countries where dedicated tariffs for EVs and off-peak tariffs are present.

Table 3-7 Survey on electricity prices

Country	Dedicated tariff for EVs	Off peak tariff
France	YES	YES
UK	YES	YES
Austria	Unknown	YES
Belgium	NO	YES
Germany	NO	Limited
Spain	YES	YES
Norway	NO	NO
Sweden	NO	YES*
Denmark	Unknown	YES
Finland	Unknown	YES
Norway	NO	YES
China	NO	YES
Japan	Unknown	Limited**

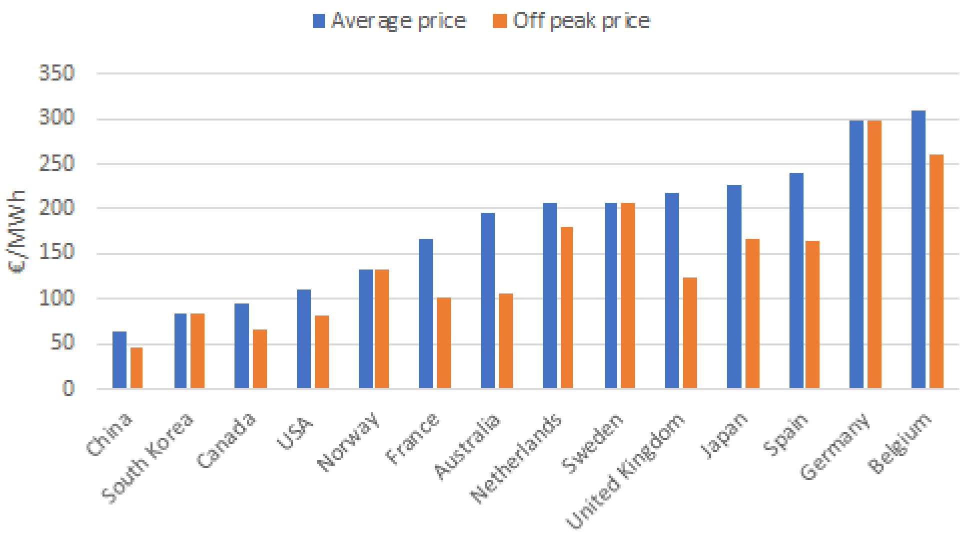
Country	Dedicated tariff for EVs	Off peak tariff
South Korea	NO	YES***
Canada (Ontario)	NO	YES
USA (California)	NO	YES
Australia	Unknown	YES

**In Sweden, utilities propose time of use prices. Only few customers choose this rate (one of the reasons is arguably that customers do not fully understand this tariff and are concerned about losing control of their bills).*
*** Japan: Incremental prices, seasonal prices. Off peak prices not well developed yet.*
****South Korea: Incremental prices, with seasonal prices. This is not really off-peak prices with differentiated prices during a day.*

In terms of the price differential between the average standard tariff and the average off-peak, we observe a substantial variation across countries. As shown in Figure 3-54, off-peak electricity prices for households (in €/MWh) could be over 40% lower than the average prices. The countries where the difference is highest are Australia, United Kingdom, France and Spain.

It is worth noting that within countries there is also a wide spread of tariffs, and the average presented is unlikely to reflect the prices most consumers would pay. Off-peak prices shown in the graph are calculated based on data collected from electricity suppliers with higher market shares and often based on a specific tariff.

Figure 3-54 **Electricity prices for households in €/**MWh (2019), our analysis from various sources



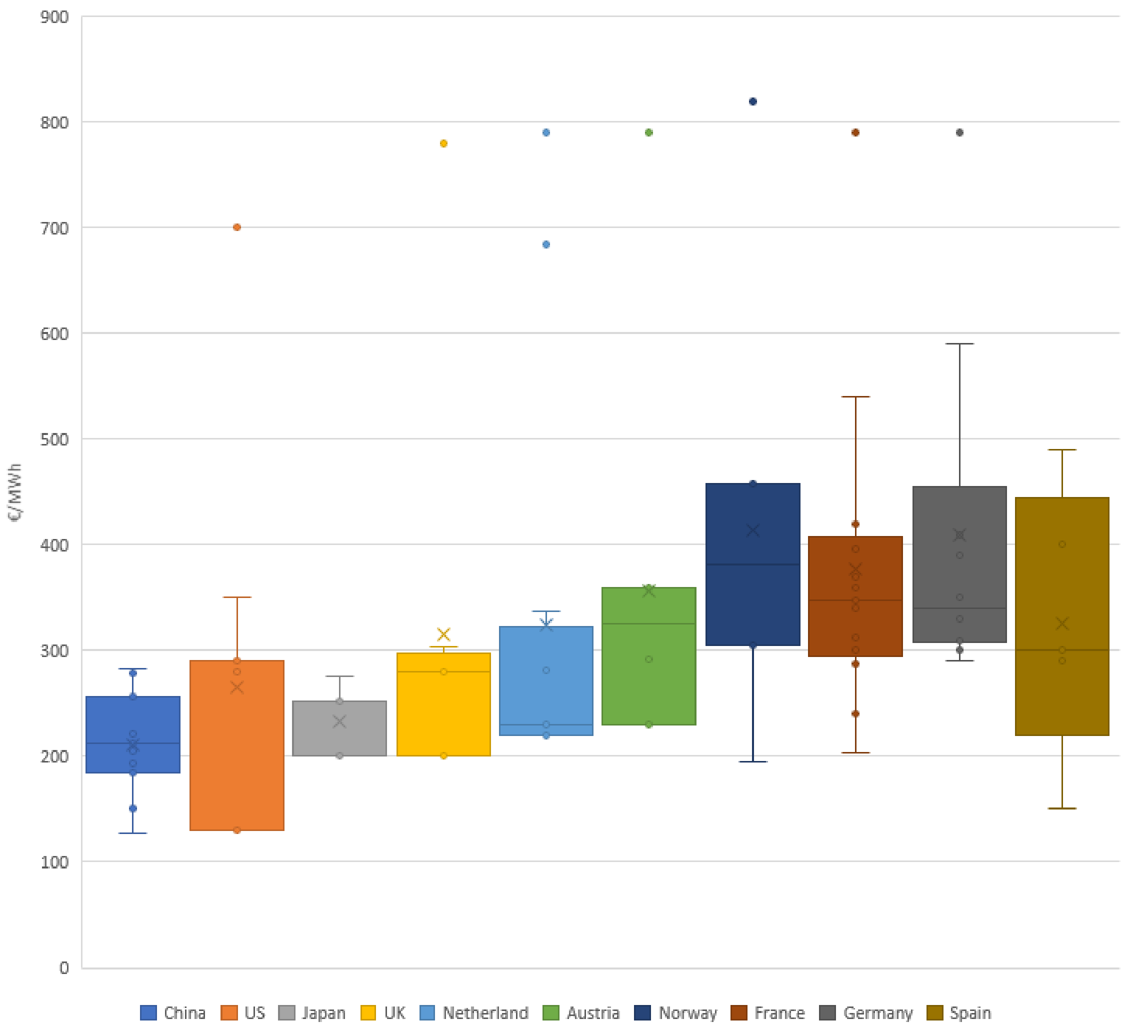
In our analysis, we identified only three countries (France, UK, Spain, but also California) where suppliers have dedicated tariffs for charging EVs, or refer to EVs in their offer without being a dedicated tariff.

Public charging stations

In order to understand trends in charging prices at public charging stations, we have focussed on countries where these are growing the fastest, and on the most representative type of charging method. In general, we found tariffs to vary according to charging capacity (which affects the speed of charge), type of batteries served, and whether the customer is part of a club (paying a membership to obtain discounted prices). Our analysis shows that, for the countries analysed, prices in general vary between 200 and 450 €/MWh, although the more expensive charging points can reach 800 €/MWh. Public charging is on average more expensive than charging at home (where prices vary between

100€/MWh and 300€/MWh), and the variation in prices between countries mirror to a large extent the variation in domestic prices. Besides the price for the electricity, EV owners have also to subscribe (with a fee) to be able to use the public charging stations. Research in the Netherlands showed that pricing is not transparent - EV owners often do not know the specific tariff applied of a public charging station. ACM (the Dutch market and consumer authority) will start an investigation about these transparency rules as more people are using these public charging stations.[57]

Figure 3-55 **Representative sample of EV public charging prices in €/MWh (Author's calculation based on several** sources (UK[58] , USA [59]China [60], The Netherlands [61], France[62], Austria [63] Norway[64], Japan[65], Germany[66])

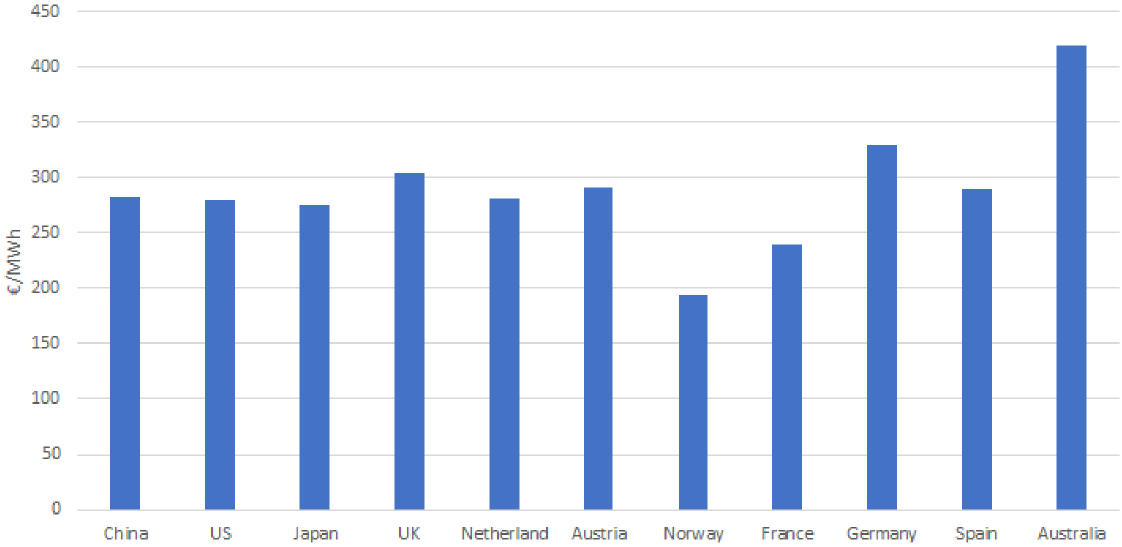


Note: the dots represent outliers in the distribution

[57] https://www.gaslicht.com/energiebesparing/kosten-opladen-elektrische-auto#:~:text=U%20betaalt%20enkel%20het%20stroomtarief,%E2%82%AC%200%2C60%20per%20kWh.
[58]https://www.drive-electric.co.uk/how-much-does-it-cost-to-charge-an-electric-car
[59] https://www.evgo.com/charging-plans/ , https://www.electrifyamerica.com/pricing and https://www.myev.com/research/ev-101/what-it-costs-to-charge-an-electric-vehicle
[60] https://blog.cometlabs.io/china-expands-ev-charging-to-satisfy-millions-of-evs-on-the-road-d6c977da9a31
[61] https://amsterdamhangout.com/how-to-charge-electric-car-in-the-netherlands/
[62] https://www.izivia.com/wp-content/uploads/2020/04/Prix-reseaux-borne-de-recharge-voiture-electrique-Pass-Izivia-France-Europe.pdf
[63] https://www.evn.at/Privatkunden/E-Mobilitat/E-Mobilitaet/Haufige-Fragen.aspx
[64]https://static1.squarespace.com/static/5beeb85155b02c87c213e1c6/t/5c6570eb971a187c66374a35/1550151945024/Fortum_EspenSkaar_OleGudbrannHempel_LearningsEmobilityMassMarket.pdf
[65] https://ev.gogo.gs/contents/1487399529 and https://www.nippon-juden.co.jp/tk/cd/
[66] https://www.electrive.com/2020/01/16/ionity-launches-new-pricing-structure-based-on-kwh/

Tesla, besides its EV cars, has developed and operates its own charging network, which includes fast and superfast charging points. Its network (available only to Tesla owners) currently counts around 16 000 charging points in 36 countries (at the end 2019), representing around 7-8% of the total Public fast charging points in 2018. Given that Tesla's network covers several countries with a fairly homogenous technical offer (charging stations with same technical specifications) it is possible to compare their prices to gauge how prices vary between countries. Figure 3-56 provides an overview of prices charged by Tesla in different countries.

Figure 3-56 EV fast and superfast **public charging prices in Tesla network (€/**MWh).



Source: Tesla, n.d.[67]

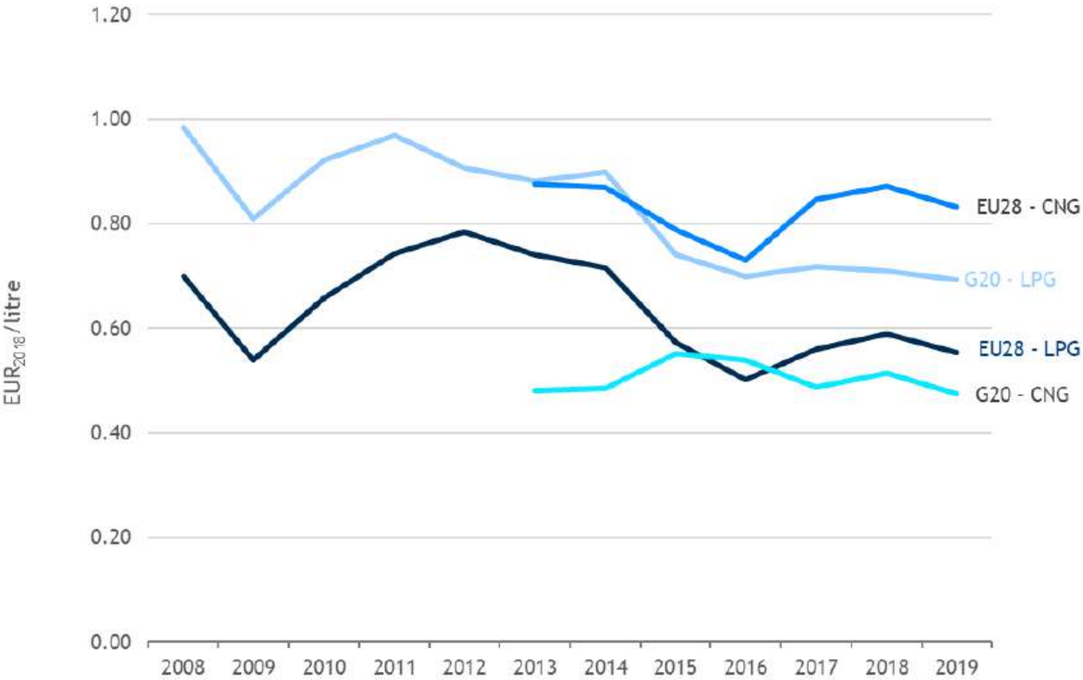
Summary of petroleum alternative fuels price analysis

Our analysis of alternative fuels (Biofuel, LPG, CNG and electricity) product prices in the EU and main trading partners in the G20, is summarised below and in Figure 3-57 for CNG and LPG, and the analysis as a whole found that:

- Average EU prices for CNG show that the EU has been significantly more expensive in general (50-75%) than the average for G20 countries;
- The situation is reversed for LPG prices, with the EU being always cheaper than the average G20 during the observed period. Both series peaked around 2011, then decreased and have remained relatively stable starting from 2016;
- Biofuel prices (biodiesel, ethanol) have shown decreasing and converging trends across the observed markets, excluding T2 FOB ethanol (Rotterdam barge) which affects EU prices;
- For Electric Vehicles the available price data suggests public charging prices of €150-€250/MWh in China, the United States and Japan. These prices are lower than those observed in Europe, with prices of €200-€350/MWh observed in the UK, Austria and Netherlands, and the highest prices of €250-€450/MWh observed in Norway, France, Germany and Spain. This points to a differential in pricing similar to that also observed for household retail electricity consumption, see section 3.2.1, with EU prices tending to be higher than other prices globally, it is unclear if the difference is also driven in part by higher taxes.

[67] https://www.tesla.com/support/supercharging?redirect=no

Figure 3-57 Comparison of EU28 weighted average prices with G20 (trade) weighted average prices



Source: Own calculations
Note: the G20 weighted averages are calculated on the basis of all available price data for a particular year, weighted in the total price by the share a country had in EU imports+exports 2017-2019

4 Task 2 - Analysis of energy costs for industry in the EU and EU major trading partners

4.1 Methodology and data

4.1.1 Objective and scope

The aim of this task is to assess energy costs for industry in the EU and its major trading partners. It comprises five sub-tasks:

- Subtask 2.1 Data collection from top-down approach;
- Subtask 2.2 Data collection from bottom-up approach;
- Subtask 2.3 Update of an existing database on energy costs and related EU energy intensive industries;
- Subtask 2.4 Assessment of impact of energy costs on the competitiveness of industrial sectors;
- Subtask 2.5 Development of communication materials.

The task was based on the approach adopted in the previous study: updating the information with the latest data and enlarging the analysis with a focus on energy intensive sectors, via a questionnaire (excel sheet) for the EU industry associations (bottom-up approach).

Scoping of countries

Throughout this task, data has been collected for three distinct sets of countries: the EU 27, non-EU G20 nations, and the EU trade partners (as defined by DG ENER) Norway, Switzerland, Iceland, and the United Kingdom. These trade partners were selected due to their proximity to the EU and due to their high levels of activity in the industrial sectors relevant to this task. As data on Iceland was not included in the previous study, it has been newly incorporated into the existing database.

Of all in-scope nations, the USA and China are the EU's primary trade partners according to 2018 figures. In-scope non-EU countries are ranked according to their total 2018 trade value in the table below. The UK is not included in this table because it was part of the EU until January 2020, but it should be noted that its trade value with other EU MS accounted for 486.7 billion EUR (a comparable share of ~11% of the EU27 extra-trade) in 2018; the UK will therefore be highlighted in our analysis as a top-three trading partner of the EU 27.

Table 4-1 EU-28 trade in goods by partner (2018)

Partner Extra EU-28	Region	Total Trade Value (bln EUR)	Share (%)
USA	G20	675.0	17%
China	G20	604.4	15%
Switzerland	Non-EU	265.5	7%
Russia	G20	253.4	6%
Turkey	G20	153.3	4%
Norway	Non-EU	137.7	4%
Japan	G20	134.7	3%
South Korea	G20	100.7	3%
India	G20	91.5	2%

Partner Extra EU-28	Region	Total Trade Value (bln EUR)	Share (%)
Canada	G20	72.4	2%
Mexico	G20	65.4	2%
Brazil	G20	65.3	2%
Saudi Arabia	G20	60.9	2%
South Africa	G20	48.2	1%
Australia	G20	47.6	1%
Indonesia	G20	26.185	1%
Argentina	G20	17.719	1%
Iceland	Non-EU	7.038	0.2%
Other partners	Non-EU	905.7	28%

Source: DG TRADE, 2019.[68]

Scoping of sectors and subsectors

The analysis in Task 2 focuses on industry sectors in the scope of the existing tool: a selection of 30 sectors at NACE 2 and NACE 3-digit level for section C (Manufacturing) and 13 sectors at NACE 1 or 2-digit level for the other sections (see Table 4-2). These sectors are in line with those analysed in the 2018 DG ENER study on energy prices and costs, which were selected based on their energy intensities, levels of trade exposure, and economic relevance.

Table 4-2 Sector scope of the analysis for Task 2.

Section (NACE 2)	Code (NACE 2 or 3)	Description
A - Agriculture, forestry and fishing	A	Agriculture, forestry and fishing
B - Mining and quarrying	B	Mining and quarrying
	B06	Extraction of crude petroleum and natural gas
	B07	Mining of metal ores
	B08	Other mining and quarrying
C - Manufacturing	C103	Processing and preserving of fruit and vegetables
	C106	Manufacture of grain mill products, starches and starch products
	C11	Manufacture of beverages
	C132	Weaving of textiles
	C161	Sawmilling and planning of wood
	C171	Manufacture of pulp, paper and paperboard
	C172	Manufacture of articles of paper and paperboard
	C192	Manufacture of refined petroleum products
	C201	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms
	C206	Manufacture of man-made fibres
	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations

[68] DG Trade Statistical Guide, July 2019 . Available at: https://trade.ec.europa.eu/doclib/docs/2013/may/tradoc_151348.pdf and Client and Supplier Countries of the EU28 in Merchandise Trade (value %)
(2018, excluding intra-EU trade). Available at: http://trade.ec.europa.eu/doclib/docs/2006/september/tradoc_122530.pdf

Section (NACE 2)	Code (NACE 2 or 3)	Description
	C222	Manufacture of plastics products
	C231	Manufacture of glass and glass products
	C232	Manufacture of refractory products
	C233	Manufacture of clay building materials
	C234	Manufacture of other porcelain and ceramic products
	C235	Manufacture of cement, lime and plaster
	C237	Cutting, shaping and finishing of stone
	C239	Manufacture of abrasive products and non-metallic mineral products n.e.c.
	C241	Manufacture of basic iron and steel and of ferro-alloys
	C244	Manufacture of basic precious and other non-ferrous metals
	C245	Casting of metals
	C25	Manufacture of fabricated metal products, except machinery and equipment
	C26	Manufacture of computer, electronic and optical products
	C27	Manufacture of electrical equipment
	C28	Manufacture of machinery and equipment n.e.c.
	C29	Manufacture of motor vehicles, trailers and semi-trailers
	C30	Manufacture of other transport equipment
	C32	Other manufacturing
	C33	Repair and installation of machinery and equipment
D - Electricity, gas, steam and air-conditioning supply	D35	Electricity, gas, steam and air conditioning supply
E - Water supply, sewerage, water management and remediation activities	E38	Waste collection, treatment and disposal activities; materials recovery
F - Construction	F	Construction
G - Wholesale and retail trade	G	Wholesale and retail trade
H - Transportation and storage	H49	Land transport and transport via pipelines
	H51	Air transport
I - Accommodation and food service activities	I	Accommodation and food service activities
J - Information and communication	J	Information and communication

Moreover, we pay particular attention to a limited number of EU energy intensive industry sectors with the highest energy costs shares and levels of international competitiveness pressure. To ensure a good representation of their costs, we focus on these energy intensive industry sectors in bottom-up data collection under subtask 2.2. The selected sectors are listed in Table 4-3 below (depending on the collaboration of the sector).

Table 4-3 Selected energy intensive subsectors for bottom-up data collection in subtask 2.2

Energy intensive sectors	Code (NACE 4-digit)	Description
C192 - Manufacture of refined petroleum products	C1920	Manufacture of refined petroleum products
C201- Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	C2015	Manufacture of fertilisers and nitrogen compounds
C231- Manufacture of glass and glass products	C2311	Manufacture of flat glass
C241- Manufacture of basic iron and steel and of ferro-alloys	C2410	Manufacture of basic iron and steel and of ferro-alloys
C244- Manufacture of basic precious and other non-ferrous materials	C2443	Lead, zinc and tin production
J Information and communication	J631	Data processing, hosting and related activities; web portals

Scoping of data and timeline (top-down approach)

In this task, our aim was to update the existing Excel database on industrial energy costs. Given Eurostat SBS data availability, we updated the main indicators with figures from 2008 until the latest available year (2017 for some indicators and countries, and 2018 for others) for the following sections of the database:

- Purchases of energy products in million EUR (€ m);
- Personnel costs in million EUR (€ m);
- Total purchases of goods and services in million EUR (€ m);
- Gross operating surplus in million EUR (€ m);
- Value added (at factor cost) in million EUR (€ m),
- Production value in million EUR (€ m);
- Energy consumption split by fuel: total, coal, oil, gas, electricity, other in million tons of oil equivalent[69] (Mtoe).

Using data collected in Task 1, we also updated the following indicators where possible across sectors:

- Energy prices (including all taxes and levies);
- Energy prices (excluding VAT and recoverable taxes for electricity and gas; excluding taxes for oil and coal[70]).

4.1.2 *Data gathering*

Top-down data collection

The available range of data in the model was expanded (where possible based on data availability) using public sources from 2008-2016 to 2008-2018. Where discrepancies between figures in public data sources and existing figures in the database were discovered, the database was updated to include the figures reported in public and private sources. Data on energy prices were incorporated into the updated version of the Task 2 model partly based on Task 1 input.

[69] By using the International Energy Agency conversion coefficients
[70] Since recoverable taxes are not a cost for the industry, prices used should exclude them. For oil and coal, prices excluding VAT are not available.

The following public sources and sources provided by the EC were processed and integrated into the tool, covering the corresponding countries and variables:

- Eurostat SBS provides data on Number of Companies, Turnover, Production Value, Value added, Gross Operating Surplus, Total Purchases of Goods and Services, Personnel Costs, and Purchases of Energy projects for EU countries, Norway, Switzerland, Iceland, Turkey and the United Kingdom;
- Eurostat Energy Balances provides data on Energy Consumption per fuel types in the transport sector for EU countries, Norway, Switzerland, Iceland, Turkey and the United Kingdom;
- Data received from the Confederation of European Paper Industries (CEPI) provides data on Energy Consumption per fuel types in the pulp and paper sector (NACE 3 level) of several EU Member States;
- IEA World Energy Balances provides data on Energy Consumption per fuel types across several non-EU G20 countries;
- Odyssee (by Enerdata) provides data on Energy Consumption per fuel types and on Value Added for several EU countries and Norway;
- **OECD's S**DBS database provides data on Number of Companies, Production Value, Value Added, Gross Operating Surplus, Total Purchases of Goods and Services, Personnel Costs, and Purchases of Energy Products for several EU and non-EU G20 countries;
- **IHS Markit's database** provides data on Turnover, Total Purchases of Goods and Services, Gross Operating Surplus, and Value Added for non-EU G20 countries, Norway, and Switzerland.

The following national databases were consulted and integrated into the tool, covering different variables:

- The US Bureau of Economic Analysis (BEA) provides data on Total Purchases of Goods and Services, Personnel Costs, and Purchases of Energy Projects for the United States;
- The Brazilian Institute of Geography and Statistics (IBGE) provides data on Turnover, Total Purchases of Goods and Services, and Value Added for Brazil;
- The UK Department for Business, Energy and Industrial Strategy (BEIS), Statistics Netherlands (CBS Statline), the Central Statistical Bureau of Latvia (CSB Latvia), the Federal Statistical Office of Germany (DESTATIS), the US Energy Information Administration (EIA), the Mexican National Institute of Statistics and Geography (INEGI), the National Bureau of Statistics of China (NBS), Statistics Canada (STATCAN), Statistics Finland and Statistics Norway provide data on Energy Consumption per fuel types.

Detailed tables on data imported per sector, as well as remaining data gaps carried over from the previous version of the tool, are included in Annex C.

Bottom-up data collection

A bottom-up approach (subtask 2.2) was also developed that allows for a deeper dive into a specific set of sectors in order to be able to deal with the aspect of heterogeneity of certain sectors that is encountered based upon a top-down approach on NACE 2 or 3 level. The purpose of this approach is not to provide exhaustive and complete coverage of all different sectors and subsectors nor to duplicate the work conducted in analysis of top-down data (subtask 2.1), but rather to provide some quantitative as well as qualitative indicators that allow for a better understanding of the data collected in subtask 2.1 and a better assessment of the impact of energy costs on the competitiveness of industrial sectors in subtask 2.3.

We contacted European industry associations and invited them to provide information related to energy and production costs at company/plant level via questionnaire. We discussed the draft questionnaire bilaterally with the industry associations to perform a quality analysis of the content and completeness of the questionnaire. The industry associations that we contacted and who provided responses to our questionnaire are listed in the table below.

Table 4-4 EU Industry associations invited to fill in the questionnaire

Energy intensive sector	EU Industry association invited to participate
Manufacture of refined petroleum products	• Fuels Europe - European Petroleum Refining Association • CONCAWE
Chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	• Fertilizers Europe - major fertilizer manufacturers in Europe
Manufacture of basic iron and steel and of ferro-alloys	• EUROALLIAGES - Association of European ferro-alloys and silicon producers
Manufacture of basic precious and other non-ferrous metals	• EUROMETAUX - European non-ferrous metals association • International Zinc Association
Manufacture of flat glass	• Glass for Europe

Note: Industry associations for paper, cement, glass (other than flat glass), ceramics, refractories, steel, nickel and Data Centres were also contacted, but their members did not participate in filling the questionnaire due to constrains caused by timing and personnel constrains due to COVID-19 situation. Initially, the members of aluminium and chemical and copper sectors agreed to participate, but due to the low number of questionnaires received these sectors could not be included in the analysis.

Trinomics provided confidentiality agreements to all participants and will respect the utmost compliance to confidentially of any received information. We have received the filled in the questionnaires for the sectors listed in the table above and have completed analysis of responses received, detailed in Annex D. We are still in the process of iterating with individual plants and asking them clarifications about outliers, in order to ensure the correct filling of the questionnaires and interpretation of the obtained data.

To ensure the confidentiality of the respondents, we provide a regional analysis only in the cases where we have received at least three plants from three different companies per region, grouping the country as follows:

- North Western Europe (NWE) - Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden;
- Central Eastern Europe (CEE) - Lithuania, Romania, Bulgaria, Czech Republic, Hungary, Estonia, Latvia, Slovakia and Poland;
- Southern Europe (SE) - Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, and Spain.

Similar to the confidentiality measures for EU plants, for data received on non-EU countries (UK and Norway), averages per country is provided only if there is data from at least three different plants from three different companies. This is to ensure the confidentiality of the respondents.

We complement the results from analysing the questionnaires with data at NACE 4-digit level collected from publicly available sources (Eurostat SBS, PRODCOM and COMEXT), and desk research on the selected energy intensive sectors. Sector-specific secondary sources of information used in the description of the sectors and of their processes include:

- Web sites of the respective industry associations;
- Previous report by CEPS and Ecofys71;
- Competitiveness reports produced for DG ENTR (now GROW)72 that detail the stages of the production processes;

Draft findings were shared with the energy intensive sectors with their respective Industry Association so they could validate the results, and if necessary, provide additional insights. After these, wefinalised the overview on energy intensive subsectors. The key results of this bottom up exercise were summarised in this report; the complete overview of theresults per energy intensive subsector are included in Annex D.

4.1.3 Data gap management

The analysis of energy costs, gross operating surpluses, energy intensities, energy carriers, and energy prices in the Task 2 model relies on the methodologies developed in the 2018 Energy Prices and Costs study. In updating the model to account for new data, several detailed formulae were altered to simplify computations and reduce processing times, but all principal calculations have been updated only to account for new data.

Additionally, the structure of calculations has been altered to account for the fact that the UK is no longer a Member State of the European Union; i.e., the “EU28” throughout the model has been re-labelled the “EU27”, and the UK has been labelled a “non-EU G20” country. Calculations also account for the inclusion of data on Iceland in the model for the first time.

Key analytical steps are described per topic subsequently, along with details on methodologies to manage data gaps to ensure completeness of analyses.

Energy costs

Energy costs are assessed in total, as shares of industrial production costs, and as shares of industrial production values. Data collected on *Purchases of energy products in value* serves as a proxy for *tal energy costs* . These data are widely available across EU countries, accessible via Eurostat SBS. For non-EU G20 countries, variables relevant to cost calculations have been collected from international and national sources where possible.

Where data could not be collected, estimations on energy costs are made (where possible). As in the first iteration of this study, where energy costs (purchases of energy) data are not available but energy consumption and price data are available, energy costs (purchases of energy) are calculated as energy consumption multiplied by prices.

[71] CEPS and Ecofys, 2018, “Composition and Drivers of Energy Prices and Costs: Case Studies in Selected Energy Intensive Industries, Final Report Annex A - Sectoral analyses”
[72] Ecorys, 2018, “Competitiveness of the European Cement and Lime Sectors - Final report”
Ecorys, 2008, “FWC Sector Competitiveness Studies - Competitiveness of the Ceramics Sector”
Oxford Economics, 2014, “Evolution of competitiveness in the European chemical industry: historical trends and future prospects” (for Cefic)
Ecorys, 2008, “FWC Sector Competitiveness Studies - Competitiveness of the Glass Sector”
CEPS, 2014, “Final report for a study on composition and drivers of energy prices and costs in energy-intensive industries: the case of the flat glass industry”
Ecorys, 2008, “Competitiveness of the EU Non-ferrous Metals Industries FWC Sector Competitiveness Studies - Final Report”

Energy prices

Energy prices were imported into the new dataset using the data so far collected for Task 1, as well as supplementary Eurostat datasets. In the case of missing energy prices data, energy prices for each sector are estimated based on:

- The prices per type of consumer;
- An estimation of the average electricity and gas consumption for a typical consumer.

The estimation of the average electricity and gas consumption for a typical consumer is calculated as the ratio of the average energy consumption of a sector in the country and the average number of companies with more than 20 employees in a sector in that country. Then, based on the resulting average consumption for a typical consumer the sector is allocated to one of the consumption bands from Eurostat.[73] This is in line with the methodology from the previous iteration of the study.

Energy consumption

Energy consumption data for in-scope NACE sectors is generally limited for both EU27 and international countries. In an effort to cover as many sectors as possible in spite of limited data availability, the Member States used to calculate average EU energy intensities per sector were not always the same year-to-year.

Energy consumption data is even more limited for G20 countries than for EU countries. The bottom-up data collection (Subtask 2.2) described in the subsequent section has prioritised the collection of energy consumption data to address data gaps in sectors with particularly high energy intensities: C171 - Pulp and paper, C192 - Refineries, C201 - Basic chemicals, C235 -Cement, lime and plaster, C241 - Iron and steel, C244 - Non-ferrous metals, and C231 - Glass. Following this analysis, where data gaps remain unaddressed, energy consumption figures were estimated as energy costs divided by prices, where energy costs and price data were available.

Data on energy consumption per fuel type is limited - especially granular data on energy consumption per fuel type per sector. Bottom-up data collection has focused on filling identified gaps, but where gaps remained and where possible, figures on energy consumption per fuel type were estimated by dividing energy costs by energy prices. This estimation depended on data availability of energy costs per fuel type and energy prices per fuel type across the different sectors.

4.2 Analysis of energy costs for industry

This section presents analysis on energy costs, the drivers of energy costs, and profitability for manufacturing and non-manufacturing industries.

4.2.1 Analysis of energy costs as a share of total production costs and value for EU industry and local competitors

To gauge the impact of energy costs on the competitiveness of EU industries, energy costs are analysed with respect to total operational production costs and to total production values. Calculations on energy costs rely on three variables: Data collected on $Purchases\ of\ energy\ products\ in\ value$ serves as a proxy for $Total\ energy\ costs$, while:

73 Reference Metadata in Euro SDMX Metadata Structure (ESMS) for data series nrg_pc_202 and nrg_pc_204.

$$Energy\ costs\ as\ a\ share\ of\ total\ production\ costs = \frac{Purchases\ of\ energy\ products\ in\ value}{Personnel\ costs + \ Purchases\ of\ good\ and\ services}$$

and,

$$Energy\ costs\ as\ a\ share\ of\ total\ production\ value = \frac{Purchases\ of\ energy\ products\ in\ value}{Production\ value}$$

According to Eurostat, Purchases of goods and services include the value of all goods and services purchased during the accounting period for resale or consumption in the production process, including purchases of energy products but excluding capital goods (the consumption of which is registered as consumption of fixed capital).

Personnel costs are defined as the total remuneration, in cash or in kind, payable by an employer to an employee (regular and temporary employees as well as home workers) in return for work done by the latter during the reference period. Personnel costs are made up of wages and salaries and employers' social security costs, which include taxes and employees' social security contributions retained by the unit as well as the employer's compulsory and voluntary social contributions.

Table 4-5 summarises energy cost shares over time for all the sectors of the study. The table presents the changes over the period 2010-2017, 2010-2013, 2013-2017, as well as the average rate, and the maximum and minimum levels reached, to show the variability of cost shares over years.

Table 4-5 Evolution of energy costs as shares of total production costs for all sectors studied, averaged across the EU27

Sectors C	2010	2011	2012	2013	2014	2015	2016	2017	Absolute change 2010-2013	Absolute change 2014-2017	Absolute change 2010-2017	Relative change 2010-2017	Average	Max. level
C103 - Fruit and vegetables	2.9%	2.9%	3.1%	2.9%	3.0%	2.5%	2.5%	2.3%	0.0%	-0.7%	-0.6%	-21.9%	2.8%	3.1%
C106 - Grain products	3.7%	3.4%	3.6%	3.4%	3.6%	3.3%	2.8%	2.6%	-0.4%	-1.0%	-1.1%	-30.5%	3.3%	3.7%
C132 - Textiles	3.7%	2.5%	2.7%	2.3%	2.2%	2.0%	2.1%	2.2%	-1.3%	0.0%	-1.5%	-40.4%	2.5%	3.7%
C161 - Sawmills	3.5%	4.0%	3.6%	3.5%	3.4%	3.1%	3.2%	3.1%	0.0%	-0.4%	-0.4%	-12.7%	3.4%	4.0%
C171 - Pulp and paper	11.4%	11.3%	10.7%	9.8%	9.0%	8.4%	6.9%	6.7%	-1.6%	-2.3%	-4.7%	-40.9%	9.3%	11.4%
C172 - Articles of paper	3.0%	2.7%	2.8%	2.9%	2.5%	2.4%	2.1%	2.1%	-0.1%	-0.4%	-0.9%	-29.3%	2.6%	3.0%
C192 - Refineries	2.2%	2.0%	2.2%	2.1%	2.0%	2.3%	1.8%	1.6%	0.0%	-0.5%	-0.6%	-28.0%	2.0%	2.3%
C201 - Basic chemicals	6.8%	7.1%	6.4%	6.4%	5.8%	5.5%	5.0%	4.6%	-0.4%	-1.2%	-2.2%	-32.7%	5.9%	7.1%
C206 - Man-made fibres	6.8%	6.8%	5.9%	8.5%	6.4%	6.2%	7.2%	5.3%	1.7%	-1.2%	-1.5%	-22.2%	6.6%	8.5%
C222 - Plastics products	2.9%	2.9%	2.7%	2.9%	2.7%	2.5%	2.3%	2.2%	0.0%	-0.5%	-0.7%	-23.1%	2.6%	2.9%
C231 - Glass	8.4%	8.4%	9.7%	9.5%	8.6%	8.0%	6.8%	6.6%	1.1%	-2.0%	-1.8%	-21.7%	8.2%	9.7%
C232 - Refractory products	6.5%	6.3%	7.0%	7.2%	6.3%	6.5%	6.8%	5.3%	0.7%	-1.0%	-1.2%	-18.6%	6.5%	7.2%
C233 - Clay building materials	12.1%	11.0%	12.4%	12.4%	11.2%	11.1%	9.6%	9.0%	0.3%	-2.2%	-3.0%	-25.1%	11.1%	12.4%
C234 - Porcelain and ceramics	5.2%	5.4%	5.6%	5.7%	5.3%	4.5%	4.4%	4.0%	0.5%	-1.3%	-1.2%	-22.6%	5.0%	5.7%
C235 - Cement, lime and plaster	20.3%	21.2%	19.1%	19.3%	18.6%	17.6%	15.4%	15.2%	-1.0%	-3.4%	-5.1%	-25.3%	18.3%	21.2%
C237 - Stone	3.5%	3.6%	2.9%	4.6%	3.1%	3.4%	2.6%	3.3%	1.1%	0.1%	-0.2%	-5.7%	3.4%	4.6%
C239 - Abrasive products	5.0%	4.8%	5.1%	5.2%	5.0%	5.0%	5.0%	4.6%	0.2%	-0.4%	-0.4%	-7.3%	5.0%	5.2%
C241 - Iron and steel	9.5%	7.5%	8.2%	8.2%	7.0%	7.5%	7.2%	6.6%	-1.3%	-0.4%	-2.9%	-30.8%	7.7%	9.5%
C244 - Non-ferrous metals	4.1%	4.0%	3.9%	4.1%	3.8%	3.8%	3.1%	3.1%	0.0%	-0.7%	-1.0%	-23.5%	3.7%	4.1%
C245 - Casting of metal	6.1%	5.3%	5.5%	5.5%	5.3%	4.9%	4.8%	4.6%	-0.6%	-0.7%	-1.5%	-24.4%	5.2%	6.1%
C11 - Beverages	2.6%	2.7%	2.7%	2.6%	2.6%	2.4%	2.2%	2.2%	0.0%	-0.4%	-0.4%	-15.8%	2.5%	2.7%
C21 - Pharmaceutical products	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%	1.0%	1.0%	0.0%	-0.2%	-0.2%	-18.6%	1.1%	1.2%
C25 - Fabricated metal products	2.3%	1.9%	2.0%	2.1%	2.0%	1.9%	1.8%	1.7%	-0.2%	-0.3%	-0.6%	-24.9%	1.9%	2.3%
C26 - Computer and electronics	0.7%	0.7%	0.7%	0.8%	0.7%	0.7%	0.7%	0.6%	0.1%	-0.1%	0.0%	-0.5%	0.7%	0.8%
C27 - Electrical equipment	1.0%	1.0%	1.0%	1.0%	1.1%	0.8%	0.8%	0.7%	-0.1%	-0.3%	-0.3%	-27.7%	0.9%	1.1%

Source: Study on energy prices, costs and their impact on industry and households

Sectors C	2010	2011	2012	2013	2014	2015	2016	2017	Absolute change 2010-2013	Absolute change 2014-2017	Absolute change 2010-2017	Relative change 2010-2017	Average	Max. level
C28 - Machinery and equipment	1.0%	0.9%	0.9%	0.9%	0.9%	0.8%	0.8%	0.7%	0.0%	-0.2%	-0.2%	-24.0%	0.9%	1.0%
C29 - Motor vehicles	0.8%	0.8%	0.8%	0.8%	0.7%	0.7%	0.6%	0.6%	0.0%	-0.1%	-0.3%	-31.0%	0.7%	0.8%
C30 - Other transport equipment	0.9%	0.9%	0.9%	0.9%	0.7%	0.8%	0.6%	0.5%	0.0%	-0.2%	-0.3%	-38.8%	0.8%	0.9%
C32 - Other manufacturing	1.1%	1.1%	1.0%	1.0%	1.0%	0.9%	0.9%	0.8%	-0.1%	-0.2%	-0.3%	-29.5%	1.0%	1.1%
C33 - Repair of machinery	1.0%	1.1%	1.1%	1.1%	1.1%	0.9%	0.8%	0.8%	0.1%	-0.2%	-0.2%	-18.4%	1.0%	1.1%
Other sectors														
B - Mining and quarrying	2.9%	2.8%	2.8%	2.9%	2.9%	3.0%	3.1%	5.1%	0.0%	2.2%	2.2%	76.2%	3.2%	5.1%
B06 - Oil and gas	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.9%	0.0%	0.6%	0.7%	380.6%	0.3%	0.9%
B07 - Mining of metal ores	19.7%	20.8%	19.6%	19.4%	17.7%	18.4%	16.7%	17.1%	-0.3%	-0.7%	-2.7%	-13.5%	18.7%	20.8%
B08 - Other mining	8.6%	9.6%	9.6%	9.7%	9.2%	8.9%	8.0%	8.7%	1.1%	-0.5%	0.1%	1.6%	9.0%	9.7%
D35 - Electricity, gas and steam	16.2%	15.8%	14.0%	12.7%	11.9%	11.9%	14.5%	13.0%	-3.5%	1.1%	-3.2%	-19.7%	13.7%	16.2%
E38 - Waste management	2.0%	1.9%	2.0%	2.3%	2.3%	2.0%	1.7%	1.7%	0.3%	-0.6%	-0.3%	-15.5%	2.0%	2.3%
F - Construction	1.2%	1.3%	1.2%	1.2%	1.2%	1.1%	1.1%	1.0%	0.1%	-0.2%	-0.2%	-18.0%	1.2%	1.3%
G - Wholesale and retail trade	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.4%	0.4%	0.0%	0.0%	-0.1%	-14.2%	0.4%	0.4%
H49 - Land transport	30.1%	36.3%	33.3%	31.4%	29.3%	24.8%	27.9%	26.7%	1.3%	-2.6%	-3.4%	-11.3%	30.0%	36.3%
H51 - Air transport	16.6%	18.7%	19.0%	16.3%	17.0%	15.3%	19.8%	18.6%	-0.4%	1.6%	2.0%	12.1%	17.7%	19.8%
I - Accommodation and restaurants	4.7%	4.3%	4.3%	4.2%	3.7%	3.4%	3.5%	3.3%	-0.5%	-0.4%	-1.4%	-29.6%	3.9%	4.7%
J - Information and communication	1.2%	1.0%	1.0%	0.9%	0.9%	0.8%	0.9%	0.9%	-0.3%	0.0%	-0.4%	-29.7%	0.9%	1.2%

In addition, Table 4-6 groups the sectors studied based on the observed changes in energy and production in absolute terms (i.e. in million €) between 2010 and 2017. This analysis shows that the majority of the sectors experienced reduced energy costs in parallel to increased production costs during the studied period.

The full tables with details on the historic energy and production costs in absolute terms can be found in Annex C accompanying this report.

Table 4-6 Categorisation matrix of absolute changes in energy and production costs for all sectors studied

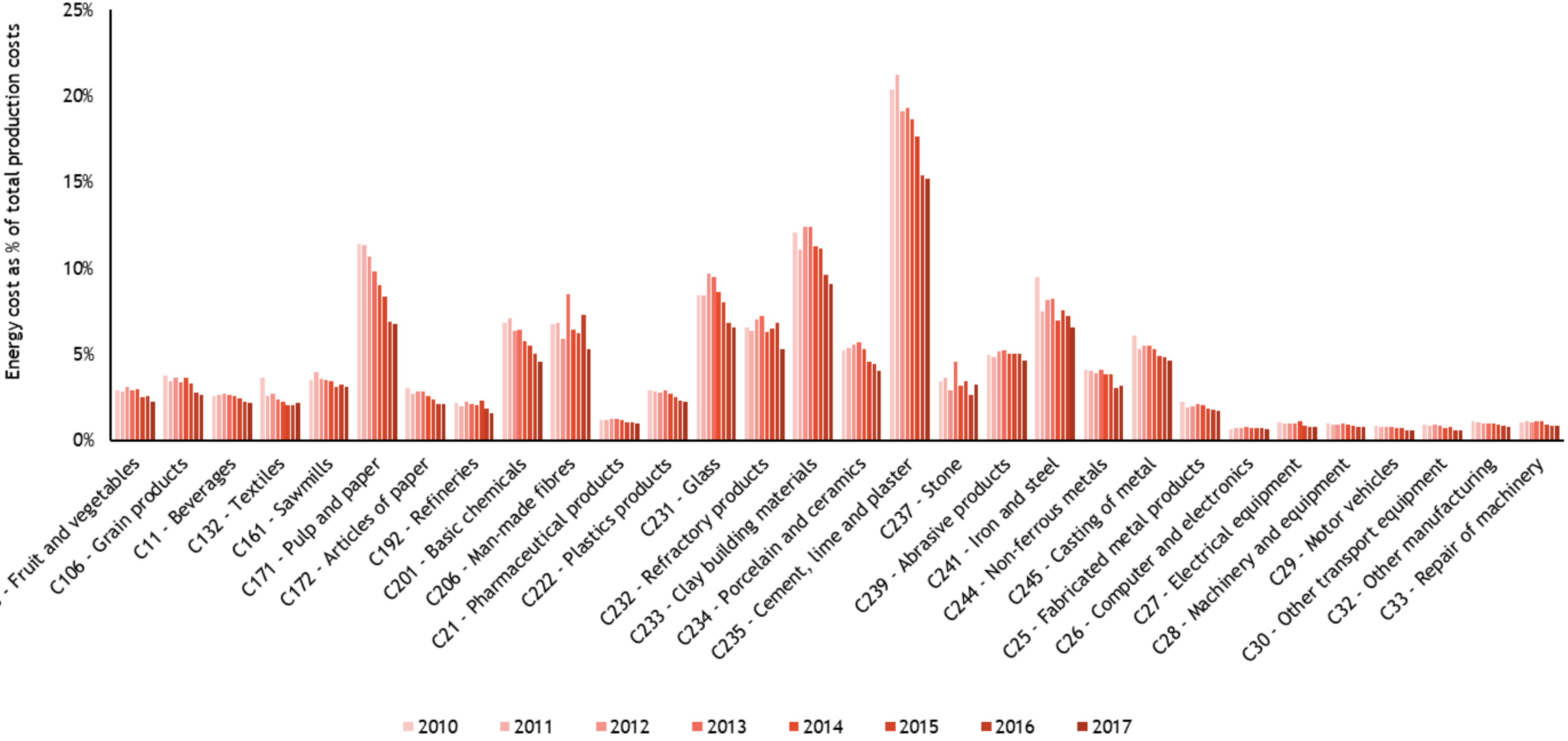
	Reduced energy costs 2010-2017	Increased energy costs 2010-2017
Reduced production costs 2010-2017	• C26 - Computer and electronics • C232 - Refractory products • C235 - Cement, lime and plaster • C237 - Stone • C192 - Refineries • C132 - Textiles • B - Mining and quarrying • B08 - Other mining	• B06 - Oil and gas • B07 - Mining of metal ores
Increased production costs 2010-2017	• C33 - Repair of machinery • C244 - Non-ferrous metals • C222 - Plastics products • C11 - Beverages • C21 - Pharmaceutical products • C32 - Other manufacturing • C106 - Grain products • C25 - Fabricated metal products • C245 - Casting of metal • C234 - Porcelain and ceramics • C27 - Electrical equipment • C30 - Other transport equipment • C201 - Basic chemicals • C231 - Glass • C206 - Man-made fibres • C172 - Articles of paper • C233 - Clay building materials • C241 - Iron and steel • C171 - Pulp and paper • D35 - Electricity, gas and steam • I - Accommodation and restaurants • E38 - Waste management	• C29 - Motor vehicles • C239 - Abrasive products • C103 - Fruit and vegetables • C28 - Machinery and equipment • C161 - Sawmills • H49 - Land transport • H51 - Air transport • G - Wholesale and retail trade • F - Construction

The results of the analysis of energy costs as a share of production costs for manufacturing sectors in the EU are depicted in Figure 4-1, which illustrates energy costs as a share of total production costs for subsectors C from 2008 to 2017. The figures show that:

- In the period 2008-2017, energy costs for the selected manufacturing sectors typically constituted between 1-10% of total (operational) production costs, although for several sectors the costs exceeded 10% (e.g. Cement, lime and plaster, and Clay building materials);
- Energy costs for several sectors exceeded 9% of their total production costs in at least one year. These energy intensive sectors - including Pulp and Paper, Glass, Clay building materials, Cement, lime and plaster, and Iron and steel - are most sensitive to energy prices, and cost changes and differentials;
- Among less energy intensive manufacturing sectors, energy costs typically constitute only 1-3% of operational (production) costs and are therefore a relatively minor cost component for most businesses in these sectors. In several manufacturing sectors - including Computer and electronics, Machinery and Equipment, Motor Vehicles, and Other Transport Equipment - energy costs do not exceed 1% of production costs;
- Over the period 2010-2017, energy cost shares fell in every sector. The largest percentage point decline in cost share can be observed in the Pulp and Paper sector, in which costs fell from a 11.4% share in 2010 to a 6.7% share in 2017;
- Other energy intensive industries including Iron and Steel, Cement, Lime and Plaster, and Clay Building Materials, experienced declining energy cost shares as well during the same time period;
- Some of the other sectors with smaller percentage point declines still saw proportionally high decreases in their energy cost share ratios, such as Non-ferrous metals, Basic Chemicals, and Plastics Products;
- Energy cost shares have fallen across all sectors not only over the full period covered, but more steeply in recent years, where declining energy costs between 2013-2017 made up for slightly increasing energy cost shares between 2010-2013 in the stone, man-made fibres, computer and electronics, and glass sectors.

The results of this analysis for non-manufacturing sectors are depicted in Figure 4-2. Energy cost shares are particularly high in five sectors, at levels comparable to or even higher than the cost shares of energy intensive manufacturing sectors. These sectors include Land transport (30%), Air transport (18%), Mining of metal ores (19%), Electricity, gas and steam (11%), and Other mining (9%). Fuel costs are clearly important drivers of production costs in the transport, electricity and gas sectors, and mining is an inherently energy intensive activity. It is also notable that energy cost shares for Accommodation and Restaurants are between 3-5%, levels comparable to many energy-intensive manufacturing sectors. Energy cost shares are lower for the Construction and Wholesale and Retail trade sectors.

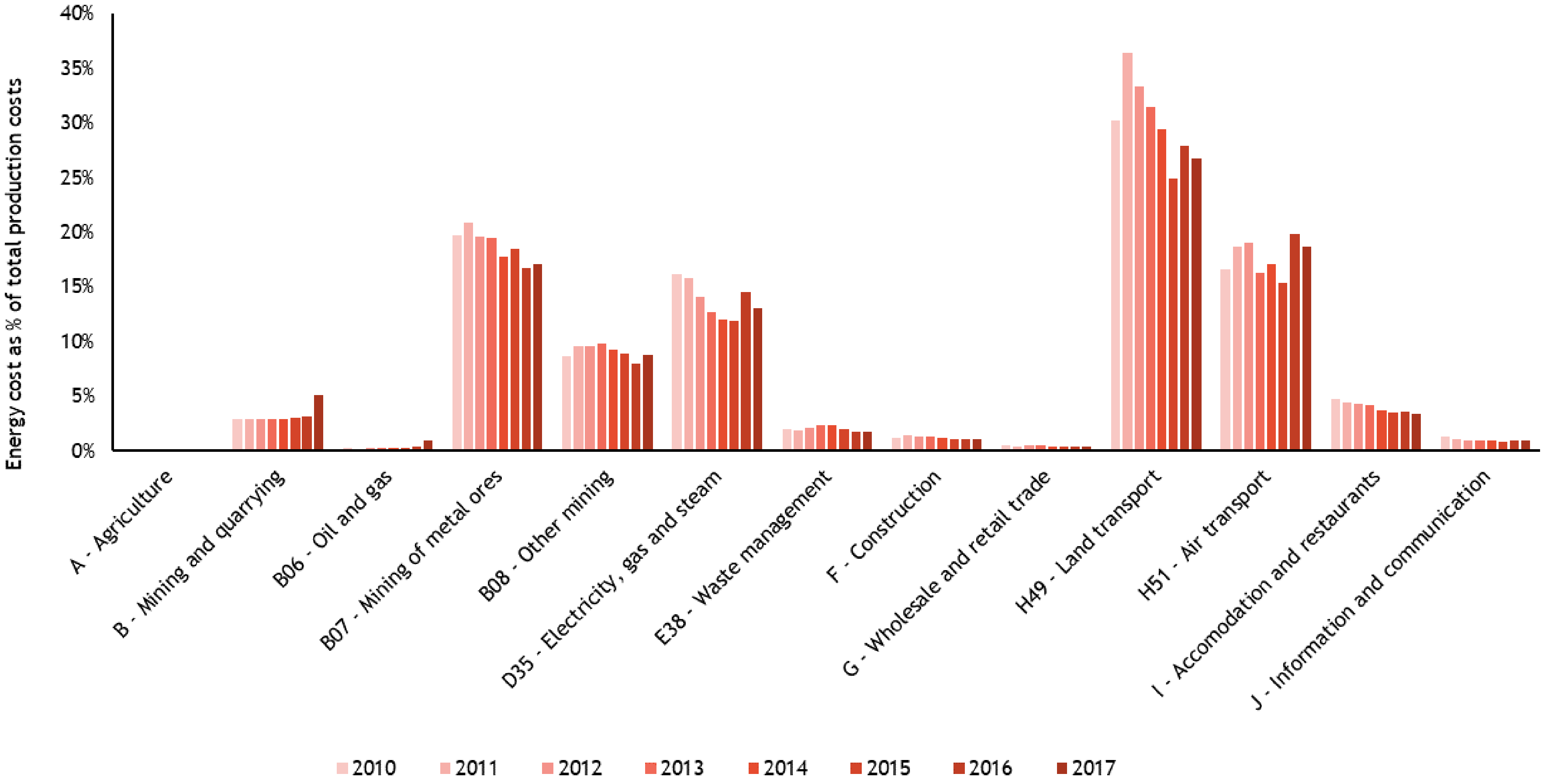
Figure 4-1 Average energy costs (as shares of production costs) for manufacturing sectors, averaged across the EU27



Source: Own calculations based on data from Eurostat SBS

Source: Study on energy prices, costs and their impact on industry and households

Figure 4-2 Average energy costs (as shares of production costs) for non-manufacturing sectors, averaged across the EU27



Source: Own calculations based on data from Eurostat SBS

Box 4-1 Analysis of energy costs for non-manufacturing sector J631 Data processing, hosting and related activities; web portals (Data Centres).

Data centres consist of a very large number of server computers concentrated in one location, that provide on-line services over the Internet, with a high availability and reliability which are part of the contract offered to the customer. This concentration enables the sharing of a common infrastructure, such as electric power supply, cooling, high-bandwidth Internet access, security, redundancy, data storage. The servers themselves often are custom-designed and manufactured for the operator of the data centre, to achieve high performance and low energy consumption. The main energy consuming units are[74]:

- the servers, which contain the central processor (CPU) and the memory (RAM): 41.3% of total energy consumption of the sector in the EU27 in 2018 (in an upward trend since 2010, when they represented only 33.7% of the total);
- the cooling, which prevents the damaging of the servers by evacuating their excess heat: 28.9% of total energy consumption of the sector in the EU in 2018 (in an downward trend since 2010, when they represented only 32.8% of the total);
- the uninterrupted power supply - UPS - which ensure that the servers are permanently fed with electric power, including in case of micro-interruptions of the network supply: 11.3% of total energy consumption of the sector in the EU in 2018 (in a slow downward trend since 2010, when they represented only 15.0% of the total);
- the data storage (generally as hard disk drives): 12% of total energy consumption of the sector in the EU (constant over time);
- the connection to the network: 3.7% of total energy consumption of the sector in the EU (constant over time).

The evolution over time shows an increased technical efficiency of data centres, whereby a growing fraction of the energy consumption is used by the productive units (the servers, the storage and the communication network), and a decreasing part by the ancillary services that address the inefficiencies of the system, namely overheating and power interruptions (respectively: the cooling system and the UPS).

Electricity costs of the sector of Data Centres in the EU27 has been rising sharply over the years 2010 - 2015 (from 3,600 M€ in 2010 to 5,020 M€ in 2015), and has remained stable over the years 2015 to 2018. This evolution is essentially related to the evolution of the prices for electricity for large industrial users, which followed the same pattern. Electricity costs in the UK display similar evolutions.
The estimated electricity costs represent a significant share of the overall production costs of the EU27 sector of data centres, comparable to that of the other energy-intensive industries: between 10.8 and 14.7% over the years 2010 - 2017. They also represent a small, but significant fraction of the production value of the sector: between 9.1 and 12.0%. These fractions have reached their peak in 2014 and decreased between then and 2018. The details of electricity costs and electricity costs as a share of production costs per Member State are presented in Section 11.1 Data centres of Annex D.

Figure 4-3Error! Reference source not found. depicts energy costs as a share of production costs for manufacturing sectors in the EU27 compared to those in its trade partners. Data could only be depicted for trade partners where figures on purchases of energy products, personnel costs and total purchases of goods and services were publicly available. Data gaps were addressed where possible by estimating purchases of energy products as:

$$Purchases\ of\ energy\ products\ \approx\ \sum_{Over\ all\ fuel\ types} Energy\ consumption_{Fuel\ type} \times Price_{Fuel\ type}.$$

[74] Source: Montevecchi, F., Stickler, T., Hintemann, R., Hinterholzer, S. (upcoming). Energy-efficient Cloud Computing Technologies and Policies for an Eco-friendly Cloud Market—SMART 2018/0028. carried out for the European Commission by Environment Austria and Borderstep Institute. The study will be published in November 2020.

Of the EU's top trade partners, sufficient data for calculations was publicly available for most sectors in:

- The United Kingdom;
- Norway;
- Turkey;
- The United States;
- Mexico;
- Japan;
- Korea.

Data on purchases of energy products, personnel costs, and total purchases of goods and services in manufacturing sectors was not publicly available for:

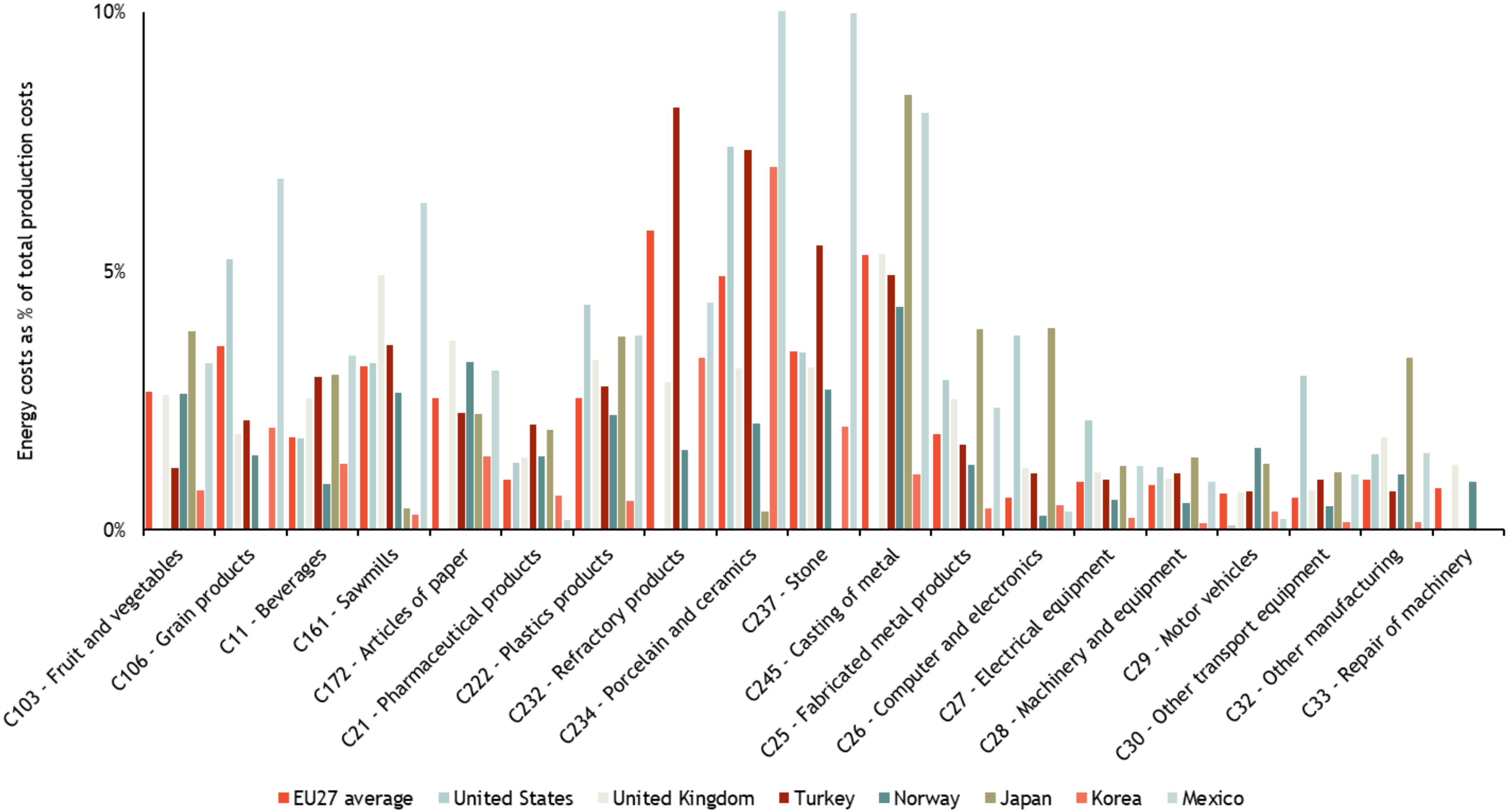
- China;
- Russia;
- Switzerland (where in the Eurostat database, reported values are "N/A").

Values for purchases of energy products were estimated for China and Russia based on reported energy consumption and energy price figures, as described above. However, as figures on total purchases of goods and services per sector in these countries were not accessible, energy cost shares could not be calculated for the comparison. These countries are included in the international comparisons of energy intensity and sector profitability, included in sections 4.2.2 and 4.2.3.

Trends in energy cost shares internationally vary per sector. Notably, across energy intensive subsectors:

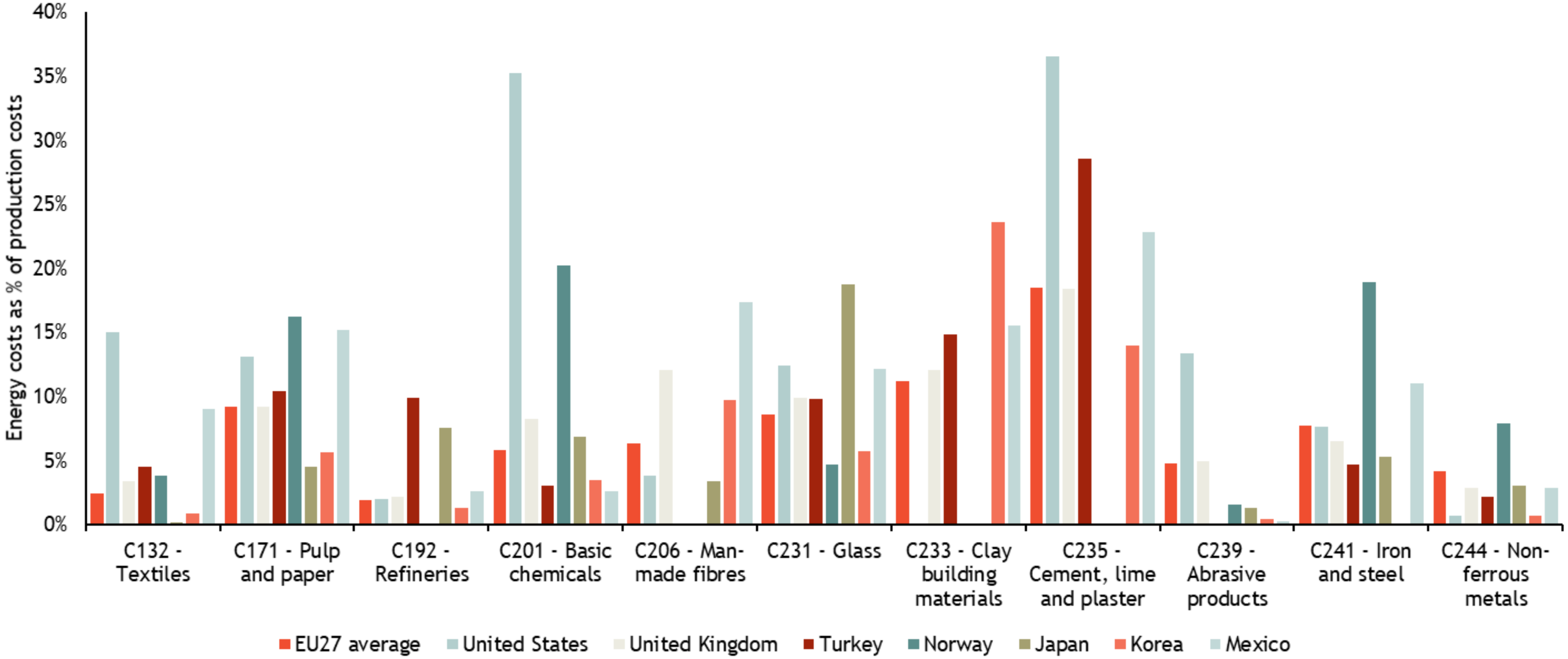
- Norway has the highest energy cost shares in the Pulp and paper (C171) and Non-ferrous metals (C244) sectors in spite of lower electricity and natural gas prices than the EU's, due to their relatively higher energy consumption;
- Turkey has the highest energy cost share in the Refineries (C192) sector, followed by Japan;
- Japan has the highest energy cost share in the Glass (C231) sector;
- The United States has the highest energy cost shares in the Basic chemicals (C201) and Cement, lime and plaster (C235) sectors;
- On average, the EU27 has energy cost shares comparable to those of most international trade partners;
- The EU27 has a relatively high energy cost share in Iron and steel (C241) and Non-ferrous metals (C244);
- The EU27 has a relatively low energy cost share in Refineries (C192).

Figure 4-3 Average energy costs (as shares of production costs) for less energy-intensive manufacturing sectors in the EU 27 and immediate trade partners



Source: Eurostat SBS, National data sources, IHS database, OECD SISS database

Figure 4-4 Average energy costs (as shares of production costs) for more energy-intensive manufacturing sectors in the EU 27 and immediate trade partners



Source: Eurostat SBS, National data sources, IHS database, OECD SISS database

Trends in energy cost components - a simple decomposition analysis

To provide a more granular understanding on the drivers of energy costs, trends in production costs, personnel costs, and purchases of energy products are analysed per sector in further detail. Below we present the results of this simple decomposition analysis for the examples of manufacturing sectors Pulp, paper and paperboard (Figure 4-5), Clay building materials (Figure 4-6), Cement, lime and plaster (Figure 4-7), and Iron, steel and ferro-alloys (Figure 4-8).

The analysis across these manufacturing subsectors indicate that rises in total operating costs between 2010-2017 were primarily driven by consistent increases in purchases of goods and services other than energy products, and in some sectors (like those depicted below) due to later-stage (2010-2017) increases in personnel costs as well. In recent years especially, purchases of energy products in value have decreased for all the manufacturing sectors analysed as part of sector C. This in part explains why the share of energy costs with respect to total production costs has on average decreased in most sectors within the set timeframe.

Figure 4-5 Breakdown of (operational) production costs for C171- Pulp, paper and paperboard between 2010-2017, average across EU27

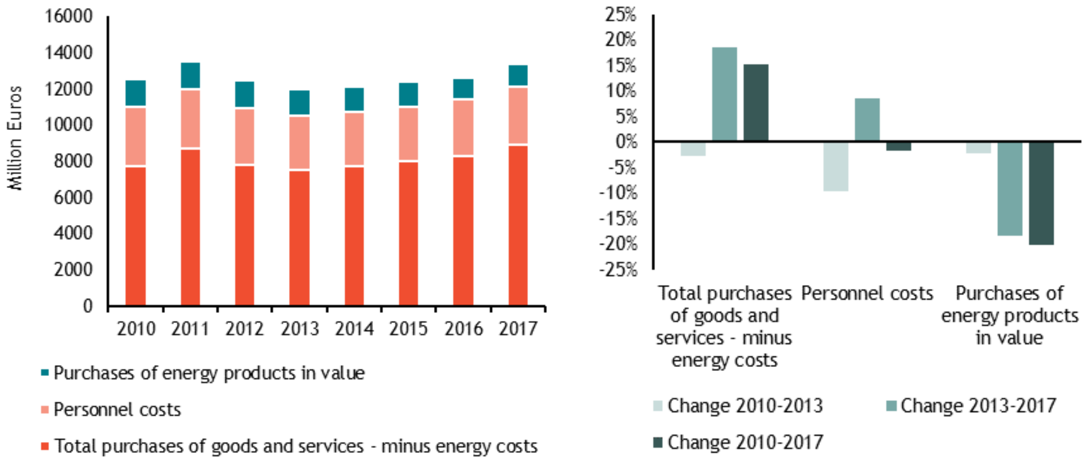
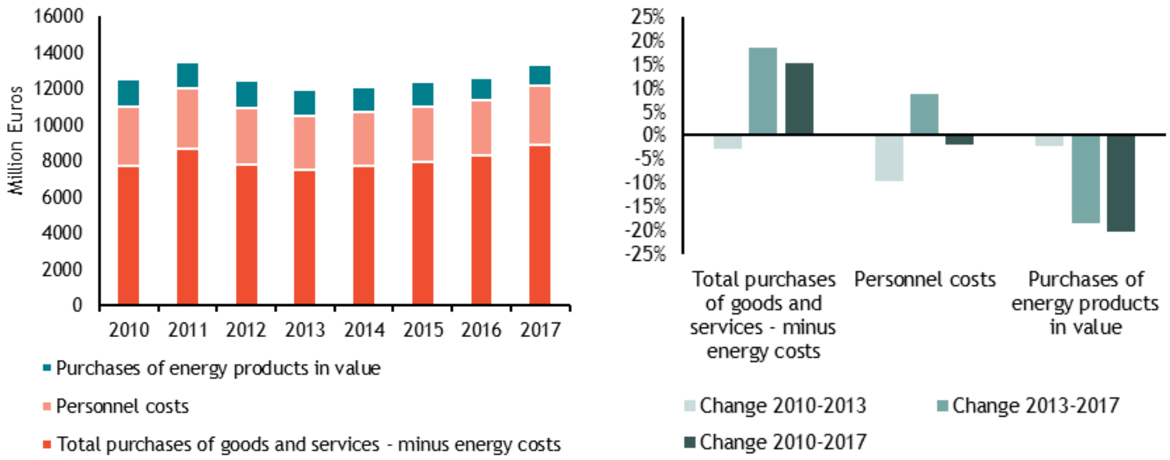


Figure 4-6 Breakdown of (operational) production costs for C233 -Manufacture of clay building materials between 2010-2017, average across EU27



Source: Study on energy prices, costs and their impact on industry and households

Figure 4-7 Breakdown of (operational) production costs for C235 -Manufacture of cement, lime and plaster between 2010-2017, average across EU27

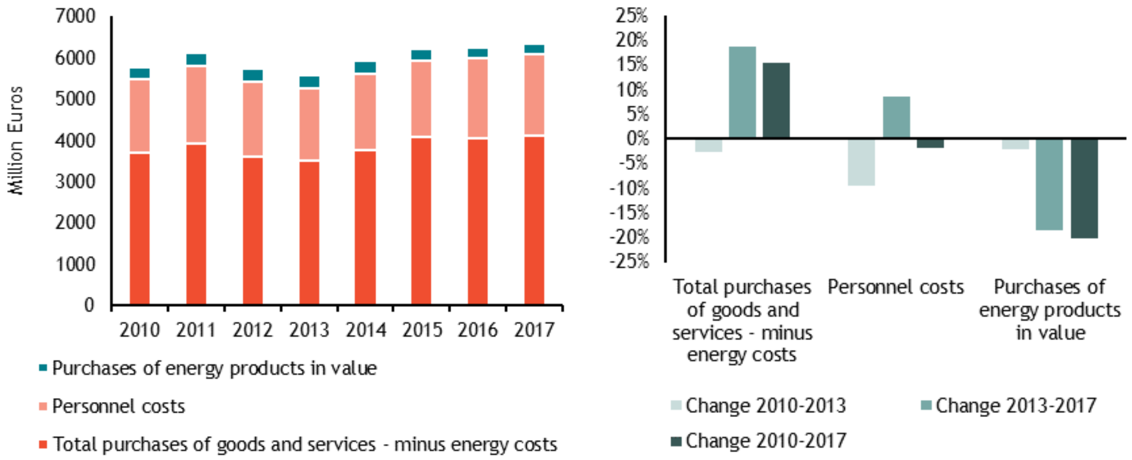
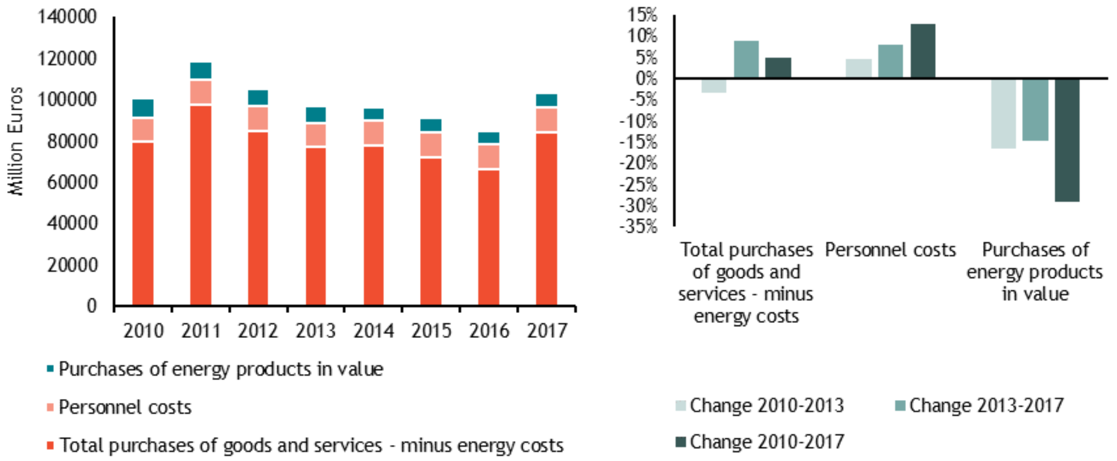


Figure 4-8 Breakdown of (operational) production costs for C241- Manufacture of basic iron, steel and ferro-alloys between 2010-2017, average across EU27



Subtask 2.4, described in section 4.4, provides a more sophisticated decomposition analysis of energy costs and the factors that drive their changes.

4.2.2 Analysis of energy intensity for EU and international industry

Energy consumption and energy cost shares per energy carrier

Two primary factors drive energy costs: energy prices and quantities of energy consumed. Prices vary per fuel type and per consumption levels, while consumption levels vary per fuel type per industry. A breakdown of energy consumption per fuel type per manufacturing sector is illustrated in Figure 4-9.

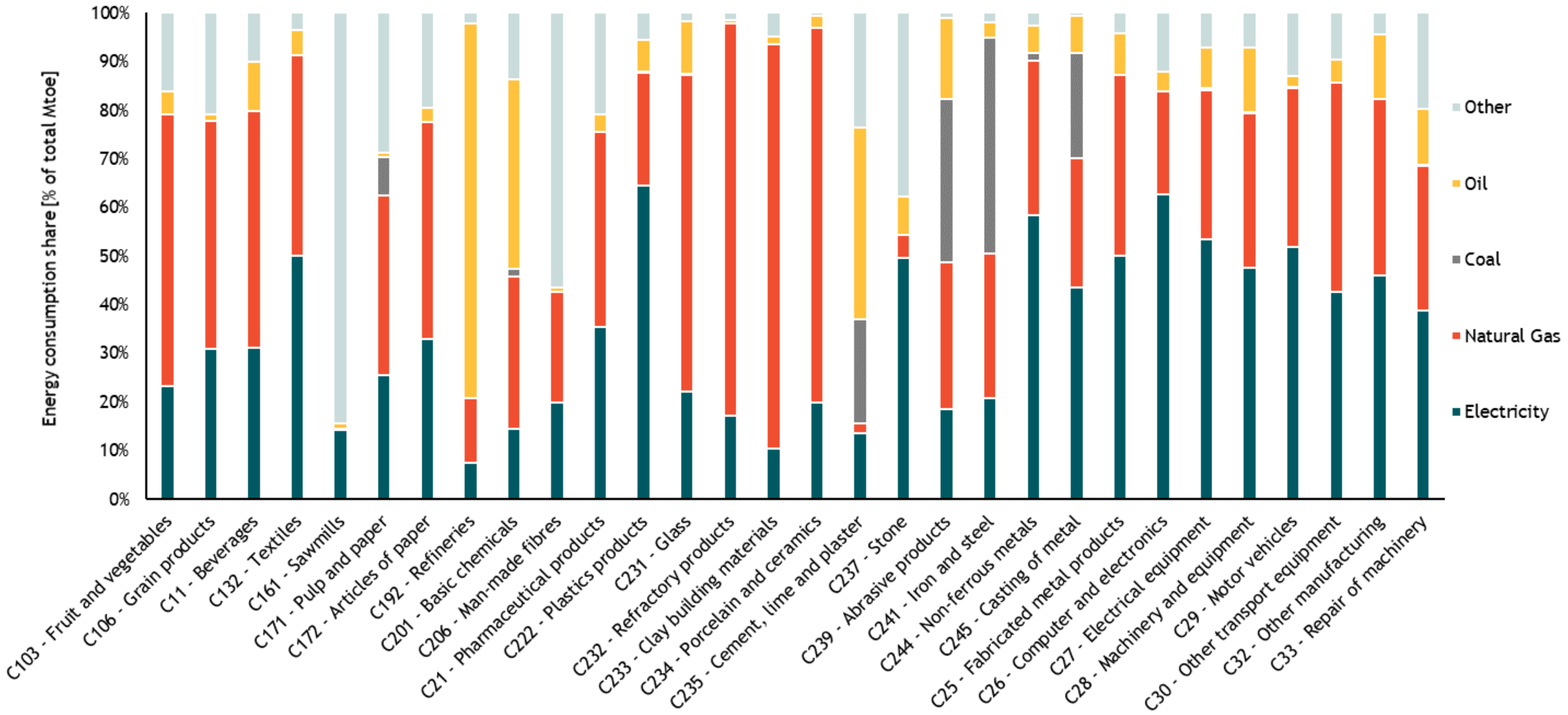
This figure shows the relevance of different energy carriers per sector, given their proportional contribution to total energy consumption, on average. The decomposition analysis in Section 4.4 describes how prices per fuel type translate these consumption values into total energy costs.

The figure shows that:

- For some sectors, electricity consumption has a bigger influence on total energy costs than other energy carriers. Fluctuations in electricity prices impact all sectors, but particularly impact Plastics products, Non-ferrous metals, and Computers and electronics;
- Natural gas consumption drives energy costs in particular for the sectors Glass, Refractory Products, Clay Building Materials, and Porcelain and Ceramics;
- Coal still plays a major role in the manufacturing of Cement, lime and plaster, Abrasive products, and Iron and steel. It is worth noting that in the case of the Iron and steel sector, a large part of coal consumption is as a feedstock in iron ore reduction, not solely as an energy carrier;
- Oil plays a substantial role in Refineries and in the manufacturing of Basic chemicals and Cement, lime and plaster;
- "Other energies", particularly biomass, contribute significantly to energy consumption for select sectors including Sawmills (where it comprises more than 80% of the energy consumed), Man-made fibres (with 57%), Stone (with 38%) and Pulp and paper (with 29%).[75]

[75] The Confederation of European Paper Industries (CEPI) reports that biomass comprises 60% of total fuel consumption in EU pulp and paper plants, on average. Granular data provided by CEPI has been inputted into the Task 2 database on energy consumption for the pulp and paper industry, for several Member States where there were still data gaps.

Figure 4-9 Breakdown of energy consumption per energy carrier for manufacturing subsectors, averages across available EU27 countries, 2010-2017



Source: Own calculations based on Odyssey and national sources.

Source: Study on energy prices, costs and their impact on industry and households

Energy intensity

Energy intensity is analysed at country and sector levels as:

$$Energy\ intensity = \frac{Energy\ consumption\ (Total)}{Value\ added\ (at\ factor\ cost)}$$

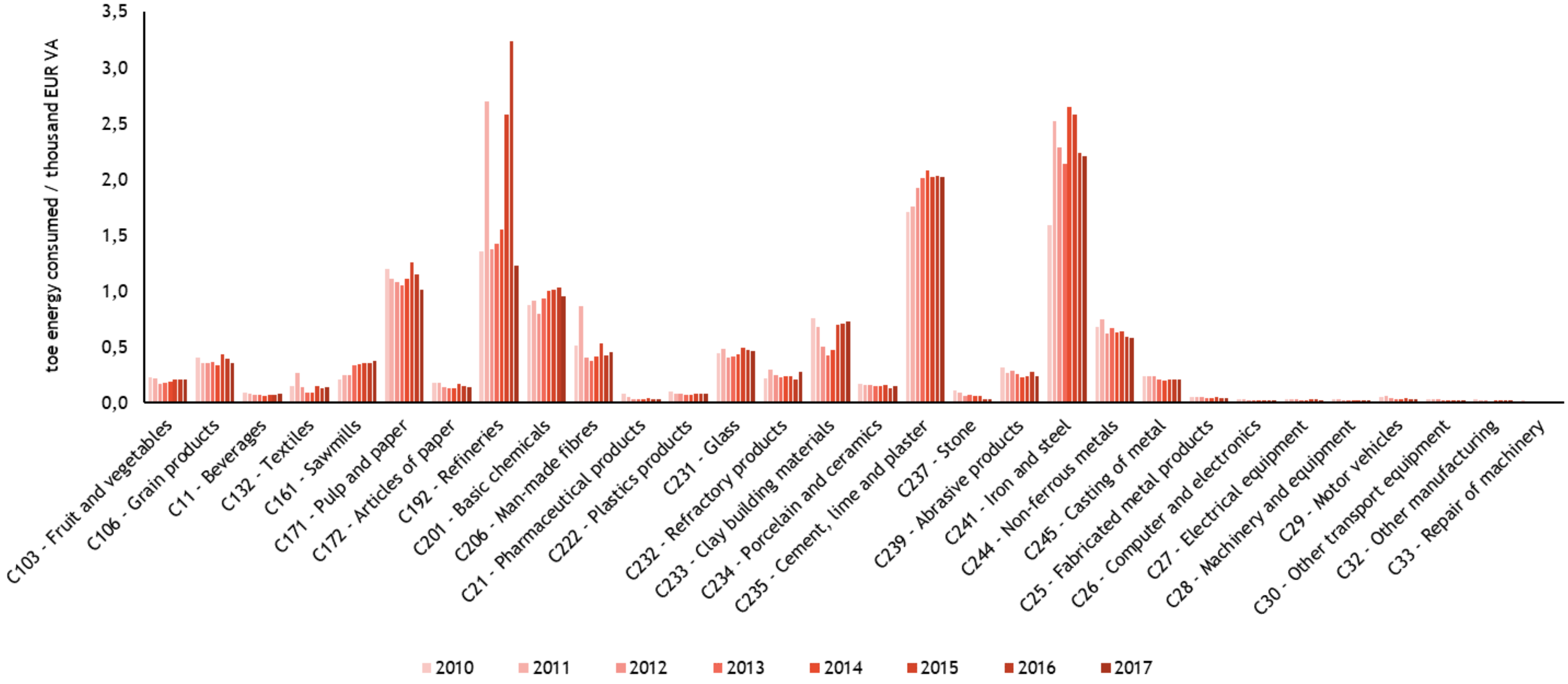
Energy intensity (energy consumption per thousand euros GVA) approximates the energy efficiency of production. As it is denominated with respect to GVA produced, it is not a direct measure of the physical energy efficiency of production, since it is subject to price effects and other factors. But it is a commonly used approximation as production volume data is not comparable across sectors.

Figure 4-10 presents the energy intensities of industrial manufacturing sectors in the EU and shows that:

- Energy use varies considerably depending on the sector:
    - Refineries, the Iron and steel sector and the Cement, lime and plaster sector are the most energy intensive sectors. They typically require more than 2 toe/energy consumption per thousand Euros of GVA;
    - These are followed by the Pulp and paper and Basic chemicals sectors, which require around 1 toe/energy consumption per thousand Euros of GVA.
- The energy intensities of the Refineries, Iron and steel, Clay building materials, and Man-made fibres sectors are most volatile; they experienced sharp spikes in energy intensity between 2014-2016 as their value added (at factor cost) periodically rose and fell;
- Fluctuations in value added that caused energy intensity volatility in these sectors can be attributed to multiple causes: in the refineries sector, value added was linked to unstable international oil price dynamics; in other sectors, value added was linked to decreased economic activity levels following the 2014 crisis in the EU.

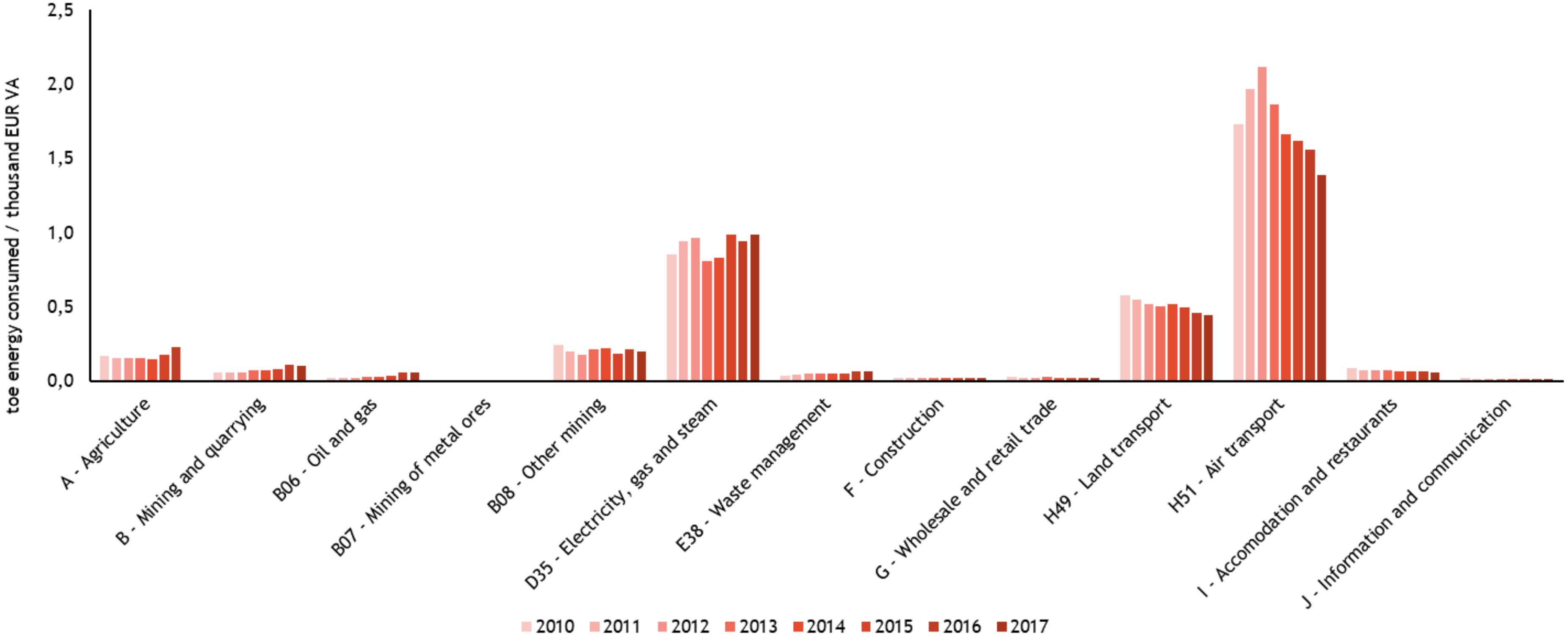
Figure 4-11 presents the energy intensities of non-manufacturing sectors in the EU, where the highest intensities are consistently observed in Air transport, Electricity, gas and steam, and Land transport.

Figure 4-10 Energy intensities of industrial manufacturing sectors, 2010-2017, averages over limited number of EU Member States with available data



Source: Own calculations based on Eurostat SBS, national sources.

Figure 4-11 Energy intensities of non-manufacturing sectors, 2010-2017, averages over limited number of EU Member States with available data

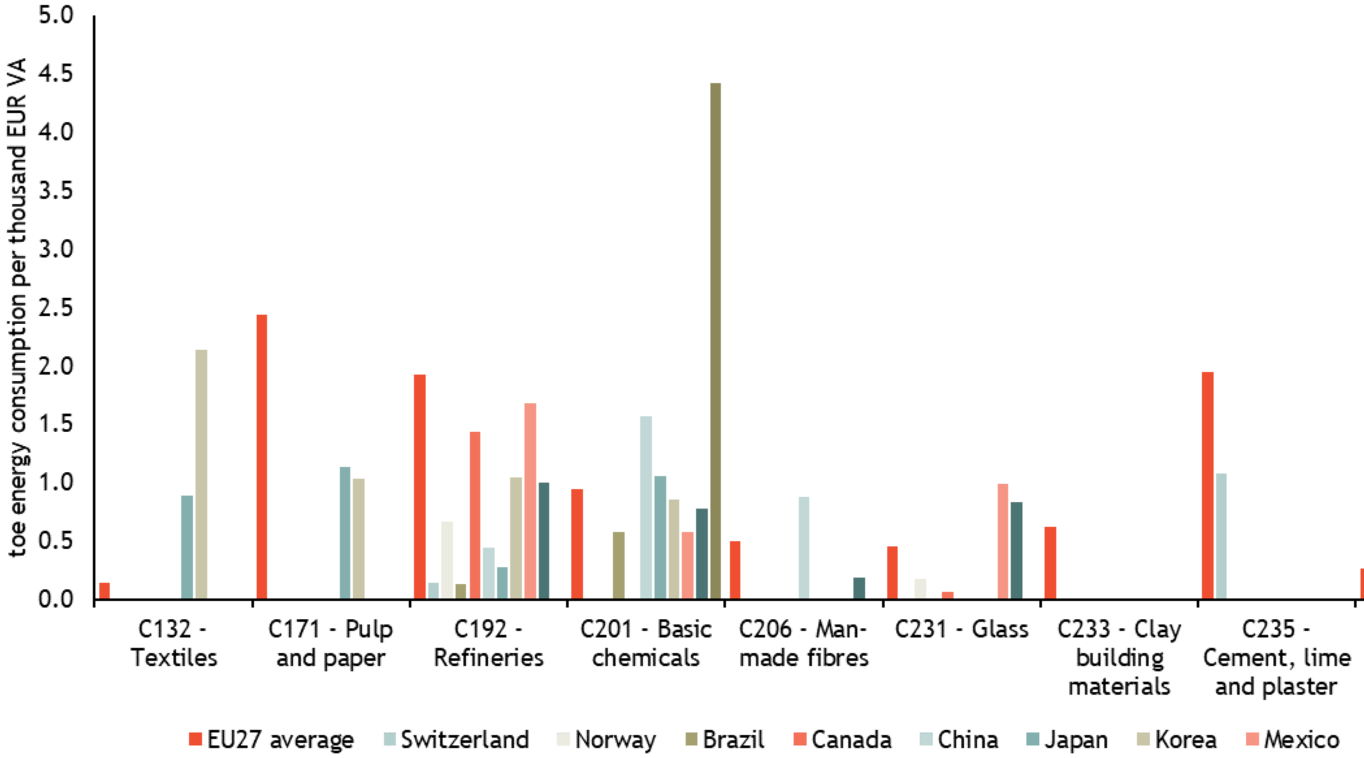


Source: Own calculations based on Eurostat SBS, national sources

Source: Study on energy prices, costs and their impact on industry and households

Figure 4-12 and

Figure 4-13 Energy intensities of more energy-intensive manufacturing sectors, Average 2010-2017, across the EU27, trade partners and G20 countries with available data



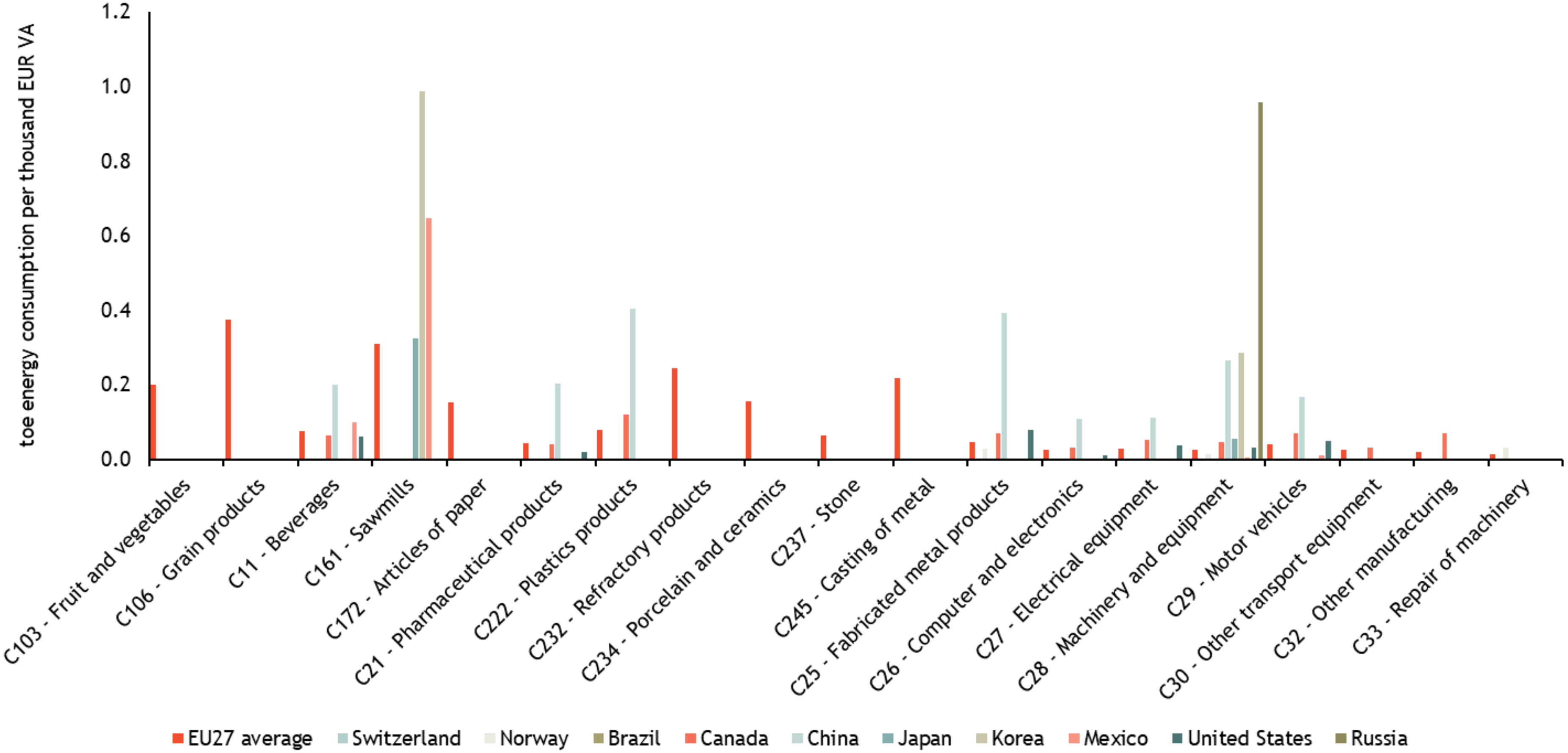
Source: Own calculations based on IHS database, national sources on energy consumption levels

Figure 4-14 depict energy intensities over time in the EU27 and select G20 countries and trade partners; the figures show only sectors for which data across countries was sufficiently available. As energy consumption data is not widely available for international manufacturing sectors, some gaps remain.

The energy intensities of manufacturing and non-manufacturing sectors varied considerably across countries:

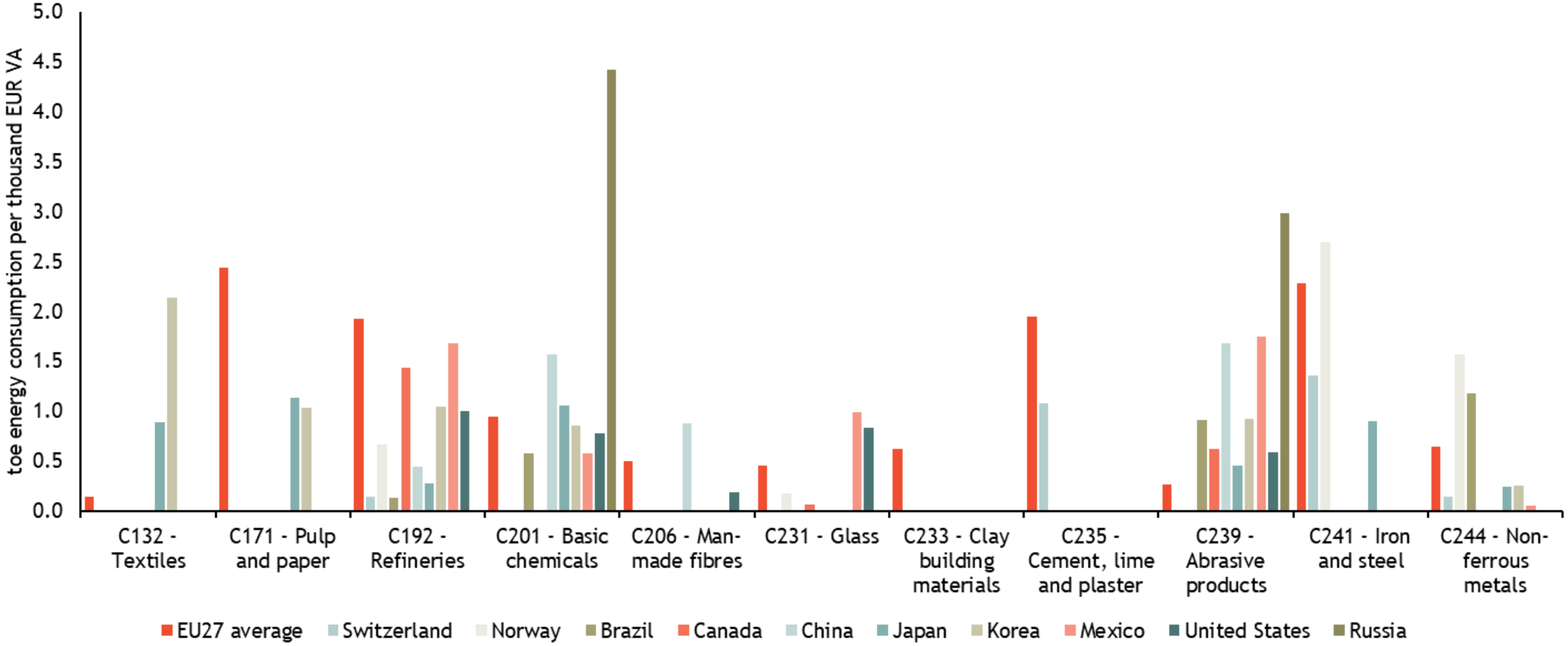
- In Pulp and Paper (C171), the EU27's average energy intensity is more than twice as high as Japan and Korea's due to higher energy consumption on average in EU plants;
- In Refineries (C192), again due to higher energy consumption levels, energy intensity for the EU27 is higher than all of its international trade partners for which data was available, and significantly higher than energy intensity for refineries in Switzerland, Brazil, China and Japan;
- In Basic Chemicals (C201), the EU27 has a lower than average energy intensity due to larger gross value added figures on average, where energy intensities for chemicals in China, Japan and Brazil all higher than in the EU;
- The EU27 has the lowest intensity levels of all international counterparts in Abrasive Products (C239), though intensity levels for the manufacture of abrasive products in Japan and the US are only slightly higher than in the EU;
- In Iron and Steel (C241) and in Non-ferrous metals (C244), the EU27 has higher intensity levels than Switzerland but lower levels than Norway due to higher energy consumption levels in Norway (partly attributable to the distribution of upstream and downstream manufacturing processes across these countries);
- In Glass (C231), the EU27 has lower energy intensity levels than Mexico and the United States, but higher intensity than Norway and Canada;
- The EU27 has lower than average intensity levels in Beverages (C11), Pharmaceutical products (C21), Fabricated metal products (C25), Computer and electronics (C26), Electrical equipment (C27), Machinery and equipment (C28), and Motor vehicles (C29);
- In Agriculture, all countries and the EU27 have comparable energy intensities, with the exception of Mexico, where energy intensity is nearly three times as high as in Canada, which has the next highest intensity for agriculture;
- In Construction, energy intensities are relatively low compared to other sectors:
    - Turkey and China have the highest comparative energy intensities;
    - Energy intensity for construction in the EU27 is on par with Norway, Canada, Mexico, Japan and South Africa and slightly higher than in Switzerland, Australia, India and Indonesia.

Figure 4-12 Energy intensities of less energy-intensive manufacturing sectors, Average 2010-2017, across the EU27, trade partners and G20 countries with available data



Source: Own calculations based on IHS database, national sources on energy consumption levels

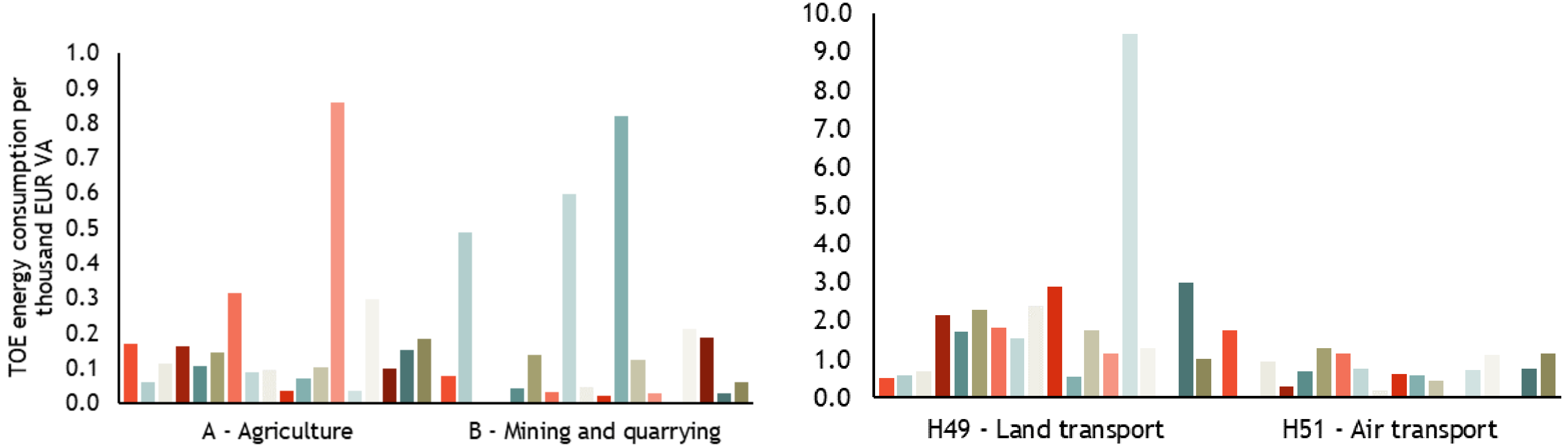
Figure 4-13 Energy intensities of more energy-intensive manufacturing sectors, Average 2010-2017, across the EU27, trade partners and G20 countries with available data



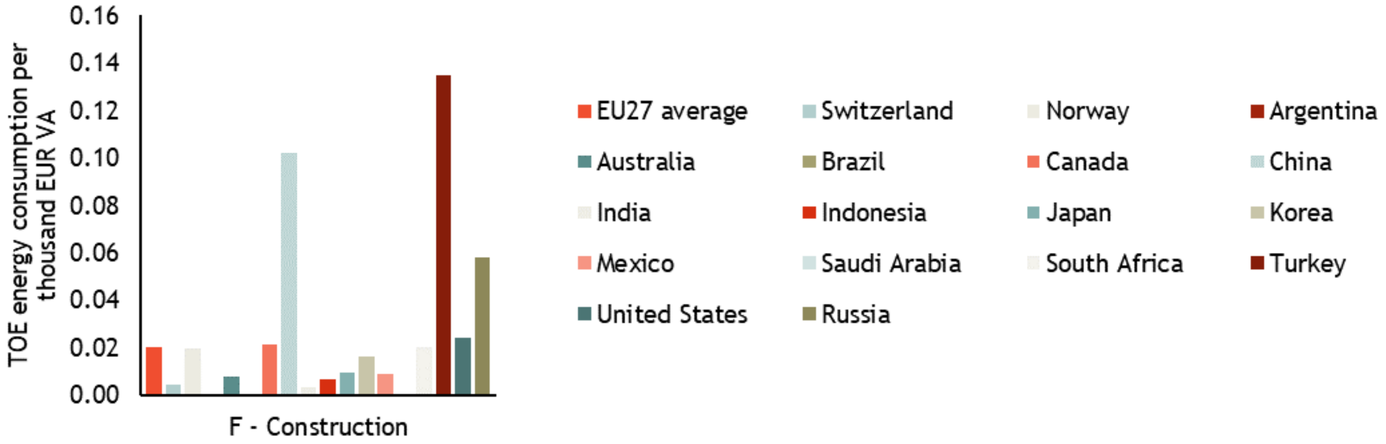
Source: Own calculations based on IHS database, national sources on energy consumption levels

Figure 4-14 Energy intensities of non-manufacturing sectors, Average 2010-2017, across the EU27, trade partners and G20 countries with available data

(a) Sectors A, B, H49 and H51



(b) Sector F



Source: Own calculations based on IHS database, national sources on energy consumption levels

Source: Study on energy prices, costs and their impact on industry and households

4.2.3 Analysis of profitability of EU industry

Achievable margins also drive the competitiveness of industries. To calculate achievable margins, figures on gross operating surpluses act as proxies for profit. They are analysed with respect to total operational production costs and to total production values, i.e.:

$$GOS\ as\ a\ share\ of\ total\ production\ costs = \frac{Gross\ Operating\ Surplus}{Personnel\ costs + \ Purchases\ of\ good\ and\ services}$$

and,

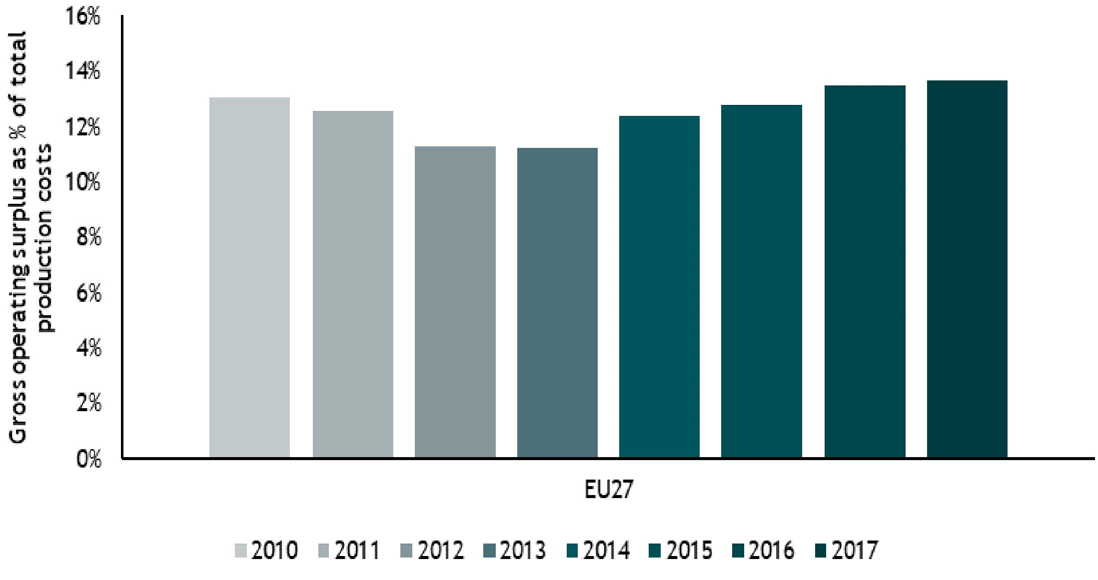
$$GOS\ as\ a\ share\ of\ total\ production\ value = \frac{Gross\ Operating\ Surplus}{Value\ added\ (at\ factor\ cost)}$$

EU27 profitability analysis

Figure 4-15 shows the EU27 average gross operating surplus as percentage of production costs for the years 2010-2017. Figure 4-16 shows these values broken down per Member State. In the EU27 over this period, average gross operating surplus was approximately in the range of 10-14% per annum. GOS on average decreased by ~1% between 2010-2014 and increased by ~2% between 2014-2017.

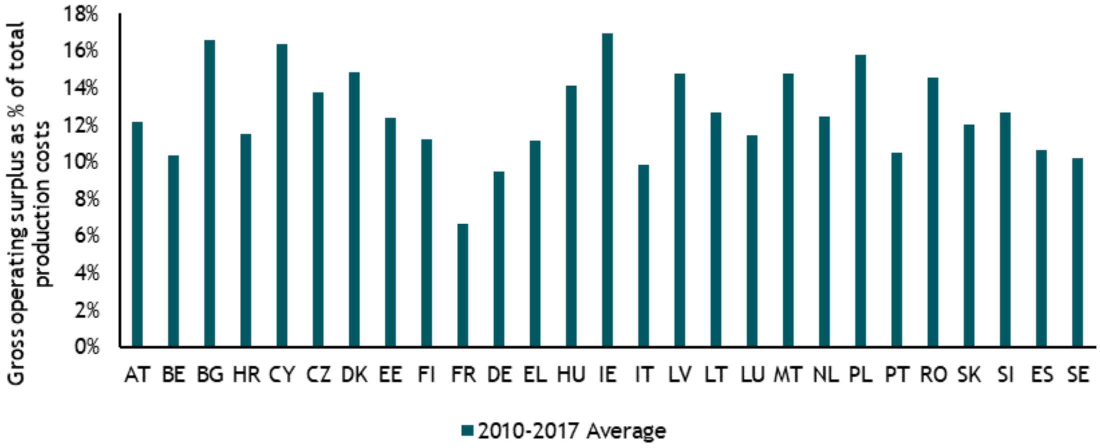
There are large differences in gross operating surplus as a percentage of production costs between Member States. Ireland, Poland and Bulgaria have the highest surpluses, over 16%. These are closely followed by Cyprus and Romania. The lowest surpluses are found in France, Germany, and Italy.

Figure 4-15 Gross operating surplus as % of total production costs, average across all manufacturing sectors at EU27 level, 2010-2017



Source: Own calculations based on Eurostat SBS

Figure 4-16 Gross operating surplus as % of total production costs, average across all manufacturing sectors at Member State levels.



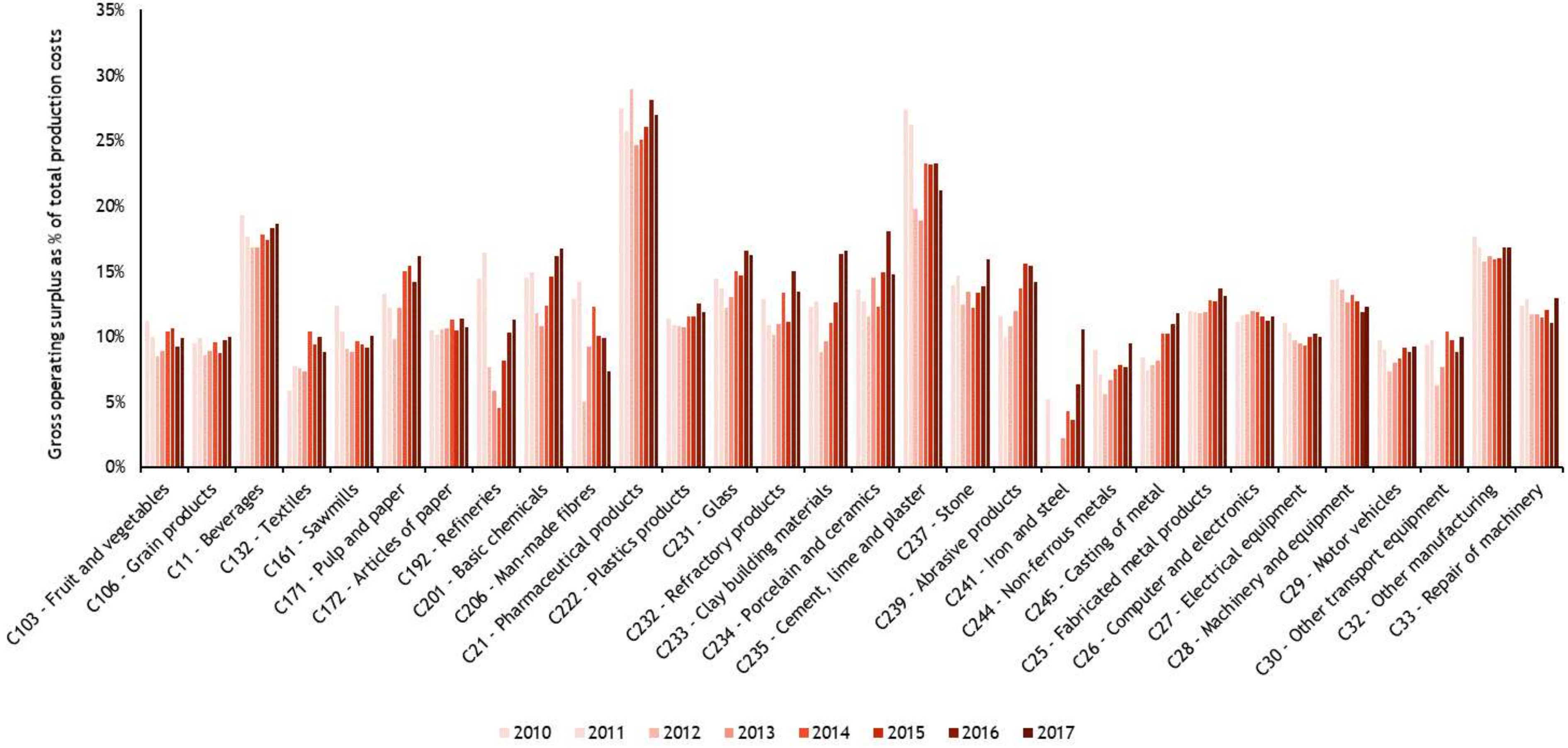
Source: Own calculations based on Eurostat SBS

These figures present results averaged across all manufacturing sectors. Figure 4-17 in contrast presents trends across individual sectors, averaged across Member States. Analysis indicates that:

- Most EU sectors maintained an average GOS share between 5-15%;
- The Pharmaceuticals and Cement sectors maintained the highest GOSs as shares of production costs;
- The Non-ferrous metals and Iron and steel sectors maintained the lowest GOSs as shares of production costs, on average 7.6% and 4% respectively;
- The average EU gross operating surplus in the Iron and steel sector shrank to near-zero in 2011 and 2012, due to negative GOS values reported by the Hungarian and Greek iron and steel sectors in those years;
- Between 2010-2017, average gross operating surplus in general increased across most sectors;
- The highest proportional increases in GOS were experienced in the Iron and steel sector (103%), the Textiles sector (52%), and the Casting of metal sector (41%);
- GOS did proportionally decrease in several sectors, including Man-made fibres (-43%), Cement, lime and plaster (-23%), and Refineries (-21%).

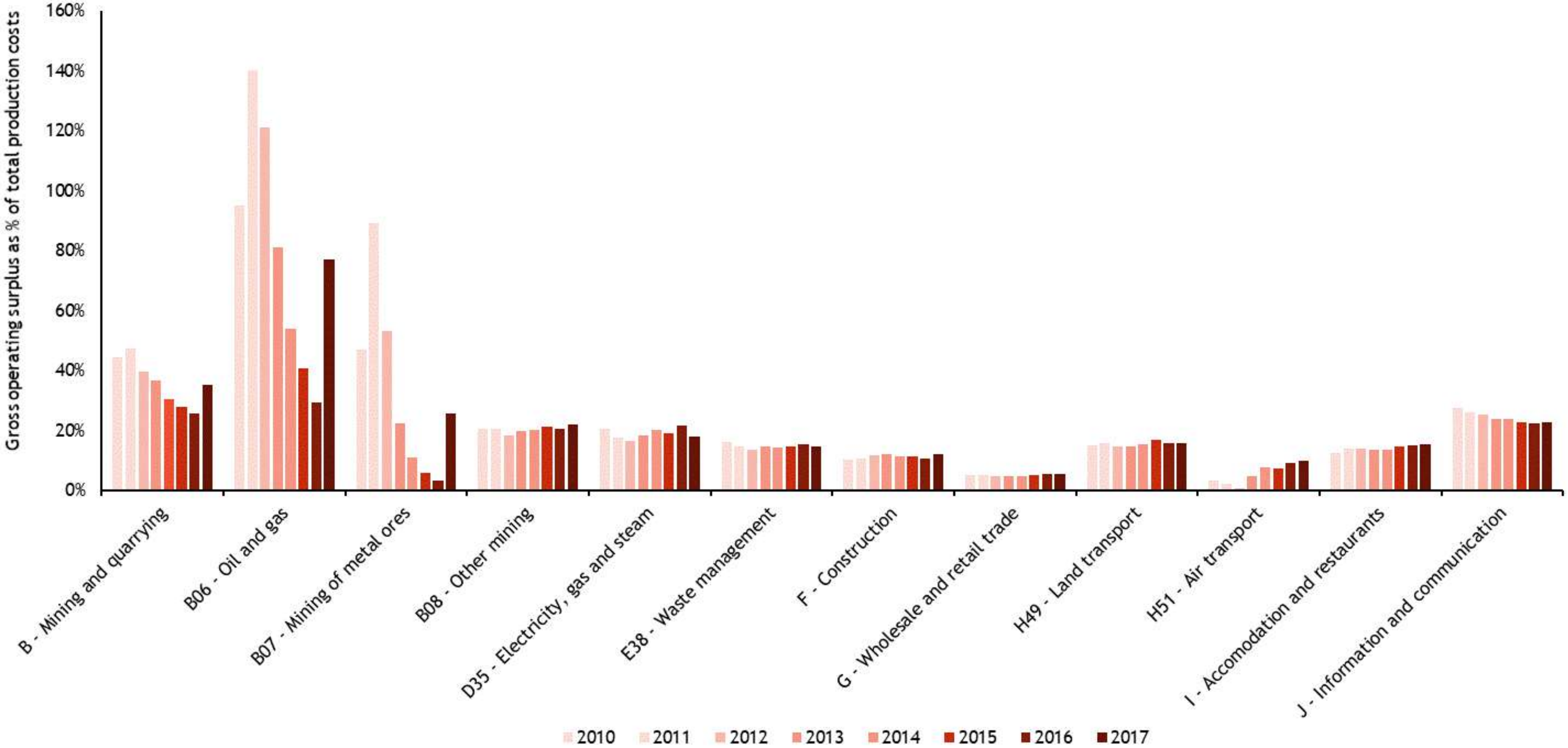
Figure 4-18 presents trends across non-manufacturing sectors, averaged across EU Member States. The Oil and gas and Mining of metal ores sectors maintained much higher GOSs than manufacturing sectors on average, though surpluses in the Mining sector steadily decreased until 2017. Other non-manufacturing sectors maintain surpluses on par with their manufacturing counterparts, on average between 5-20%.

Figure 4-17 Gross operating surpluses as a percentage of total production costs for EU manufacturing sectors, averaged across MSs with available data between 2010-2017.



Source: Own calculations based on Eurostat SBS

Figure 4-18 Gross operating surpluses as a percentage of total production costs for EU non-manufacturing sectors, averaged across MSs with available data between 2010-2017.



Source: Own calculations based on Eurostat SBS.

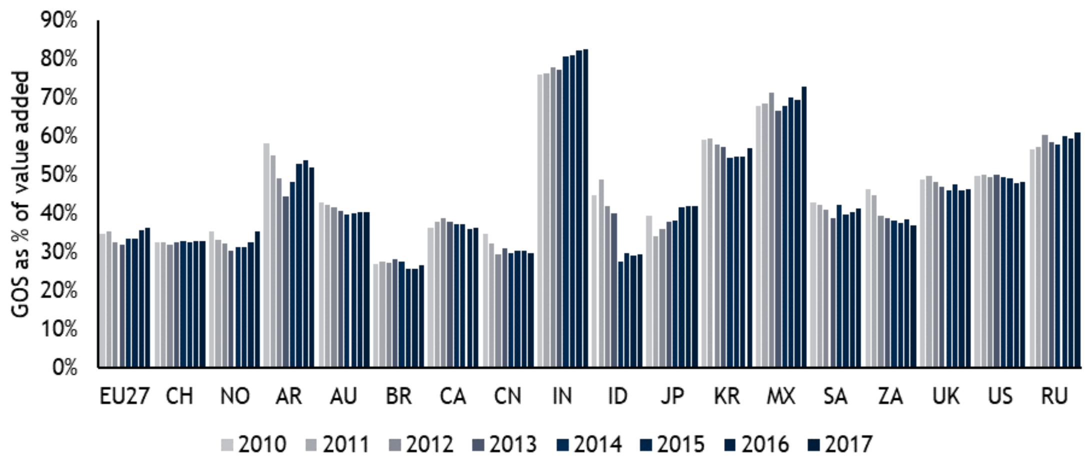
International profitability comparison

Figure 4-19 depicts gross operating surpluses across manufacturing industries as shares of their total production value calculated for the EU27, its trade partners, and G20 countries. Iceland is excluded from the figure due to insufficient data. Figure 4-20 zooms in on these figures as a proxy of profitability for manufacturing sectors in the EU27, the United States, China and Japan.

Analysis indicates that:

- India, Mexico, Korea, Russia, and Argentina exhibit consistently high ratios of GOS to total value added;
- The EU27 exhibits average profitability compared to international counterparts, with less volatility year-to-year;
- Profitability in several countries - Argentina, Indonesia, Mexico, and Japan - has oscillated sharply in recent years;
- Profitability in many countries increased from 2015 on, including in the EU27;
- EU manufacturing sectors are on average less profitable than non-EU G20 counterparts including India, Mexico, Korea, Russia, and the United States, but as profitable as Norway and Switzerland and more profitable than Brazil.

Figure 4-19 Gross Operating Surplus as a share of value added, averaged across all available manufacturing sectors



Compared to several of its top international trade partners:

- Sectors in the United States have the highest profitability levels, on average 1.5x higher than profitability levels in the EU;
- On average, manufacturing sectors in the EU27 have lower profitability levels than sectors in Japan and the United States, and profitability levels comparable to sectors in China;
- The EU 27 experienced a relative rise in GOS as a share of value added between 2015-2017 that was not experienced in China (where GOS/value added dropped in 2016), in the US (where GOS/value added dropped in 2016 before slightly rising in 2017), or in Japan (where GOS/value added remained steady).

Figure 4-20 Zoom-in on GOS as a share of value added for manufacturing sectors in the EU27, China, Japan and the United States

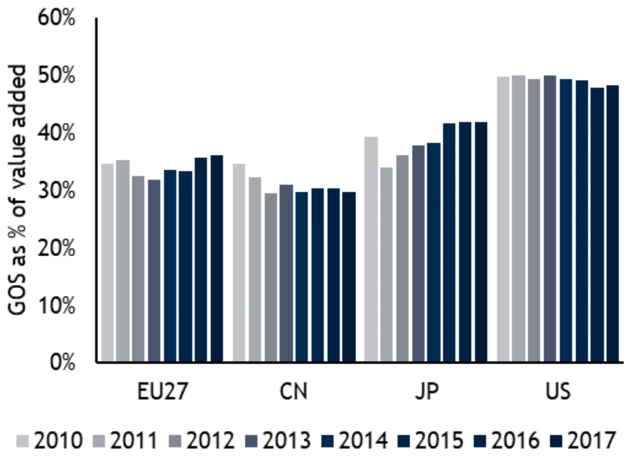


Figure 4-21 shows GOS as a share of value added averaged across non-manufacturing sectors in the EU27 and its international trade partners, and Figure 4-22 zooms in on these values for non-manufacturing sectors in the EU27, the United States, China and Japan.

In non-manufacturing sectors:

- Mexico, Saudi Arabia, and Russia consistently exhibit the highest ratios of GOS to value added
- Generally, the EU27 exhibits slightly lower-than average profitability levels compared to G20 countries, though higher profitability levels than Switzerland and China and levels comparable to the US and Japan
- Profitability levels of the EU27's non-manufacturing sectors are slightly higher (2-3% higher) than profitability levels of its manufacturing sectors, whereas in Japan and in the US, profitability levels of manufacturing sectors are higher than those of non-manufacturing sectors

Figure 4-21 Gross Operating Surplus as a share of value added, averaged across all available non-manufacturing sectors

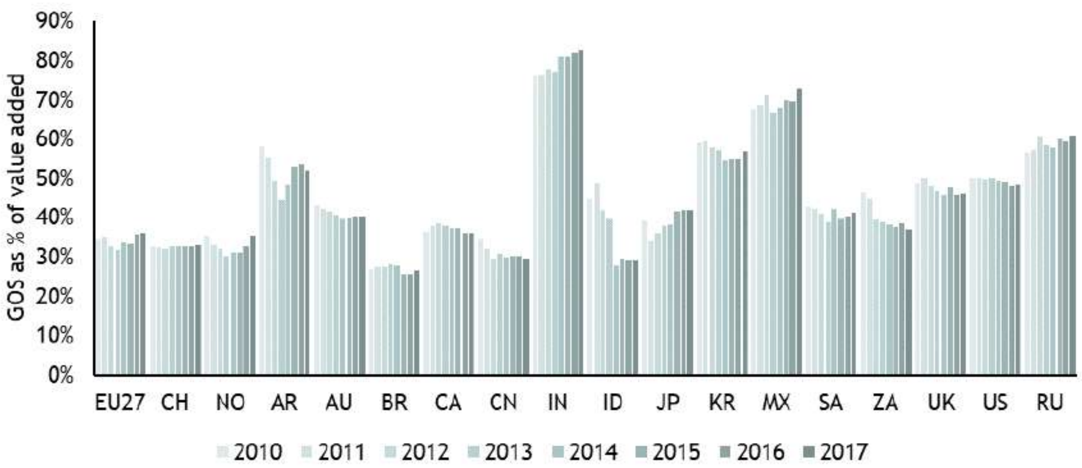
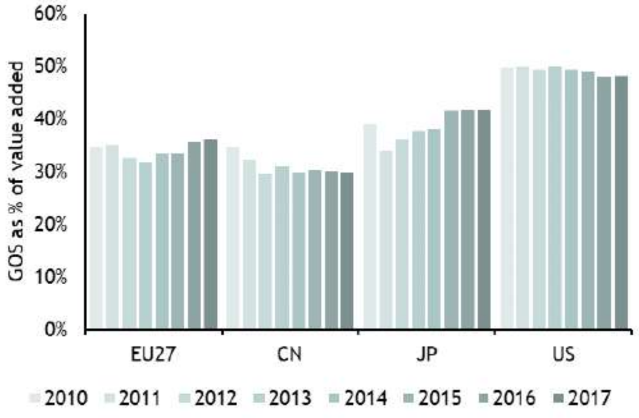


Figure 4-22 Zoom-in on GOS as a share of value added for manufacturing sectors in the EU27, China, Japan and the United States



4.3 Summary of findings from selected EIIs

To better understand how energy price and cost levels impact the profitability and competitiveness of specific energy intensive industries, bottom-up analysis was performed, complementing findings from top-down analysis. Interviews were conducted with industry associations to identify significant economic trends in each sector. The prices and costs of electricity, natural gas, and other fuels in each sector were quantitatively evaluated; energy costs as a share of production costs were calculated to provide an indication of sectors' sensitivities to potential fluctuations in energy prices. Sectors' trade situations were also analysed to provide context on their relative exposure to international trade dynamics. Results were synthesised to inform conclusions on the impact of energy prices and costs on EU EIIs' overall competitiveness.

4.3.1 Sample overview

The results of the bottom-up analysis are based on data collected from 91 plants across five industrial sectors; participating plants reflected the average features of EU installations. Surveyed plants accounted for at least 10% (and in some cases, a much higher share) of their sector's turnover or production capacity. Sample statistics are summarised in the table below.

Table 4-7 Plants participating in the study

Sector	Number of plants by geographical region					Representativeness in 2018
	Central Eastern Europe	North Western Europe	Southern Europe	Non-EU North Western Europe	Total	Share of turnover (T) or production capacity (C)
Flat glass	7	19	10	4	40	74% C
Zinc	5	1	2	-	8	97% T
Ferro-alloys and silicon	2	3	2	-	7	*NA*
Refineries	4	8	8	3	23	22% C
Fertilisers	7	3	3	-	13	90% C

4.3.2 Prices and costs of electricity and natural gas in selected EIIs

Table 4-8 presents average energy prices and costs in analysed EIIs as well as energy costs as a share of production costs. Figures are presented for 2018 only, the latest year for which data were received from all sectors. Note that natural gas costs in particular reached higher levels in 2018 than in previous years.

Table 4-8 Energy prices and costs in select EU energy intensive sectors - Simple EU27 averages, 2018. Source: Own elaboration based on data from industrial plant operators.

Sector	Electricity prices **(€/MWh)**	Electricity costs per production quantity (EUR/tonne)	Electricity costs as a share of production costs	Electricity intensity (MWh/tonne)	Natural gas price **(€/MWh)**	Natural gas costs per production quantity (EUR/tonnes)	Natural gas costs as a share of production costs	Natural gas intensity (MWh/tonne)
Flat glass	78.6	17.6	6%	0.23	25.0	54.3	19%	2.19
Zinc	45.6	190.6	31%	4.18	31.5	6.5	0.3%	0.25
Ferro-alloys and silicon	43.3	304.3	28%	7.38	40.28	1.1	0.1%	0.03
Refineries*	77.0	3.8	5%	0.05	29.9	7.0	9%	0.33
Fertilisers	72.8	10.7	7%	0.17	24.1	113.7	64%	5.01

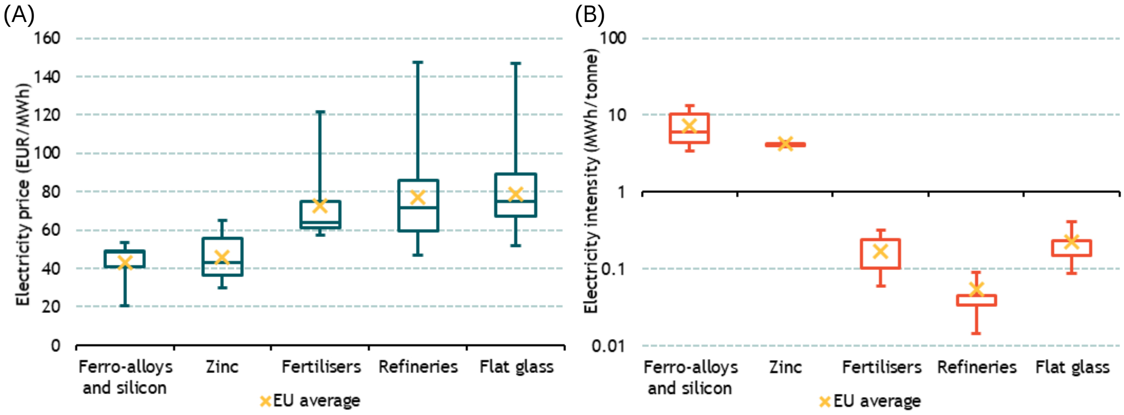
** For this project the definition of production costs included the costs of crude oil as feedstock. According to Concawe and Fuels Europe, the refining industry standard method to calculate production costs excludes the costs of crude oil. Therefore, the energy costs as a share of production costs presented in this table are lower than those calculated by the industry..*

The ranges of electricity prices paid by sectors in 2018 are depicted in Figure 4-23(A); ranges of electricity intensities (electricity consumed per tonne of production) for these sectors are depicted in Figure 4-23(B). Electricity intensities are presented on a logarithmic scale.

In line with the findings of the 2018 CEPS and Ecofys study on energy prices and costs in energy intensive industries[76], electricity prices and intensities across all analysed sectors are inversely related. Given higher energy consumption per production, sectors pay lower prices for electricity (though this effect is slightly less pronounced in the flat glass sector, where electricity price is higher on average than electricity price in the refineries sector in spite of its higher energy intensity). This inverse relationship can be attributed to several factors: larger consumers of electricity are directly connected to the transport network and thus do not pay the distribution fees; larger consumer have more sway in negotiating their prices; larger consumers of electricity are sometimes exempted from specific taxes and levies that can drive up electricity prices; and plants in some industries can adapt their manufacturing processes to better exploit cheaper, baseload electricity.

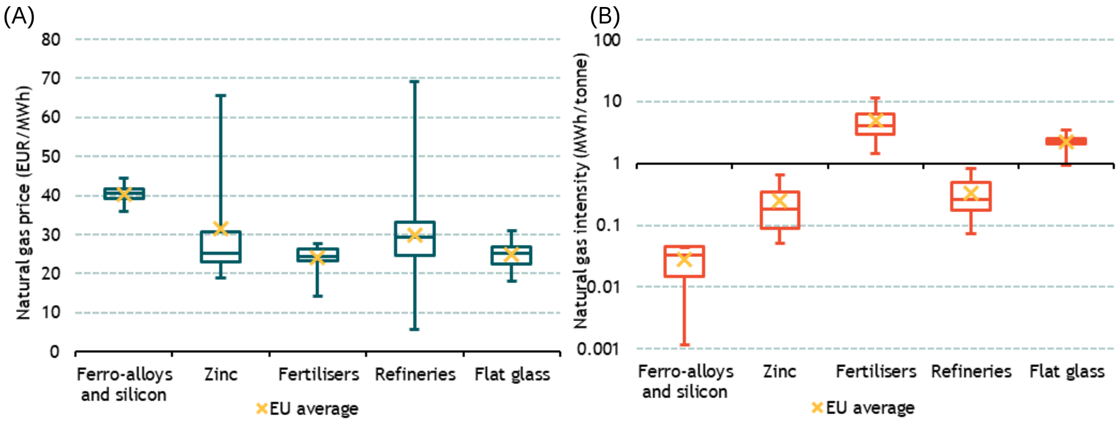
[76] CEPS and Ecofys (2018), Composition and Drivers of Energy Prices and Costs: Case Studies in Selected Energy Intensive Industries - 2018.

Figure 4-23 Electricity prices (A) and intensities (B) by sector - 2018. Source: Own elaboration based on data from industrial plant operators.



Natural gas price ranges (A) and intensity ranges (B) for analysed sectors are presented in Figure 4-24. As with electricity, sectors' natural gas intensities are inversely related to their natural gas prices. However, natural gas prices vary less widely across sectors than electricity prices as natural gas prices are largely set by international producers and cannot be negotiated down as easily as electricity prices. Interestingly, sectors that paid lower electricity prices in 2018 on average paid higher natural gas prices. This can be attributed to the different energy profiles required for sectoral manufacturing processes.

Figure 4-24 Natural gas prices (A) and intensities (B) by sector - 2018. Source: Own elaboration based on data from industrial plant operators.



4.3.3 *Trade situation of selected EIIs*

To understand how energy prices and costs might influence the international competitiveness of the analysed sectors, context on their trade situations was required. Data from PRODCOM, COMEXT, and Eurostat SBS were collected and processed to provide an overview on sectors' exposure levels to international trade, included in Table 4-9.

In 2017 and 2018, gross imports exceeded gross exports in all sectors except for flat glass. Still, a significant portion of production in each sector (except for the specific manufacturing of silicon) was dedicated to extra-EU exports. Analysis suggests that all sectors are exposed to international pricing dynamics, and that EU zinc manufacturers, ferro alloys and silicon manufacturers and refineries are particularly exposed, with more than 20% of their products exported to international buyers.

Table 4-9 Exposure of EIIs in the EU27 to international trade - 2017/2018.

Sector	Gross exports (M€)	Gross imports (M€)	Production value (M€)	Internal consumption (M€)	Share of internal consumption served by extra-EU imports	Share of production dedicated to extra-EU exports	Exposure to international trade
Flat glass[1,2]	466	270	2828	2632	10.3%	16.5%	Medium
Zinc[3]	1030	1152	5136	5258	21.9%	20.1%	High
Ferro-alloys[1,2]	528	2790	1871	4133	68.1%	27.9%	High
Silicon[1,2]	56	577	412	933	62.3%	14.1%	High
Refineries[1,3]	74051	57087	123947	106983	53.4%	59.7%	Extremely high
Fertilisers[1,2]	-	4098	-	13778	29.7%	-	High

Sources: 1. COMEXT, 2. PRODCOM, 3. Eurostat SBS

Fluctuations in energy prices and costs that drive increases in product costs for EU manufacturers can decrease their competitiveness in international markets where cost differentials can be narrow. Specific details on recent trade dynamics of each sector were also accounted for when considering industry competitiveness; these are discussed further in Annex D.

4.3.4 Impact of energy costs on the competitiveness of selected EIIs

The influence of energy prices and costs on EII competitiveness varies by sector. Conclusions on the relative impact of energy costs in each sector are summarised subsequently; they are contextualised in greater detail in Annex D.

Flat glass

Energy costs account for a significant share (~25%) of the total production costs of flat glass companies in the sample. Energy costs per tonne in the sector declined sharply between 2014 and 2016 before stabilising at lower levels. At the same time, the EU flat glass sector lost a share of its trade balance to other international manufacturers between 2015-2018, during a period of steady energy costs and gross operating profits per tonne. Therefore, while energy costs have contributed positively to the restoration of the sector's profitability since 2016, they have not contributed to increasing the external competitiveness of the EU flat glass sector with respect to its non-EU competitors.

This is due to the fact that competitor countries have experienced even sharper declines in energy costs than the EU in recent years. For example, the absolute energy costs of the flat glass sector in Russia were much lower than in the EU27: about half the cost for electricity and about one quarter of the cost for natural gas. They were also lower in relative terms: energy costs represented 15% of production costs in Russia vs. 26% in the EU27. The flat glass sector in the EU27 can perform well against competitors with comparable energy costs, but is at a strong cost disadvantage compared to competitors with a low-cost access to natural gas resources. Extra EU imports of flat glass are highest from countries with low-cost energy and increasing production capacities (including Russia, Belarus, Algeria, Turkey, and Egypt). The EU flat glass sector compensates for differences in energy prices by competing on the technical quality of its products.

Zinc

The international competitiveness of zinc companies is difficult to assess based on trade balances, which mirror variations in the geographic regions of demand, rather than in the fixed geographic locations of zinc producers. The market-price of zinc is established by international trading platforms such as the London Metal Exchange (LME), and all quantities of zinc produced are sold each year; thus differences in competitiveness manifest as differences in the profitability of companies. The international competitiveness of the EU zinc sector can therefore only be assessed by analysing the full cost structures of plants.

A JRC study covering the years 2012 and 2013[77] concluded that the costs of the zinc sector in the EU27 were lower than those of its main competitors (China, Russia, Norway and Namibia), though higher than costs in Kazakhstan. Interviews with the International Zinc Association confirm that the economic situation of the sector has negatively evolved since then. EU production costs are reportedly volatile, and in more recent years have approached average (and occasionally higher-than-average) international values.

Ferro alloys and silicon

Electricity costs primarily drive energy costs for the ferro-alloys and silicon sector. Natural gas costs are negligible (~0.1% of production costs on average). Electricity costs of surveyed facilities consistently rose between 2016 to 2019. This increase in the electricity price reduced the profitability of the sector, despite a concurrent increase in selling prices.

The EU ferro-alloys sector has managed to maintain a steady trade balance since 2016, but the sector remains threatened by overcapacities outside of Europe and especially in China, which dominates the international ferro-alloys market and is the main ferro-alloys and silicon supplier in Europe. Alloys with the highest energy intensities (i.e., Ferro-silicon and Silicon) are currently protected by anti-dumping protective measures which have levelled the playing field and enabled EU producers to remain competitive with Chinese producers. Still, some Chinese producers have attempted to circumvent these measures which has to a certain degree undermined their efficacy.

As price points are determined by production costs in the sector, ferro-alloys manufacturers view energy costs as key determinants of product competitiveness. Even small increases in energy costs can threaten the competitiveness of EU plants, which in many cases are struggling to keep their costs as low as possible. The share of energy costs compared to production costs for the sector has remained steady since 2016, which has enabled the industry to maintain a relatively steady trade balance in recent years.

Refineries

When considering purchased energy only, the energy costs of refineries account for a significant portion of their total production costs (between 8 and 14% on average).[78] When analyising self-produced fuels, we can see that these play a significant role in the total production costs of refineries: between 8 and

[77] Aikaterini Boulamanti, Jose Antonio Moya, "Production costs of the non-ferrous metals in the EU and other countries: Copper and zinc", Resources Policy, Volume 49, 2016, Pages 112-118, https://doi.org/10.1016/j.resourpol.2016.04.011 .

[78] For this project the definition of production costs included the costs of crude oil as feedstock. According to Concawe and Fuels Europe, the refining industry standard method to calculate production costs excludes the costs of crude oil. Therefore, the energy costs as a share of production costs presented in this table are lower than those calculated by the industry.

13% [79] taking crude oil price into account as production costs, while if crude oil costs are excluded from production cost (industry standard method), energy costs are estimated to be between 49 and 55%[80].

The operating costs of refineries are therefore dominated by the “other costs” (essentially the supply of the raw material, namely crude oil). Consequently, the profitability of refineries is essentially determined by the international markets: the price of crude oil is determined by the international oil market (Brent quotation), while refined products are priced as well on an international market driven by supply/demand equilibrium. The products quality are relatively homogeneous between the world regions and therefore, it is relatively easy to substitute domestically produced petroleum products with imported products from outside the EU if domestic production becomes too expensive (depending on transport costs of refined products, local production costs and market). The limited ability to make more specialised products, and the resulting inability to fully pass on increased costs reduces the profit margin of some European refineries. As a result, exposure of some refineries to international competition is relatively high.

Fertilisers

The European fertilisers sector views energy costs – and specifically, gas costs – as the most important determinant of industry competitiveness. International energy cost dynamics are just as influential as domestic cost dynamics; even if EU fertilisers are produced more cheaply due to lower gas costs over time, they cannot be marketed competitively if international fertilisers can be produced even more cheaply due to even lower gas costs.

Although gas prices in Europe have overall shown a downward trend over the last years, they have also fluctuated importantly and depending on the year,EU fertiliser producers were still paying from twice up to four times as much for gas as their competitors in the US, Russia, Algeria and Belarussia. With some fluctuations, international gas prices have remained relatively stable in recent years. However, gas price differentials translate sharply into fertiliser production cost differentials, as gas costs can account for 50-65% of fertiliser production costs. Market share losses for EU producers can thus be directly attributed to competition from Russian, American and North African fertiliser producers with vastly lower production costs in particular when international gas prices gaps are important.

Other EIIs

The bottom-up analysis carried out by this study covered only the selected sectors described above. However, trends on the impact of energy costs on the competitiveness of other energy intensive sectors for years 2008-2017 were described in a study carried out by CEPS and Ecofys[81], including:

- Aluminium: Electricity acounts for the majority of the energy costs of the primary aluminium sector. Between 2008 and 2017 the share of electricity costs as a share of production costs increased from 28.7% to 38.3%, even though the absolute changes of both electricity and production costs in €/tonne decreased over the same period. The share of natural gas costs as a share of production costs remained relatively stable at between 1.3% and 1.9% during the same period;

[79] Based in the results of own analysis from collected questionnaires of EU27 refineries.
[80] Solomon Associates (2019) via Concawe. Shares are the result of dividing energy costs (USD/bbl) by Cash OpEx (USD/bbl) for the EU28 for years 2016 and 2018. Cash OpEx is the sum of personnel costs, energy costs and other costs.
[81] CEPS and ECOFYS (2018) Composition and drivers of energy prices and costs: Case studies in selected energy intensive industries – 2018. Final report. DOI 10.2873/004141

- Steel: For the Electric Arc Furnace (EAF) steel sector the electricity costs represented around 10% of total production costs between 2008 and 2017. Natural gas costs represented 3% of the total production costs. In the case of the Basic Oxygen Furace (BOF) steel sector the electricity costs were smaller than those of EAF steel, at around 3% of total production costs, while natural gas costs were between 1-2%.

4.3.5 COVID-19 pandemic and its impacts on energy costs of selected EIIs

During the interactions and discussions with the different industry associations between June and September 2020, we received feedback regarding the possible impacts of COVID-19 on energy costs and their economic consequences for the different industries.

In the short term, most of the manufacturing sectors consulted have been substantially impacted by the COVID-19 crisis. COVID-19 has curbed significantly demand for products, reducing the sales revenues of industrial sectors and triggering reductions of production output in plants.

For the Refineries sector, the lockdown measures had huge consequences on the petroleum product demand, as the transport of people and goods were heavily restricted. In countries with a strict lock-down, such as France, Italy and Spain, the demand for diesel and gasoline dropped by 60 to 80% yoy. Regarding jet fuel, the impact was even worse with the demand reduced by 80 to 95% yoy, and recovery post lock down being much slower. In response to negative net margins, many refineries have reduced to minimum operating capacity.

In the case of the Flat glass sector half of the manufacturing sites were put "on hold"[82] by reducing flat glass furnace temperatures to 1200°C (normally they work at 1500-1600°C). As a result, energy costs per tonne of product will likely spike in 2020, reaching around 20 to 40% higher levels compared to 2019.

Manufacturing operations were able to continue in the Zinc sector, however Zinc consumers often stopped their operations. This resulted in depressed demand and large stockpiling of zinc. The sector expects that production output will fall by around 15% in 2020 (compared to 2019 levels).

Similarly, in the Ferro-alloys and silicon sector production cutbacks and closures of companies already started. COVID-19 impacts in the medium to long-term are also expected by the sector. Since Global steel production has dropped, Ferro-alloys stocks increased. A surge of international imports is expected after the immediate crisis, together with aggressive policies from non-EU countries to revitalise their economies (e.g. product dumping into EU) in order to reduce excess stocks. As an example, China is reportedly planning to revoke export taxes for ferro-alloys as an incentive to resume production.

Finally, the EU fertiliser industry has been able to maintain its production operations during the crisis mainly due to the sector being recognised as indispensable part of the food-chain. As a result, the Fertilisers sector was the only one that reported only a limited impact in their products demand and operations due to COVID-19.

[82] The "hot hold" is a means through which to avoid shutting down furnaces, as furnaces need to be completely rebuilt after full shutdowns, at the cost of tens of millions of euros and several months dedicated to the rebuild.

That said, in this context of low production and sales, it is important to assess what role energy costs play in the economic situation of most energy intensive industries. COVID-19 induced economic crisis and mobility restrictions have prompted a very significant fall in energy prices during the first half of 2020 (as signalled in the first chapters of this document). The sudden and notable fall in energy prices is not being followed by equivalent declines in the costs of other non-energy production inputs. Operational production costs were reduced as much as possible (especially thanks to the technical unemployment and other short-term aid programmes), but most of the other costs (e.g. renting of offices, plants and payments of interests) didn't change. All this implies that that for sectors that are able to continue or modulate their production and accordingly adapt their energy consumption, the purchases of energy (the energy costs) should fall much more than the expenditure related to other non-energy production costs, resulting in lower shares of energy costs compared to production costs.

In certain cases, energy costs still have a role in eroding profits in certain energy intensive sectors. This is the case for sectors which have an important amount of their energy consumption that is fixed or cannot be reduced along with the decline in output. In these cases, the firm could be suffering a disproportionate increase in the share of their energy costs in production costs (as is the case of the Flat glass sector).

4.4 Decomposition analysis of energy costs

4.4.1 Key findings

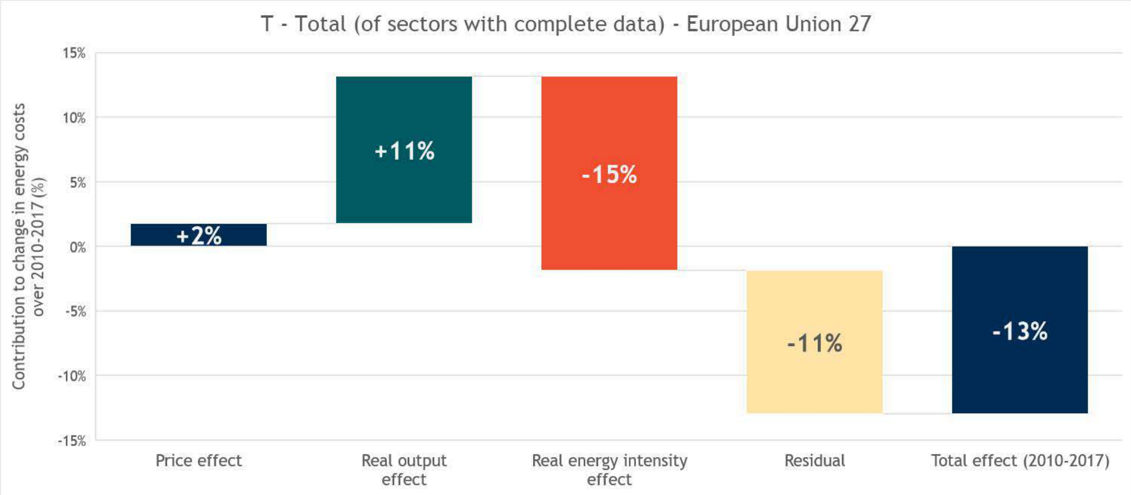
At an aggregate level across all the manufacturing sectors considered, energy costs for EU industry over the period 2010-2017 decreased by ~13%. Increasing industrial sector output, predominantly driven by domestic demand, has increased the industrial demand for energy as a production input and increasing energy prices, especially electricity prices, have pushed energy input costs upward. However, this upward pressure on energy costs has been entirely offset by improvements in energy intensity, which for the most part have come directly from improvements in energy efficiency rather than changes in the structural composition of industry or fuel switching.

Decomposition of energy costs:

- The decomposition approach (using the Log Mean Divisia Index (LMDI)) shows, for a given percentage change in energy costs over time, the extent to which this change is attributable to changes in the three main components of energy costs:
    - Real output effects - the effect of changes in industry production leading to changes in demand for energy as a production input. This is broken down further into domestic demand and trade effects;
    - Real energy intensity effects - the effect of changes in energy per unit of output over time due to energy efficiency measures, fuel mix and industry structural change;
    - Fuel price effects - the effect of changes in current coal, gas, oil and electricity prices on energy costs.
- The summary findings for each of these effects are discussed below:

Source: Study on energy prices, costs and their impact on industry and households

Figure 4-25 Breakdown of drivers of the changes in energy costs over the period 2010-2017 (EU27 average across all industry sectors considered)



Source: Own estimates

Real output effect

- Output increased in most EU27 industry sectors increasing industrial energy use and costs (in absolute terms). Energy intensive sectors[83] had the lowest output growth, while sectors with lower energy intensity generally saw higher output growth;
- Two sectors, manufacture of coke and petroleum products and the manufacture of furniture, registered falling output;
- For most industry sectors, output growth was driven by growth in demand within the EU27 (domestic demand), implying that the EU's international competitiveness in manufacturing has remained relatively unchanged over the period. A few industry sectors saw an improvement in trade that contributed to the increase in sector output:
  - Pharmaceuticals sector where net exports grew substantially over the period;
  - Motor vehicles and transport equipment, where exports growth outweighed import growth.
- By contrast, a few sectors saw a reduction in the net trade position:
  - For computers and electronics and the manufacture of textiles imports grew faster than both exports and domestic demand, suggesting a loss of EU competitiveness despite increasing domestic demand and export growth.
- Sectoral output has generally increased over time in the EU's main trading partners, driving up energy demand and therefore costs with the exception of the UK where industrial output has contracted since 2010.

Real energy intensity effects

- For aggregated industrial sectors in the EU27, an improvement in energy intensity contributed to a reduction in energy costs between 2010-2017. This trend is reflected in all but two industry sectors (coke & petroleum and Wood products);
- The largest reduction in energy intensity was observed in the less energy intensive sectors. This reduction in energy intensity typically happened in sectors where output had increased.

[83] Energy intensive sectors for the analysis refers to the six manufacturing sectors with the highest energy intensity (Energy consumption per unit of turnover). The energy intensive sectors are Chemicals, Paper & Paper Products, Basic Metals, Coke & refined Petroleum, Other non-metallic minerals and wood & wood products.

There are two plausible explanations for this. First that the reduction in energy intensity came through economies of scale. Second, fast output growth might have also led to investments in new, more efficient, industrial equipment and factories;

- The most energy intensive industries saw much smaller improvements in energy intensity over the period. This could be because these industries have already invested heavily in energy efficiency to maintain international competitiveness;
- The energy intensity effect was analysed further to see the extent to which industry structural change or fuel switching contributed the improvements in energy intensity observed over the period. Overall, neither structural change nor fuel switch was found to be a substantial driver of the energy intensity effect. This suggests that real energy efficiency improvements drove the reduction in energy intensity over the period;
- As in the EU27, industrial sectors in the US, and China have generally experienced improvements in energy intensity that have driven down energy costs over time. Overall China saw the largest reductions in energy intensity than the EU over the period although in many sectors, the average energy intensity in the EU is still much lower especially for lower energy intensive sectors. This aligns with the detailed international comparison shown in the earlier section 4.2.2 where EU27 is among the least energy intensive regions.

Fuel price effects

- In most EU27 industry sectors, increases in average energy prices have contributed to an increase in energy costs over the period 2010-2017. This is largely driven by increases in industrial electricity prices;
- Sectors where oil, coal or gas make up a larger share of the energy mix have seen smaller impact of energy prices on energy costs, as prices have fallen for these fuels over the period;
- Within the EU27, large relative increases in output are evident in countries where the average prices has decreased and large decrease in output are evident in countries where the average price has increased between 2010-2017. This suggests that energy prices impacted output growth for some industry sectors;
- Average Energy prices increased over the period for most country-sector combinations in the EU27's major trading partners (US, UK, and China) as with the EU27 this was driven by higher electricity prices;
- We observe that for most sectors there is a positive price effect and a negative energy intensity effect, suggesting that higher prices might have been an important element in driving down energy costs through improved real energy efficiency improvement.

EU27 Data concerns (residual effects)

- Comparing the EU27 energy costs estimated from its components (price and energy consumption) with the Eurostat SBS purchase of energy products shows there is a residual effect contributing to the evolution of energy costs. The residual effect for most sectors shows a negative bias implying we are not capturing some factor reducing energy cost over the period;
- This residual effect encapsulates some known limitations of the analysis:
  - Price trends of other fuels - energy price data is only available for the four main fuels (coal, electricity, gas, oil). Some sectors have large shares of alternative fuels (biomass, waste & heat) in their fuel mix which we cannot capture in the price effect. Examples include Wood & Paper (high use of biomass and waste) and Chemicals (High use of heat);

- Addition exemptions from taxes & levies **-** In the analysis we use average industry prices for each fuel (excluding VAT and recoverable taxes) however for some energy intensive, there are other specific exemptions from taxes and levies. These could include sectors such as the manufacture of Chemicals and Basic Metals;
- Issues with the underlying data - This includes missing data or inconsistencies in the Eurostat SBS data, which is based on a survey of businesses.

- Regression analysis shows that across the whole manufacturing sector and EU27, the individual drivers of turnover, average energy prices and energy intensity do explain a reasonable proportion of the variance in SBS energy cost data.

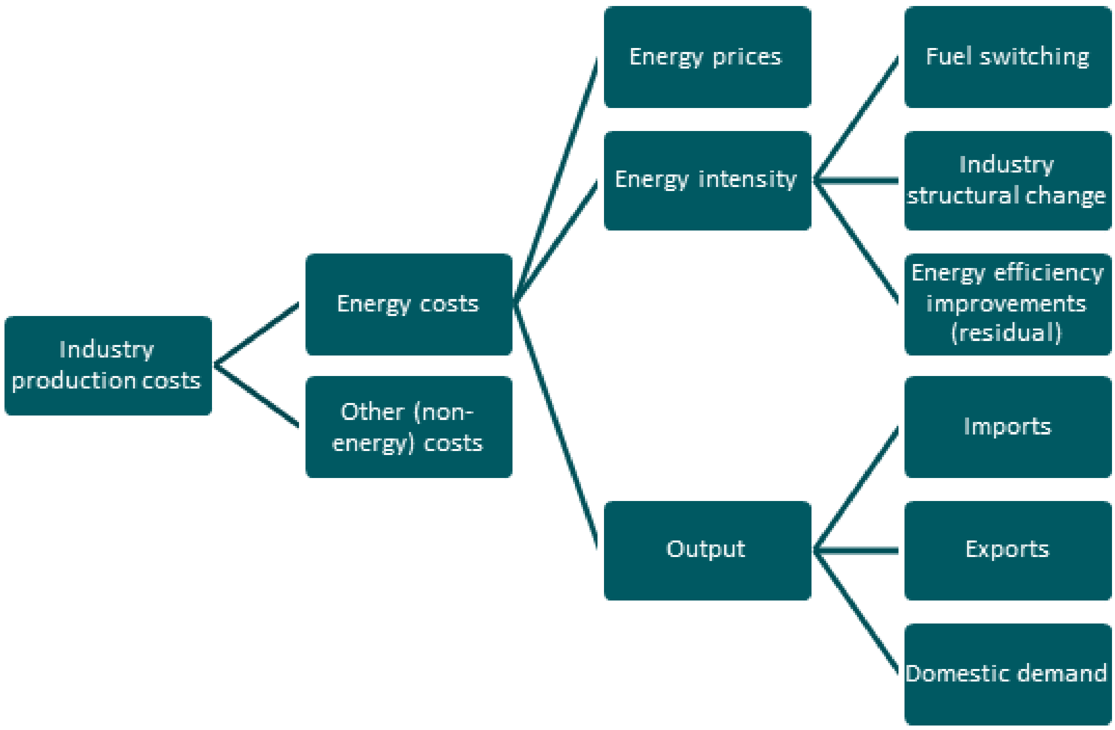
Energy Costs contribution to Production costs

- At the EU27-level, an increase in total industry production costs over the period is almost entirely explained by increases in other (non-energy) costs. Energy costs have contributed to a very small, almost insignificant, reduction in total production costs;
- Furthermore, the share of energy costs as a proportion of total production costs is lower in 2017 when compared to the share in 2010 for most industrial sectors;
- Estimated **energy costs in the EU's main trading partners (US, UK, and China) have** generally increased over the past years.

4.4.2 *Introduction*

The purpose of this sub-task is to understand how energy costs have affected industry production costs and competitiveness in EU27 and G20 regions. To do this, the analysis that was created for the 2018 version of this study was developed and extended. As indicated in Figure 4-26 we firstly assess the role of energy costs in affecting total production costs and competitiveness and then decompose the various drivers of changes in energy costs.

Figure 4-26 Overview of the decomposition analysis of industry production costs and energy costs



The decomposition analysis is comprised of four interrelated parts:

1. A decomposition of industry production costs into energy costs and other (non-energy) costs. This relies on Eurostat SBS data at the NACE 2-digit level for the EU27 and was not carried out for G20 countries due to limited data availability;
2. A decomposition of energy costs into average energy prices, sectoral output, and energy intensity effects. For EU27 countries, this relies on Eurostat SBS data at the NACE 2-digit level, Eurostat energy consumption data at the NACE 2-digit level, and (NACE 2-digit and 3-digit) energy prices collected in Task 1:
    a. Where data inconsistencies still lead to an unexplained residual for EU27 countries, a regression analysis is used to identify the significance of the drivers of energy costs. The rationale for this approach is that, in some cases, there are legitimate reasons why energy costs (as calculated from prices and consumption) are not consistent with the Eurostat SBS data for energy purchases. For instance, this could be due to differences in fuel coverage, price discounts, or tax exemptions that are available to certain industries. In these cases, the regression analysis can be a useful tool for explaining the most important drivers of changes in energy purchases (as reported in Eurostat SBS) over recent years.
3. For G20 countries, the database prepared in Subtask 2.1, the OECD STAN database, Asian Development Bank data, and the IEA world energy balances are used;
4. A decomposition of output effects into imports, exports, and domestic demand. This relies on the OECD STAN database, the Eurostat SBS database, and the database prepared in Subtask 2.1;
5. A decomposition of energy intensity into fuel switching, industrial structural changes, and energy efficiency improvements. This relies on Eurostat SBS database, and energy consumption data processed for the main energy decomposition analysis.

Addressing challenges from the 2018 study

The preparation of the 2018 study showed that there are two main challenges in this task:

1. Dealing with the issue of relative scarcity of data (over time/ by region); and
2. Dealing with large residuals (unexplained part of the decomposition) in the decomposition analysis of EU27 energy costs due to inconsistencies between different data sources (i.e. energy costs data calculated bottom up from the various components, versus the energy purchases data available from Eurostat SBS).

Although these challenges have partially been addressed when the database used in the 2018 project was updated for this project, significant data gaps still existed after the database was populated with published data. To account for this, several data filling techniques were applied to the EU27 and G20 raw data to reduce the effects of data scarcity and large unexplained residuals.

The decomposition analyses are carried out at the industrial NACE 2-digit level. Although carrying out the analysis at the NACE 2-digit level increases data reliability, the trade-off is a reduction in the detail of information about the drivers of changes at the sub-sector level. However, more granular NACE 3 or 4-digit data was not reliable or comprehensive enough for this analysis. Therefore, the decomposition analysis that follows relies on data collected in previous subtasks but at a higher sectoral aggregation.

4.4.3 Decomposition analysis of energy costs

Changes in energy costs over time are driven by a range of factors. By decomposing the different components that drive energy costs, this analysis can provide some insight about how these drivers have changed over time and assesses the extent to which changes in drivers have contributed to changes in the total energy costs over recent years for selected industrial sectors. The sectoral aggregation used for EU27 countries are shown in Table 4-10 and in Table 4-11 for the G20 countries.

Table 4-10 Sector scope of the EU27 decomposition analysis

Section	Code (NACE 2)	Description
C - Manufacturing	C10_C12	Manufacture of food products; beverages and tobacco products
	C13_C15	Manufacture of textiles, wearing apparel, leather and related products
	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	C17	Manufacture of paper and paper products
	C19	Manufacture of coke and refined petroleum products
	C20	Manufacture of chemicals and chemical products
	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	C22	Manufacture of rubber and plastic products
	C23	Manufacture of other non-metallic mineral products
	C24	Manufacture of basic metals
	C25	Manufacture of fabricated metal products, except machinery and equipment
	C26	Manufacture of computer, electronic and optical products
	C27	Manufacture of electrical equipment
	C28	Manufacture of machinery and equipment n.e.c.
	C29	Manufacture of motor vehicles, trailers and semi-trailers
	C30	Manufacture of other transport equipment
	C31_C32	Manufacture of furniture; other manufacturing
	C33	Repair and installation of machinery and equipment
	T	Total (Of sectors with complete data)

Table 4-11 Sector scope of the G20 decomposition analysis

Section	Code (NACE 2)	Description
C - Manufacturing	C10_C12	Manufacture of food products; beverages and tobacco products
	C13_C15	Manufacture of textiles, wearing apparel, leather and related products
	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	C17	Manufacture of paper and paper products
	C19_C21	Manufacture of coke, refined petroleum products, chemicals and chemical products, basic pharmaceutical products, and pharmaceutical preparations
	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	C22_C23	Manufacture of rubber, plastic products, and other non-metallic mineral products
	C24	Manufacture of basic metals

Section	Code (NACE 2)	Description
	C25	Manufacture of fabricated metal products, except machinery and equipment
	C26	Manufacture of computer, electronic and optical products
	C27	Manufacture of electrical equipment
	C28	Manufacture of machinery and equipment n.e.c.
	C29	Manufacture of motor vehicles, trailers and semi-trailers
	C29_C30	Manufacture of motor vehicles, trailers and semi-trailers, and other transport equipment
	C30	Manufacture of other transport equipment
	C33	Repair and installation of machinery and equipment

To isolate the impact of fundamental drivers of energy costs over time[84], we carry out a decomposition using the Log Mean Divisia Index (LMDI). The LMDI was first used by Ang et al (1998)[85] and is one of many methods of index decomposition analysis applied in the academic literature to assess changes in energy consumption and costs. The results from the additive LMDI show, for a given percentage change in energy costs over a time period, the extent to which this change is attributable to changes in each driver over the same period.

As shown below, energy costs can be defined as the product of industry output[86], energy consumption per unit of output (i.e. energy intensity), and the price of energy consumed:

$$Energy\ costs\ =\ Output(constant) \times \frac{Energy}{Output\ (constant)} \times\ Price\ of\ energy$$

Consistent with the equation above, using the LMDI method, the key drivers of energy costs that are isolated and quantified are:

- Real output effects - the effect of changes in production;
- Real energy intensity effects - the effect of changes in energy per unit of output over time due to energy efficiency measures, behavioural changes, industry structural change;
- Fuel price effects - the effect of changes in current coal, gas, oil and electricity prices.

$$\Delta Energy\ Costs\ = (real)\ output\ effect +\ (real)\ energy\ intensity\ effect + energy\ price\ effect$$

For EU27 Member States, the result of this calculation of energy costs from the individual components (by industry sector and Member State) is compared to the Eurostat SBS 'Purchases of Energy Products' data. The difference between the calculated change in energy costs and the change in energy costs according to published SBS data is isolated and presented as residual effect. This residual effect captures drivers of change in energy costs that are unidentifiable from the available energy

[84] The EU27 data set is mostly complete over 2010-2017. Therefore, the analysis has been restricted to only cover that time period. The G20 dataset is mostly complete over 2010-2016, restricting the analysis to a shorter timeframe.
[85] Ang et. al (1998), 'Factorizing changes in energy and environmental indicators through decomposition' *Energy, 1998, vol. 23, issue 6, pages 489-495*
[86] Turnover is used as the activity indicator. Alternative activity indicators include GVA, however, the issue with using GVA as an activity indicator is that, if intermediate consumption of energy falls (e.g. due to energy efficiency improvements), then, by definition, GVA will increase, as the total cost of energy would be lower for the same level of output. This would lead to a bias in the results, as we would underestimate the output effect.

consumption and price data. The residual effect is not estimated for G20 countries as energy costs are estimated using the individual components (energy prices x consumption) rather than published data, leading to no residual by design.

The output, energy intensity, fuel price and residual effects are estimated for a selected group of industrial sectors (some of which are energy-intensive) in each Member State. The sections below describe in more detail these three drivers of energy costs, how they are estimated, and where the required data is sourced from.

The real output effect

The real output effect incorporates the effects on energy costs resulting from changes in the level of industry production. This might include, for example, the effect of an economic recession, a boost to trade resulting from exchange rate movements, an increase in demand for a product, or reduced production due to international competitive pressures. This measure is not a perfect reflection of changes in physical output, but it is a close proxy.

Constant price gross output data (by industry sector) was used to measure the effect of changes in productive activity on energy costs in each industry sector. By using constant price data (deflated using sector-level deflators), we control for changes in sectoral price, and this indicator therefore only reflects changes in real production volumes. For the EU27 countries, constant price gross output is calculated using current price turnover data from Eurostat SBS, deflated using sector-specific deflators (at the NACE 2-digit level) from Eurostat[87]. For G20 countries, the metric is calculated using current price gross output data from the OECD STAN database[88], deflated using deflators derived from the OECD and the World Bank. Moreover, Input-Output tables and key deflators prepared by the Asian Development Bank were used to fill the gaps for some G20 countries and sectors when additional data is available[89].

The real energy intensity effect

The sum of the energy intensity effect and the output effect reflect the total impact on energy costs due to changes in energy demand. To estimate energy intensity by industry sector, by country, and in each year over the time period[90], we take the ratio of total energy consumption per unit of real output. Since the decomposition analysis is carried out at the NACE 2-digit level, total energy consumption data collected under Subtask 2.1 was used for industrial sectors in Table 4-10 and Table 4-11. However, since the other industrial sectors could not be fully aggregated up to their corresponding NACE 2-digit level, data from the Eurostat's energy and supply use database[91], DEStatis' energy use of local units in manufacturing database[92], and the IEA world energy balances[93] were extracted and used.

To fill in missing energy intensity estimates, the following filling technique is used for EU27 countries:

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[87] Eurostat (2020), National accounts aggregates by industry (up to NACE A*64) [nama_10_a64], Accessed on 20 May 2020.
[88] OECD (2020), Structural Analysis (STAN) Database - Production gross output (current prices), Accessed on 11 June 2020. Available at: https://stats.oecd.org/Index.aspx?DataSetCode=STAN
[89] Asian Development Bank (2019), Input-Output Tables for 2010 to 2017, Accessed on 12 March 2019
[90] 2010-2017 for the EU27 and 2010-2016 for G20 countries
[91] Eurostat (2020), Energy supply and use by NACE Rev. 2 activity [env_ac_pefasu], accessed on 16 June 2020.
[92] DEStatis (2020), Energy use of local units in manufacturing database, accessed on 24 June 2020, Available at: https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Energy/Use/Tables/energy-consumption-branch.html
[93] IEA (2019), World energy balances

1. For country-sector combinations where energy intensity could not be estimated in all of the years between 2010-2017 because energy consumption data, output data, or both are unavailable, the energy intensity effect was estimated using sectoral EU27 averages using data from countries where both variables are available. Therefore, in those countries where data is unavailable, the sectoral energy intensity effect is assumed to be the same as the EU27 average[94];
2. For country-sector combinations where only some energy intensity estimates are missing and some could be estimated, the EU27 sectoral average energy intensity growth rates for that sector are used to fill in the missing energy intensity values.

Since energy intensity is the ratio of total energy consumption per unit of real output, and since the above filling technique provided energy intensity estimates for each EU27 country-sector combination, missing some total energy consumption or turnover data are estimated by changing the subject of the energy intensity formula.

G20 energy intensity estimates were not filled in in any way. Although applying a regional sectoral average might be a reasonable assumption for the EU27, the differences between G20 countries is too large to assume that the sectoral average energy intensity applies throughout. Therefore, there is no data filling applied to the components making up the energy intensity estimate or the estimate itself.

The energy price effect

The energy price effect captures the effect of changes in weighted-average energy prices on energy costs faced by firms. The price effects are estimated by combining estimates of the energy mix at a sectoral level and energy price data (by fuel type) over time. This provides an average energy price indicator that reflects changes in the energy prices faced by each industry sector.

For the purposes of this analysis, annual country-sector specific prices for coal, electricity (industry prices), gas, and low sulphur fuel oil are used, Hence, the weighted-average energy prices used in the decomposition analysis only account for these fuels[95]. Moreover, averages of the country-sector-fuel specific price data collected for NACE 3-digit sectors were used as proxies for their corresponding NACE 2-digit sectors listed in Table 4-10 and Table 4-11.

Similar to the total energy consumption data used in the real energy intensity effect, fuel specific consumption data was collected using the Subtask 2.1 database, the Eurostat energy and supply use database, DEStatis data, and the IEA world energy balances. This data were used to estimate annual fuel mix shares for each country-sector combination. These are used in conjunction with fuel price data to estimate the average energy prices. This dynamic approach is an improvement on the methodology used in the 2018 study, which applied constant EU average sectoral fuel shares over the analysis period.

[94] The average of EU27 countries where both turnover and total energy consumption is available for all years between 2010 and 2017.
[95] Although these are the four major fuels used in industry, EU27 country-sector price data for other fuels which may potential be important in some sectors (such as bioenergy, renewables, and heat) are not collected.

To calculate the effects of energy prices on industry energy costs, we weight the prices of individual fuels, using country-sector fuel mix shares[96]. Since these shares are dynamic over the analytical time horizon, the energy price effect partially captures the fuel switching effect over time. As no data is available for 'other' fuel prices (biomass and heat), we implicitly assume that the price of 'other fuels' grows in line with the weighted-average energy price (considering coal, oil, natural gas and electricity prices).

Prior to estimating country-sector weighted-average energy prices, the following data filling techniques are used:

1. All countries:
    a. Since annual fuel mix shares are used for each country-sector combination, rather than static averages, there have been instances when energy consumption data for one or more fuel is missing. Since missing data will skew the fuel mix shares, the previous or following year's country-sector specific fuel mix is applied in these cases;
    b. The preferred prices used for the analysis are in current terms and exclude all recoverable costs and levies (such as VAT);
    c. If the preferred country-sector specific price series is completely missing but country-sector specific prices including taxes, levies, or recoverable costs are available, these are utilised;
    d. If the preferred country-sector specific price series is partially missing, the ratio between the values of the preferred and next best price series is used to deflate price estimates and fill in the missing gaps.
2. EU27 countries:
    e. If all values in the country-sector specific price series are missing, the EU27 average sectoral prices for the fuel are used. For each fuel, in each sector, this is estimated by taking the weighted average price in each country with a complete price series weighted by that country's total energy consumption.
3. G20 countries:
    f. If no country-sector specific coal or oil price series are available, the G20 industry (all industry sectors available) average is used if the entire price series is blank and the G20 industry average growth rates are used if the price series is partially missing. No data filling techniques were used to fill in G20 electricity and gas prices as these are bound to local, rather than global, shifts in energy prices.

The residual for EU27 countries

There are some inconsistencies between the historical energy costs data that are available from different sources. For this analysis, it is important to isolate and quantify the key drivers of energy costs at a sectoral level. To do this, we use published data for each component of the decomposition. Given the data limitations, we believe that this approach is the most robust way to quantify the relative impact of the various drivers of energy costs.

[96] To calculate a representative price for each industry sector at the EU27-level, the implied average price is estimated as the cost of energy products per unit of total energy consumption. In this case, a estimate of energy costs from individual components is used and the EU27 average price only uses data for Member States with complete data for the period 2010-2017.

However, the result of our calculation of energy costs (by sector) from the individual components for EU27 countries is, in some cases, different to the published Eurostat SBS data for 'Purchases of Energy Products' and so there appears to be a large unexplained component. The mis-match between our component calculation and the 'Purchases of Energy Products' data from the Eurostat SBS is isolated and is saved as a residual term. The residual, in part, captures the effect of fuel switching over the period. This is because only four major fuels are considered in the analysis of price effects and, therefore, the residual captures the switch to other fuels such as renewables, bioenergy, and heat. However, it is unlikely that fuel switching alone accounts for much of the data discrepancy. Another reason that the residual term may show a large discrepancy between the Eurostat SBS data and our calculation of energy costs from the individual components is because the energy prices used within the decomposition analysis do not capture industry specific effects, such as tax exemptions, that may affect the cost of energy. Although prices excluding taxes and recoverable costs where used when possible, the section related to the price effect explains that prices including taxes, and sectoral EU27 average prices are used due to data limitations.

The unexplained residual component is not attributed to any of the effects, as it is not currently possible to identify the reason for this data discrepancy. The data discrepancy is likely to arise from issues with the underlying data. As mentioned in the section above, there are a lot of missing data, such as for energy consumption and turnover. In these cases, data gaps are filled using the technique outlined in the previous sections. In some cases, this means relying on trends from a few countries to predict the wider sectoral trends at the EU27 level. It is therefore possible that our residual term is partly picking up some energy intensity effects that were impossible to identify from the limitations in the energy consumption and turnover data that was available. On the other hand, the data inconsistencies could be explained by inconsistencies in the Eurostat SBS data, which bases industry sectoral trends on results from a survey of businesses. These data discrepancies are important to be aware of when interpreting the results and making comparisons to the results reported earlier in this chapter.

The residual term is isolated and quantified for the decomposition analysis. For the purposes of this analysis, the change in energy costs over time is thus defined as:

$$\Delta Energy\ Costs\ = (real)\ output\ effect +\ (real)\ energy\ intensity\ effect + price\ effect + residual$$

In cases where the new costs, prices and consumption data is consistent and the residual is small and insignificant, we will use a standard decomposition method (e.g. Log Mean Divisia Index). However, we acknowledge that there will be cases where data inconsistencies lead to an unexplained residual, we will draw on regression analysis to decompose the drivers of energy costs.

In summary, we have identified three reasons which could explain large residual effects in the decomposition of energy costs:

1. Uncaptured fuel switching effects as a result of other fuels not accounted for in the analysis. These include renewables, bioenergy, and heat. A preliminary review of the data shows that the EU27 sectors which are likely to have a large residual effect because of uncaptured fuel switching effects are:
   a. *Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16);* and
   b. *Manufacture of paper and paper products (C17).*

2. Uncaptured industry specific price effects such as tax and levy exemptions. These uncaptured exemptions are likely to affect the results of some energy intensive EU27 sectors such as:
   c. *Manufacture of chemical and chemical products (C20)*; and
   d. *Manufacture of basic metals (C24)*.
3. Issues with the underlying data such as missing data leading to some country-sector combinations heavily relying on data filling techniques or inconsistencies in the Eurostat SBS data. This issue is not sector-specific and will be explored further in the regression-based analysis.

To ensure that the reader is aware of these caveats while reviewing the main EU27 energy decomposition results, an asterisk (*) will be used when reviewing results related to the manufacture of wood (C16*), paper (C17*), chemicals (C20*), and basic metals (C24*)

Specification for the regression-based analysis for EU27 countries

As highlighted, the unexplained residual effect can be quite large for some sectors as such reflecting period specific discrepancies between the individual components of energy costs and the SBS purchases of energy costs series. To look at how well the variation in individual drivers explain variations in the purchase of energy costs, we will carry out regression analysis.

Due to the short time series of data available, we are using panel estimation techniques for the regression analysis. The panel regression will be run across all EU Member States and all energy-intensive industry sectors. Further panel regressions can then be run for alternative groupings (for example, for the same industry across all Member States, or all industries, in the same Member State).

The specification of the equation to be estimated is, in its simplest form:

$$\text{Energy costs} = \beta_0 + \beta_1 \text{ Energy Price} + \beta_2 \text{ Energy Intensity} + \beta_3 \text{ Turnover} + \varepsilon$$

Where:

- Energy costs is the natural logarithm of energy purchases data, as reported in Eurostat SBS;
- Energy prices is the natural logarithm of energy price data published by Eurostat (after mapping energy consumption bands to industry sectors and using energy consumption data to weight prices for each fuel type);
- Energy intensity is the natural logarithm of energy consumption per million euros of Turnover (taken from Eurostat SBS database);
- Turnover is the natural logarithm of industry turnover, as reported in Eurostat SBS.

EU27 Results

The analysis and discussion of results will focus on those sectors and regions where the data is most consistent and, for the regression analysis, where estimated relationships are positive and statistically significant, since we have most confidence in drawing conclusions in these cases. This section of the report investigates the results at the EU27-level[97] for all industrial sectors explored, in aggregate and individually. The decomposition analysis on industry energy costs was also carried out at the Member

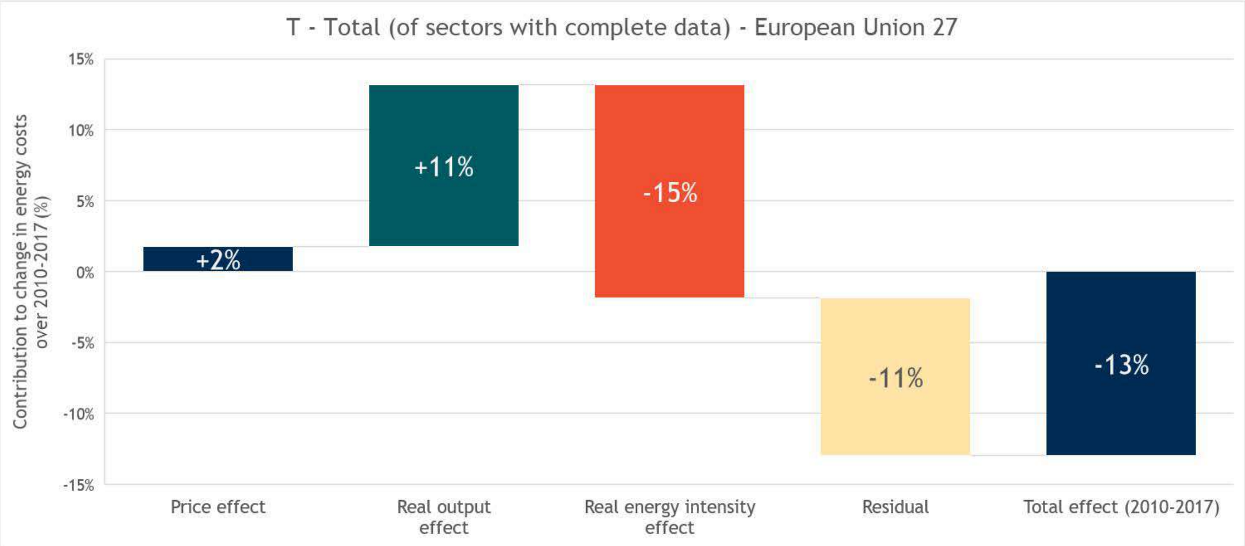
[97] It is important to note that EU27 aggregate are based on Member States which have complete datasets after all data filling techniques have been utilised. For instance, if turnover data is fully available for a Member State, but energy consumption data is not, then the EU27 aggregate does not account for this Member State. This is because the output effect would have been captured but not the energy intensity.

State level, and much of the variation can be explained by Member State-specific drivers i.e. where growth in energy prices, industry production and energy intensity have not followed EU average trends.

The drivers of change in energy costs for aggregated industrial sectors at the EU27 level are shown in Figure 4-27[98]. The figure shows that the Eurostat SBS data suggests that energy costs fell by 13% between 2010 and 2017. A reduction in energy costs was mainly driven by energy intensity improvements, which reduced energy costs by -15%. A reduction in energy costs brought about by improved energy intensity was offset by higher costs resulting from higher average energy prices (+2%) and higher costs as a result of increased real output over time (+11%). Although the energy intensity effect dominates at the EU27 level, a significant portion of the reduction in energy costs are unexplained (when compared to the component data that is available). In fact, the unexplained residual accounts for a -11% reduction in energy costs.

As previously described, the residual cannot be solely attributed to any individual effect. It may partially capture the effects of fuel switching; industry specific price effects (such as tax exemptions) which are not accounted for in this analysis; issues related to our treatment of missing data; or issues related to the raw data's estimation methodology, which is based on a survey of businesses.

Figure 4-27 Breakdown of drivers of the changes in energy costs over the period 2010-2017 (EU27 average across all industry sectors considered)



Source: Own estimates

Table 4-12 below presents EU27 results for each industry sector considered. The table lists the proposed industrial sector according to their energy intensity ranking in 2017. Therefore, in 2017, the *Manufacture of chemical and chemical products (C20*)* was the most energy intensive sector at the EU27-level and the *Manufacture of other transport equipment (C30)* was the least energy intensive.

[98] Estimates for the price, output, and energy intensity drivers are not themselves compound growth rates for the respective driver (which are not additive) but reflect each driver's contribution to the total change in energy costs over the period. The residual effect is derived as the difference between our calculation of energy costs from individual components and the 'purchases of energy' data reported in the Eurostat SBS.

In general, Table 4-12 shows that at the EU27 level, energy costs have decreased in all sectors except for three sectors with a relatively low energy intensity[99]. Generally, the real energy intensity effect has had the largest impact on changes in energy costs. This is followed by the unexplained residual effect, the real output effect, and the price effect, respectively. The results presented in Table 4-12 are also presented in Annex F as figures which depict the breakdown of energy cost driver for manufacturing sectors at the EU27 level.

Table 4-12 Decomposition of energy cost drivers at the EU27 level over the period (2010-2017)

Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual	Total effect	2017 EU27 Energy Intensity (toe per million €)
High energy intensive sectors							
C20*	Manufacture of chemicals and chemical products	-4.2%	2.0%	-6.8%	-5.6%	-14.6%	190.8
C17*	Manufacture of paper and paper products	0.7%	7.9%	-9.6%	-27.7%	-28.7%	182.3
C24*	Manufacture of basic metals	4.7%	12.7%	-12.8%	-24.2%	-19.6%	174.1
C19	Manufacture of coke and refined petroleum products	-6.3%	-34.4%	37.6%	-5.4%	-8.6%	158.8
C23	Manufacture of other non-metallic mineral products	1.3%	0.8%	-15.3%	-3.1%	-16.4%	158.2
C16*	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	10.2%	-2.2%	11.0%	-25.7%	-6.7%	75.5
Lower energy intensive sectors							
C10_C12	Manufacture of food products; beverages and tobacco products	6.7%	10.2%	-6.0%	-13.0%	-2.1%	26.9
C22	Manufacture of rubber and plastic products	2.4%	10.4%	-37.1%	22.0%	-2.3%	22.4
C13_C15	Manufacture of textiles, wearing apparel, leather and related products	8.1%	-1.4%	-9.9%	-48.7%	-51.8%	21.5
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	11.6%	14.7%	-32.3%	-3.8%	-9.8%	19.3
C25	Manufacture of fabricated metal products, except machinery and equipment	10.1%	9.3%	-14.5%	-13.2%	-8.4%	17.5
C31_C32	Manufacture of furniture; other manufacturing	2.2%	4.4%	-10.9%	-4.0%	-8.3%	11.0

[99] *Repair and installation of machinery and equipment (C33), Manufacture of machinery and equipment n.e.c. (C28), and Manufacture of motor vehicles, trailers and semi-trailers (C29)*

Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual	Total effect	2017 EU27 Energy Intensity (toe per **million €)**
C33	Repair and installation of machinery and equipment	16.7%	-5.4%	-5.7%	0.3%	5.9%	10.1
C28	Manufacture of machinery and equipment n.e.c.	13.6%	16.6%	-26.0%	-2.0%	2.1%	9.5
C27	Manufacture of electrical equipment	10.1%	4.6%	-15.3%	-14.8%	-15.4%	8.3
C26	Manufacture of computer, electronic and optical products	11.4%	14.7%	-11.1%	-23.8%	-8.9%	6.5
C29	Manufacture of motor vehicles, trailers and semi-trailers	6.9%	40.4%	-36.7%	-3.5%	7.0%	6.1
C30	Manufacture of other transport equipment	12.3%	42.0%	-60.5%	-3.0%	-9.2%	4.3
T	Total (Of sectors with complete data)	1.8%	11.4%	-15.0%	-11.1%	- 13.0%	50.6

Source: Own estimates based on the LMDI methodoloy and sorted according to energy intensity in 2017

Price effects

The results from the decomposition analysis show that, across almost all industry sectors analysed at the EU27 level, increases in current energy prices have contributed to an increase in current energy costs over the period 2010-2017.

The exceptions were two sectors which saw a reduction in energy prices contributing reduction in energy costs over the period, *Manufacture of coke and refined petroleum products (C19)* and *Manufacture of chemicals and chemical products (C20*).* The reduction in energy prices for these sectors is due to high reliance on oil consumption, as the price of oil (excluding taxes) has decreased over the period 2010-2017 in the EU27.

The sectors with the highest positive price effect on energy costs are:

- Repair and installation of machinery and equipment(C33);
- Manufacture of machinery and equipment n.e.c.(C28);
- Manufacture of other transport equipment(C30); and
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21).

Three out of these four sectors (C33, C28, and C30) heavily depend on electricity as their main form of energy consumption and the price of electricity for industry has risen notably for many EU27 Member States. This is driven by an increase in network costs and taxes as the wholesale price of electricity decreased over the period. The price of electricity excluding VAT and other recoverable costs feed into the estimation of the average energy price as it better reflects the cost faced by industry without any additional tax exemptions.

The four sectors which exhibited the highest positive price effect on energy costs are medium or low energy-intensive sectors. *Repair and installation of machinery and equipment (C33)* registered the highest positive price effect at 16%. In this sector, electricity accounts for approximately half of total energy consumption at the EU27-level. An increase in electricity price has been met with a decreased in EU27 sectoral output.

Germany, France, Italy, and the Netherlands are the four Member States with the largest share of total C33 EU27 sectoral turnover in 2017. Electricity is a main form of sectoral fuel consumption in Germany, Italy, and the Netherlands while gas consumption dominates in France. In Germany, electricity prices increased while gas prices decreased over the time period. This has led to some fuel switching from electricity to gas between 2010-2017[100] and an overall reduction in the average price of energy and energy costs. This signified that the sector is price responsive and can change its fuel requirements over time.
However, a decomposition of production costs, presented in the following section, shows that energy costs make up only a small portion of total production costs in the EU27.

On the other hand, Italy has seen a large increase in electricity prices paired with further sectoral electrification over time, leading to higher electricity costs. Although the average energy price has moved in different directions in these two countries, gross output has reduced in both. This, along with the sector's relatively low energy intensity and the fact that energy costs make up a small portion of total costs, suggests that the price of energy is not the only factor involved in sectoral changes in production.

The sectors with the lowest positive price effect are:

- Manufacture of paper and paper products (C17*);
- Manufacture of other non-metallic mineral products (C23);
- Manufacture of furniture; other manufacturing (C31_C32).

In each of these sectors, the price effect contributes to small changes in total change in energy costs (~2% or less). Although a subdued positive price effect might partially be an effect of natural gas being the primary fuel in *Manufacture of other non-metallic mineral* (*C23)* at the EU-27 level, electricity plays an important role in *Manufacture of furniture; other manufacturing (C31_C32)*. In these sectors, the reason for a subdued positive price effect on energy costs is largely because production took place in Member States where energy price rises were modest and/or because production shifted to Member States where energy prices are lower. For instance, the *Manufacture of paper and paper products (C17*)*, a highly energy intensive sector, has moved away from Italy, a country with a high sectoral average energy price in 2017. Instead, production has increased in countries with lower average energy prices, such as Finland, Germany, the Netherland, and Poland. In the case of *Manufacture of other non-metallic mineral products (C23),* another energy-intensive sector, the growth in output was highest in France, Germany, and Poland in absolute terms. This was paired with a decrease in average energy prices which decreased in both Germany and Poland over the time.

As highlighted above, part of the change in price effect at the EU27 level can be attributed to changes in the level of production between Member States. To isolate this effect, Figure 4-28 shows the energy price effect at the EU level under the assumption of constant Member State weights over 2010-2017, compared to the estimated energy price effect, when changes in Member State weights over time are

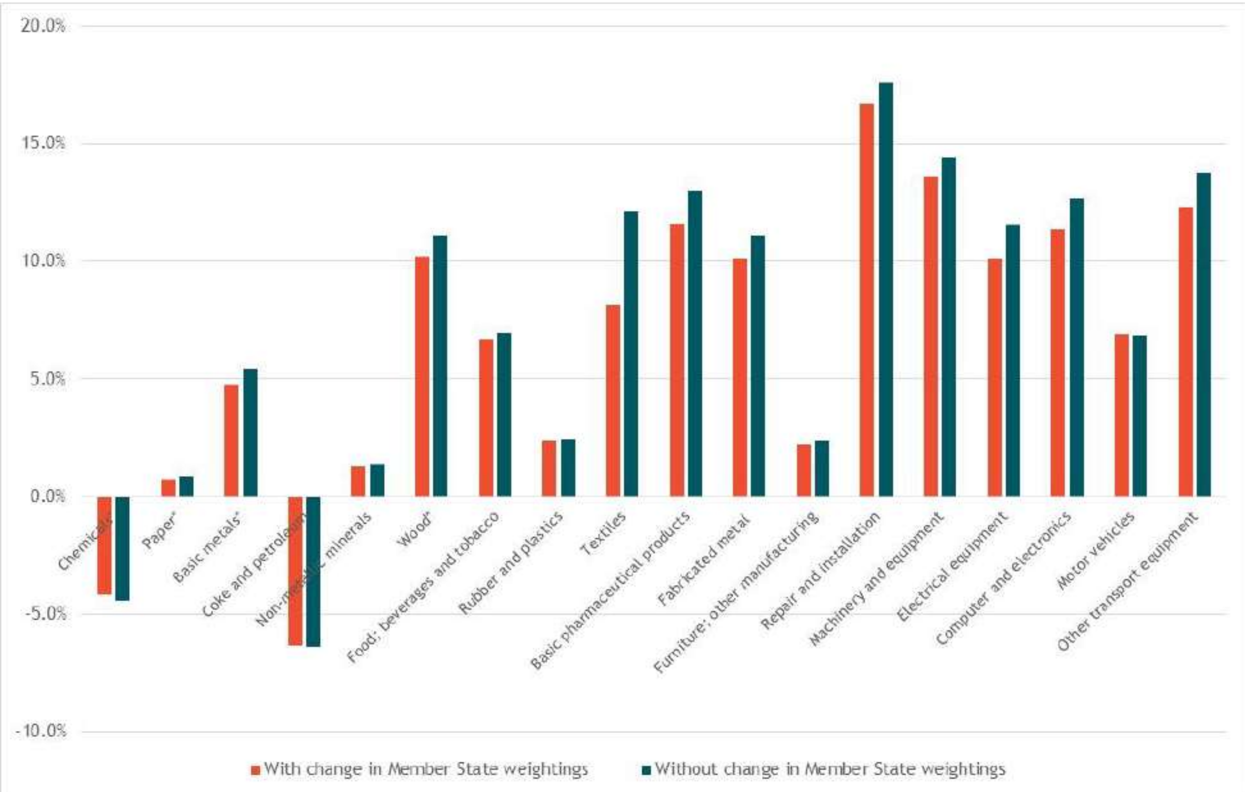
[100] Electricity consumption has fell to 45% of total consumption from 50% in 2010. On the other hand, gas consumption has increased to 47% in 2017 from 39% in 2010.

considered. The difference between the orange and green bars in this chart reflects the impact on the price effect due to changes in the location of production within Europe. The green bars are estimated by allowing the price of energy to change over time but keeping turnover constant at 2010 levels. Therefore, industry sectors where the orange and green bars are most different, reflect cases where there have been large shifts in the shares of production among EU Member States (or shifts in shares of production among Member States with very different energy prices).

This shows that the price effect is only very slightly subdued as a result of changes in the location of production.

An exception is in the *Manufacture of textiles, wearing apparel, leather and related products (C13-C15)*. EU27-wide output in this sector has decreased over the period 2010-2017, while EU27-average sectoral prices have increased in the same period. Within the EU27, large relative increases in production are evident in countries where the average price has decreased over time, such as Malta, Poland, and Hungary and large decrease in production are evident in countries where the average price has increased, such as Belgium, Ireland, and Romania.

Figure 4-28 **The 'energy price effect' with and without changes in the weights applied to Member States**



Source: Own estimates based on the LMDI methodoloy; Note: Ordered according to 2017 energy intensity

Real output effects

At the EU27-level, real output grew for 15 out of 19 NACE 2-digit sectors analysed, indicating that an increase in economic activity (measured by sectoral turnover), contributed to an increase in energy costs.

However four sectors saw a reduction in real output effect on energy costs, two are high energy-intensive industry sectors. In the case of *Manufacture of coke and refined petroleum products (C19)*, this clearly shows that a reduction in sectoral energy costs are driven by reduced economic activity at the EU27 level as 34% of the reductions in energy costs are due to the real output effect.

Member State level data show that Italy (-73%), Germany (-20%), and the Netherlands (-46%) have registered massive absolute reduction in sectoral economic activity between 2010-2017. Although Member States like Spain and Poland have seen an increase in sectoral output, output has fallen at the EU27 level. The shift in production to these Member States could be partially explained because of a lower average energy price than Germany or the Netherlands. Since this sector is heavily reliant on oil consumption, this effect indicates that the EU27 is losing its competitiveness in this sector to international partners which can offer cheaper energy prices though overall, energy cost make up a relatively small share of production costs after crude oil inputs are considered.

The sectors with the largest positive output effects included the *Manufacture of other transport equipment (C30)* and *Manufacture of other motor vehicles, trailers and semi-trailers (C29),* driven by a large increase in activity in Germany, France, and Italy (in absolute terms). In fact, increased production in these sectors has contributed to an increase in energy costs of more than 40% at the EU27 level. These sectors have experienced an increase in economic activity even though there is a positive price effect on energy costs. However, both sectors have experienced significant reduction in energy intensity, suggesting that international competitiveness has partially improved because of improved energy efficiency.

Energy-intensity effects

Data limitations

The energy-intensity effect on energy costs can only be estimated if country-sector specific data (or estimations) for both total energy consumption and turnover is available. Country-sector energy intensity time series were fully or partially blank, even though multiple data sources and different data filling techniques were used. In these cases, the sectoral EU27 average energy intensity was estimated and applied[101].

Table 4-13indicates which Member States were used to estimate each sector's average energy intensity figures as they have complete total energy consumption and output data for the period 2010-2017. The table shows that although some sectors utilise data from a variety of Member States, other utilise data from as little as three Member States.

[101] The sectoral average was applied directly when all the energy intensity figures between 2010-2017 were missing. The sectoral average growth rates were used when a time series was partially available.

Table 4-13 Member States used to estimate sectoral average energy intensity at EU27-level

NACE Code		Member State data used	Share of 2017 EU27 Gross Output
C10_C12	Food, beverages, tobacco	AT,BE,BG,CY,CZ,DE,DK,EE,EL,ES,FI,FR,HR,HU,IE,IT,LT,LV,PL,PT,SI	90%
C13_C15	Textiles	AT,BE,BG,CY,CZ,DE,DK,EE,EL,ES,FI,FR,HR,HU,IE,IT,LT,LV,MT,PL,PT,SE,SI	95%
C16*	Wood	AT,BE,BG,CZ,DE,DK,EE,EL,ES,FI,FR,HR,HU,IE,IT,LT,LV,MT,PL,PT,SI	86%
C17*	Paper	AT,BE,BG,CY,CZ,DE,DK,EE,EL,ES,FI,FR,HR,HU,IE,IT,LT,LV,PL,PT,SI	86%
C19	Coke and petroleum	DE,IT,PT	30%
C20*	Chemicals	BE,DE,DK,IT,PT	54%
C21	Basic pharmaceutical products	AT,DE,DK,IT,PT	36%
C22	Rubber and plastics	BE,DE,DK,IT,PT	52%
C23	Non-metallic minerals	BE,DE,DK,IT,PT	47%
C24*	Basic metals	AT,BE,BG,CZ,DE,DK,EE,EL,ES,FI,FR,HR,HU,IE,IT,LT,LV,MT,PL,PT,SI	89%
C25	Fabricated metal	AT,BE,DE,DK,FI,IT,PT,SI	57%
C26	Computer and electronics	AT,BE,DE,DK,FI,IT,PT	48%
C27	Electrical equipment	AT,BE,DE,DK,IT,PT,SI	59%
C28	Machinery and equipment	AT,BE,BG,CY,CZ,DE,DK,EE,EL,ES,FI,FR,HR,HU,IT,LT,LV,PL,PT,SE,SI	93%
C29	Motor vehicles	AT,BE,DE,DK,FI,IT,PT,SI	59%
C30	Other transport equipment	AT,DE,DK,FI,IT,PT	35%
C31_C32	Furniture	BE,DE,DK,IT,PT	55%
C33	Repair and installation	AT,BE,DE,DK,FI,IT,PT,SI	51%

Sectors where the average energy intensity estimate rely on a few Member States are cases where the reported energy consumption data is more limited. We find that even where the number of Member States to use as a proxy are limited, they still make up a relatively large share of EU27 output. But, there are few sectors where the share is lower, notably C19 Coke & Petroleum, C21 Basic Pharmaceuticals and C30 Other transport equipment. For these sectors, the unexplained residual effect on energy costs could partially capture some energy intensity effects from other Member States that did not have data.

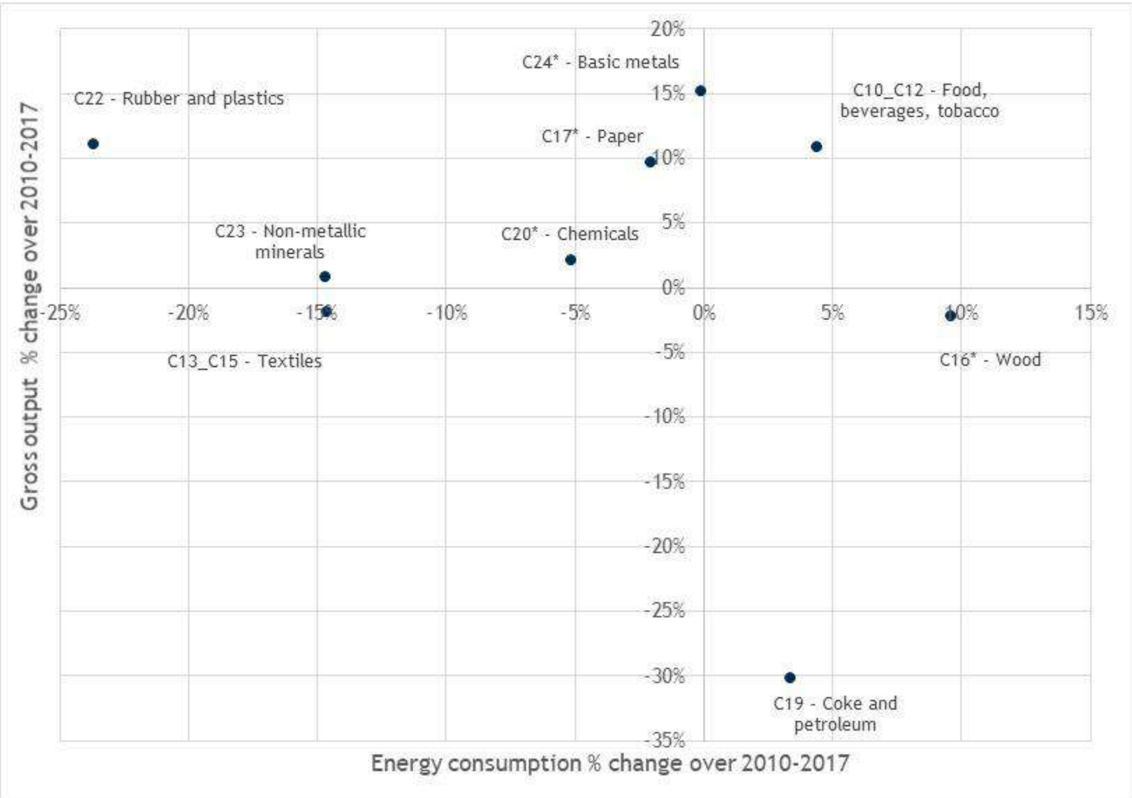
Overall, the EU27 results show that the energy-intensity effect has driven down energy costs in all but two industry sectors. These two sectors are the *Manufacture of coke and refined petroleum products (C19)* and the *Manufacture of wood and wood products (C16*)*.

A review of the components of energy-intensity at the EU27-level indicates that energy consumption has mostly decreased in industry sectors over the period whereas gross output has mostly increased, driving down energy intensity over time and reducing energy costs.

The drivers of improvements in energy efficiency could be due to a number of factors (either due to changes in the fuel mix or structural changes) within each industry sector or actual energy efficiency improvements (behavioural changes or investment in energy efficient equipment). Further analysis suggests that most of the energy efficiency observed is due to real energy efficiency rather than structural change or fuel switching . Section 4.4.6 investigates the components of the energy efficiency effect, namely: fuel switching; industrial structural changes; and energy efficiency improvements, in detail.

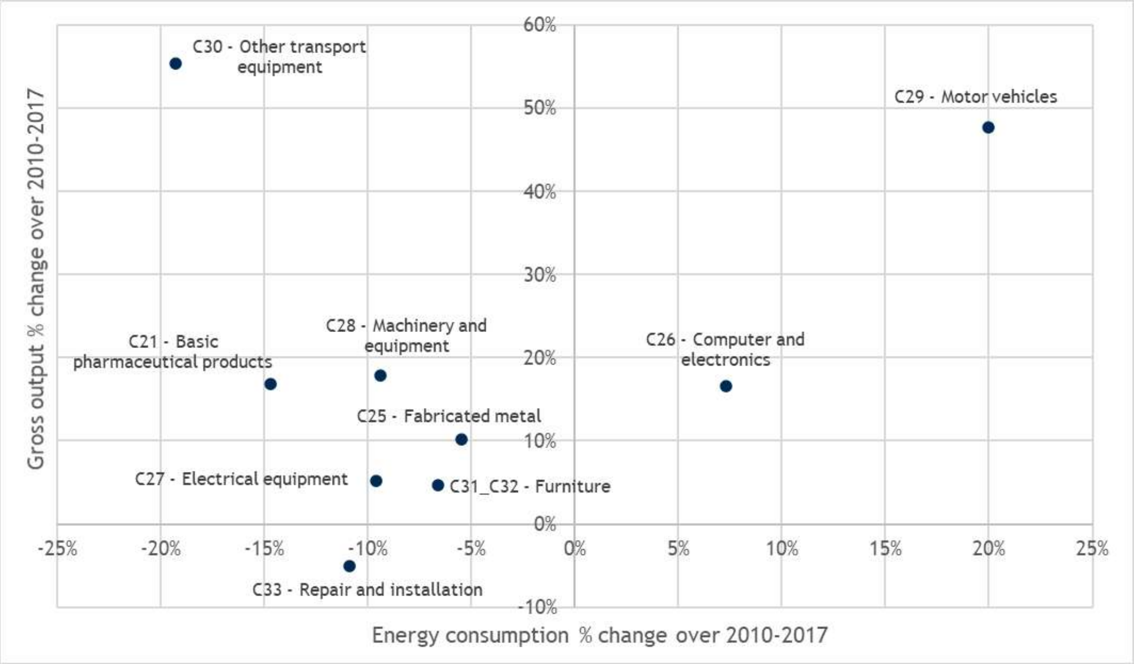
Figure 4-29 and Figure 4-30 plot the changes in gross output and energy consumption in high energy-intensive and low energy-intensive sectors respectively. These Figures show that three out of four sectors which have experienced a reduction in gross output between 2010 and 2017 have a relatively high energy-intensity in 2017. On the same note, the majority of sectors that have large energy cost savings as a result of the energy-intensity effect are lower energy-intensive sectors whereas high energy-intensive sectors have lower energy cost savings (or an increase in energy costs) as a result of changes in energy intensity over time.

Figure 4-29 Changes in gross output and energy consumption between 2010-2017 in high energy-intensity sectors



High energy-intensive sectors have had a more modest increase in output when compared to lower energy-intensive sectors while energy consumption has changed on a similar scale in both groupings. This could be because high energy-intensive sectors have already been forced to use the most energy-efficient machinery and processes to remain internationally competitive. On the other hand, higher energy cost savings occur in low energy-intensive sectors because these sectors have started reducing their energy intensities in more recent years. This could either be the result of an effort to reduce energy costs or because older, less efficient, machinery have been put out of commission over the period reviewed.

Figure 4-30 Changes in gross output and energy consumption between 2010-2017 in low energy-intensity sectors



The sectors that have seen the largest energy cost savings due to energy intensity improvements include:

- Manufacture of other transport equipment (C30);
- Manufacture of motor vehicles, trailers and semi-trainer (C29);
- Manufacture of rubber and plastic products (C22); and
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21).

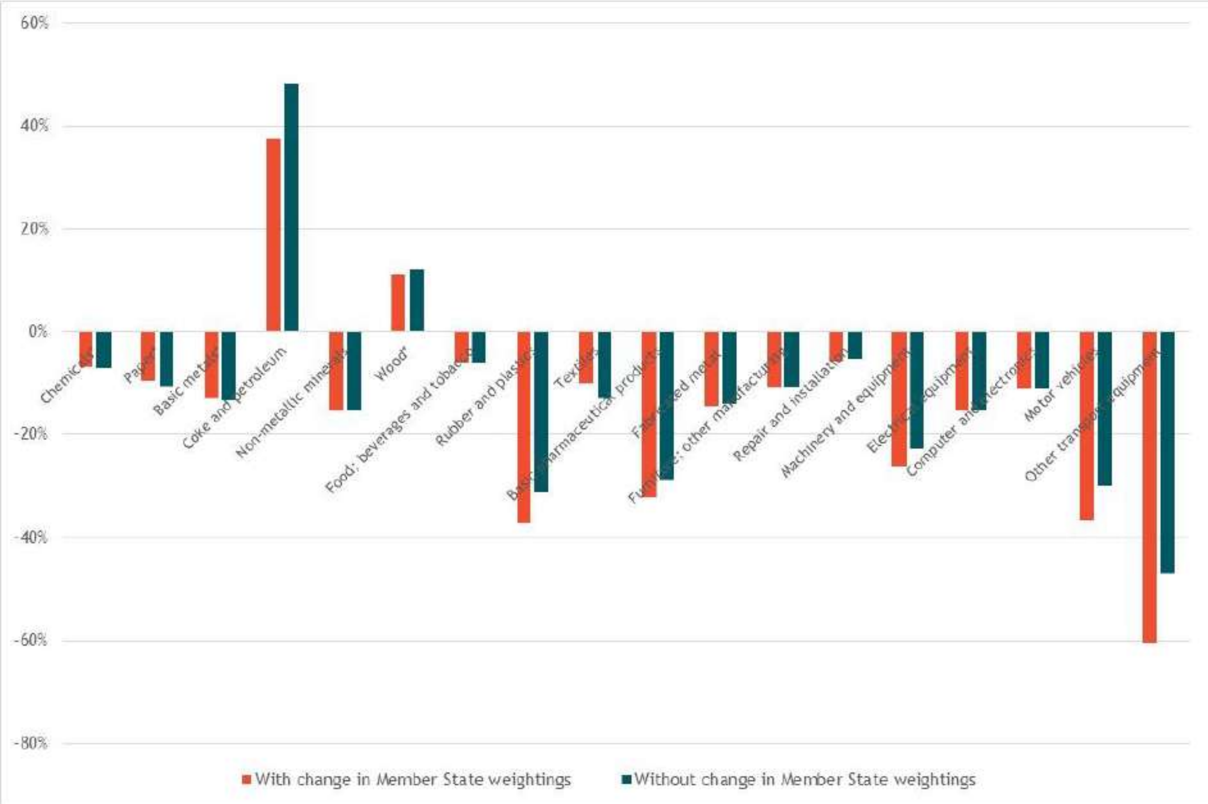
All four sectors have registered an increase in gross output and a decrease in energy consumption between 2010 and 2017. Sectors C30 and C29, two low energy-intensity sectors, have had some of the highest relative increase in gross output over the period. Apart from the reasons mentioned above (recent investments in energy efficient processes), low energy-intensive sectors may be benefiting from economies of scale.

The sectors where a positive energy intensity effect has contributed to an increase in energy costs are:

- Manufacture of coke and refined petroleum products (C19) and
- Manufacture of wood and wood products (C16*).

For these sectors with a positive energy intensity effect, it is useful to look at the components of energy intensity calculated. In both sectors, EU27 energy consumption registered increase (+3% and +10% respectively) over the period, whereas EU27 gross output has decreased (-30% and -2% respectively). EU27 gross output of *Manufacture of coke and refined petroleum products (C19)* has had the largest decrease in relative terms over the period. As concluded by the analysis of real output effects, a shift to Member States with a cheaper sectoral average energy price is evident but, overall, it is likely that the industry's production seems to have shifted away from the EU27.

Figure 4-31 **The 'energy intensity effect' with and without changes in the weights applied to Member States**



Source: Own estimates based on the LMDI methodoloy; Note: Ordered according to 2017 energy intensity

Figure 4-31 shows the changes in energy intensity at the EU27 level under the assumption of constant Member State weights over 2010-2017, compared to the estimated energy intensity effect when changes in Member States' weights over time are considered. As with the chart prepared for the price effect results, the difference between the orange and green bars in this chart reflects the impact on the energy intensity effect due to changes in the location of production within the EU. The results show that changes in the location of production has only had a small impact on the weighted-average energy intensity effect for the EU27 for most sectors. As expected, the effect is most prominent in the *Manufacture of coke and refined petroleum products (C19)*, which has already shown evidence of significant shifts in production.

Residual

For EU27 countries and sectors, the residual term isolates the unexplained component of changes in energy costs (based on available price and energy consumption data). This residual arises because there are (sometimes large) discrepancies between the calculation of energy costs and the 'Purchases of Energy Products' data from Eurostat SBS.

Figure 4-32 presents the scale of this estimated residual (the unexplained change in industry energy costs) over the period 2010-2017 against our estimates of the other energy cost drivers. The dark blue, dark green and orange shading reflects the impacts on industry energy costs due to identified changes in industry average energy prices, changes in industry output and changes in industry energy intensity, respectively. The pale blue bar shows the residual term and captures the discrepancy between the estimated change in energy costs from the Eurostat SBS data versus the estimated change in energy costs from the individual component calculation. The yellow diamond shows the net change in energy costs over the period 2010-2017 according to the Eurostat SBS data (i.e. the summation of the price effect, the output effect, the energy intensity effect, and the residual term).

Overall, the residual effect shows a downward bias suggesting some unobserved factors reducing energy costs The residual factor can be due to known data limitation as follows:

1. Uncaptured fuel switching effects as a result of other fuels not accounted for in the analysis. These include renewables, bioenergy, and heat. A preliminary review of the data shows that the EU27 sectors which are likely to have a large residual effect because of uncaptured fuel switching effects are:
    a. Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16); and
    b. Manufacture of paper and paper products (C17).
2. Uncaptured industry specific price effects such as tax and levy exemptions. These uncaptured exemptions are likely to affect the results of some energy intensive EU27 sectors such as:
    c. Manufacture of chemical and chemical products (C20); and
    d. Manufacture of basic metals (C24).
3. Issues with the underlying data such as missing data leading to some country-sector combinations heavily relying on data filling techniques or inconsistencies in the Eurostat SBS data. This issue is not sector-specific and will be explored further in the regression-based analysis.

Figure 4-32 Component drivers of change in energy costs and unexplained residual at EU27 level over 2010-2017 (%)

Source: Own estimates based on the LMDI methodoloy; Note: Ordered according to 2017 energy intensity

Regression results

As shown by the residual term from the LMDI decomposition method, there is an inconsistency in the data for the individual components of the energy costs compared to the purchase of energy products series from the SBS. As such, it is expected that the estimated coefficients will be less than 1 for these regressions. Equally whereas the LMDI analysis captures the relative impact of the drivers between just two points in time, the regression analysis allows us to confirm that there is a statistical relationship between the drivers in the calculation of energy costs from the individual components and the SBS purchases of energy costs series.

If all data sources were consistent, we would expect the coefficients on energy prices (β_1), energy intensity (β_2) and turnover (β_3) to be close to 1. A coefficient of 1 would imply that:

- a 1% increase in energy prices corresponds to a 1% increase in energy costs;
- a 1% increase in energy intensity corresponds to a 1% increase in energy costs;
- a 1% increase in turnover corresponds to a 1% increase in energy costs;

The regression results indicate that, whilst being positively related and statistically significant in most cases. However, energy purchases data, as reported in Eurostat SBS, are not fully reflecting changes in energy prices, energy intensity and turnover as observed in other data sources. At an aggregate level, using a panel regression across all industry sectors and all regions, around 35% of the observed change in energy prices, 11% of intensity and 50% of turnover are reflected in the Eurostat SBS energy purchases data. The tables below show the coefficients from the regression specified above when the panel is estimated separately for each industry (Table 4-14). and each Member State. Running the individual regressions across individual industries and Member States allows the identification of Member States/industries where data consistency is better/worse. The interpretation of the coefficients in the tables below is the percentage increase in energy costs associated with a 1% increase in energy prices, energy intensity or turnover. Highlighted green cells indicate regions/sectors where results are statistically significant at the 5% level.

Table 4-14 Regression results showing (interpretation of coefficient: % increase in energy costs associated with a 1% increase in each of energy prices, energy intensity and turnover

	All EU Member States, all industries	95% confidence interval
Energy prices (β_1)	0.35	$0.29 \le \beta_1 \le 0.41$
Energy intensity (β_2)	0.11	$0.08 \le \beta_2 \le 0.14$
Turnover (β_3)	0.50	$0.46 \le \beta_3 \le 0.55$

Table 4-15 Regression results showing the responsiveness of energy purchases as published in Eurostat SBS) to a change in energy prices, energy intensity and turnover (by industry)

	C10-C12	C13-C15	C16	C17	C19	C20	C21	C22	C23
	Food, Drink & Tobacco	Textiles & leather	Wood etc	Paper and paper	Coke & Petroleum	Chemicals	Pharmaceuticals	Rubber and plastic	Other non-metallic
Energy prices	0.40	0.48	0.11	0.43	0.15	0.71	0.19	0.21	0.65
Energy intensity	0.01	0.26	-0.12	0.21	0.22	0.48	0.11	-0.01	0.33
Turnover	0.17	0.75	0.64	-0.03	0.52	0.42	0.09	0.55	0.43

	C24	C25	C26	C27	C28	C29	C30	C31_C32	T
	Basic metals	Metal products	Computer and electronics	Electrical equipment	Machinery and equipment	Motor vehicles	Other transport equipment	Other manufacturing	Total
Energy prices	0.74	0.47	0.13	0.33	0.53	0.62	0.56	0.17	0.50
Energy intensity	0.49	0.23	-0.05	0.54	0.06	0.56	0.11	0.02	0.56
Turnover	0.83	0.38	0.28	0.51	0.55	0.67	0.71	0.63	0.63

Table 4-16 Regression results showing the responsiveness of energy purchases as published in Eurostat SBS) to a change in energy prices, energy intensity and turnover (EU Member States)

	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU
Energy prices	0.42	0.43	0.27	0.62	0.59	0.76	1.01	0.28	0.26	0.23	0.39	0.52	1.13	0.45
Energy intensity	0.07	0.59	-0.16	0.25	0.11	0.23	0.63	0.08	-0.02	-0.03	0.16	-0.16	0.56	-0.10
Turnover	0.30	0.63	0.23	0.46	0.32	0.22	0.45	0.40	0.58	0.47	0.38	-0.36	0.68	0.30

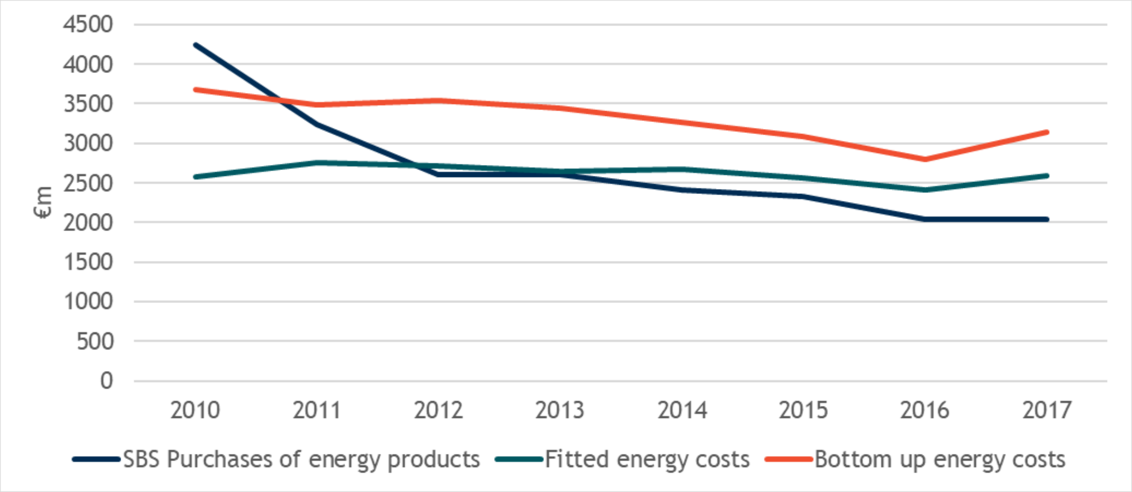
	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	EU27
Energy prices	0.15	-0.70	0.45	0.10	0.27	0.53	1.18	0.21	0.73	0.50	0.52	0.63	0.43	0.73
Energy intensity	0.27	0.90	0.40	0.30	0.08	-0.55	0.45	-0.01	0.76	-0.05	-0.09	0.78	-0.15	0.48
Turnover	0.81	1.47	0.58	0.30	1.03	0.48	0.29	0.36	0.79	0.23	0.11	0.93	0.59	0.37

Looking across sectors in Table 4-16, it is clear that for some sectors, the energy costs from individual components capture more of the changes in the SBS purchase of energy cost series. C23 Non-metallic minerals and C24 Iron & steel have relative high coefficients on all parameters. However, there are energy intensive sectors that do not show a good fit including C16 - Wood products and C17 - Paper & Pulp. As has been highlighted earlier in the analysis, these sectors have a large share of energy from other sources (biomass, waste and heat) for which prices data is not available to include in the estimate of average energy prices.

From the decomposition analysis, C13-C15 Textiles & leather showed the largest residual effect. However, from the regression analysis it shows that all three drivers are significant and apart from the energy intensity effect, a large amount of the variation of each driver is captured in the variation in the purchase of energy products.

It is important to highlight that though the regression can show how well variation of the driver explain movements in purchase of energy product over time, it does not reduce or remove the observed residual effect when looking at a specific reference period as carried out in the decomposition. Figure 4-33 shows a comparison of the energy costs as reported by Eurostat SBS, calculated from the individual components. This includes both the decomposition calculation of equal weighting and estimated energy costs based on the regression coefficients (fitted energy costs). This shows that the fitted energy costs based on the panel estimation for C13-C15 does reduce the average size of the residual but does not help to account for the sharp reductions in the SBS Purchase of energy products at the start of the period between 2010-2012.

Figure 4-33 Comparison of Purchases of energy products against energy costs from individual components and fitted energy costs of C13-C15 Textiles & leather EU27



Looking across Member States, the countries that show statistically significant results generally match those countries where the data coverage for all variables is better especially for BE, DE, DK, PT and SI. However, even in these cases with good data coverage such as DE, the magnitude of the coefficients are still substantially less than 1 suggesting underlying factors that are not captured perhaps including, industry specific tax exemptions & subsides or other fuel types not well captured that impact the true industry energy price. Equally, there are statistical differences in sources used with the purchases of energy products from Eurostat SBS collected through survey data and energy consumption data collected from energy balances.

In terms of the relative magnitude of the parameters, overall, the energy intensity parameter is consistently the smallest parameter, which suggests that energy intensity has a limited effect on the change in purchases of energy products. But this does not fit with the theory. One possible explanation is endogeneity issues including:

- Higher energy prices will likely drive reductions in energy intensity, as firms are incentivised to reduce energy use;
- Higher turnover could lead to energy intensity improvements because of economies of scale;
- Lower energy intensity, due to energy efficiency improvements could boost competitiveness and increase in turnover.

Overall, the regression analysis shows that across the whole manufacturing sector and EU27, the individual drivers of turnover, average energy prices and energy intensity do explain a reasonable proportion of the variance in the SBS purchase of energy products series. Looking at the regression result split out by sector and Member State shows that the gap between these two measures varies considerably suggesting that the factors that explain the discrepancy reflect data issues with specific regions and Member States some of which have already been identified such as the lack of price data on "other" fuel types or difference in methodology.

G20 Results

The analysis and discussion of G20 results will focus on those sectors and countries where the data is available and most consistent. For this reason, the time period was limited to 2010-2016. These results are presented in Table 4-17[102]. Out of all G20 countries analysed, complete data were only available for industry sectors in China (CN), the United Kingdom (UK), Mexico (MX), and the United States of America (US)[103]. For each of the sectors presented in Table 4-17, the G20 results available are ranked based on each country's energy intensity, with the most energy intensive G20 country ranked first for each sector.

Table 4-17 Decomposition of energy cost drivers for G20 countries over the period (2010-2016)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Total effect	2016 Energy Intensity (toe per million €)
US*	C10_C12	Manufacture of food products; beverages and tobacco products	4.7%	8.6%	2.1%	16.1%	31.2
TR			-29.5%	14.4%	32.7%	7.1%	74.4
CN			64.3%	105.8%	-54.6%	53.4%	23.4
UK			25.5%	6.3%	-10.2%	19.8%	21.0
UK	C13_C15	Manufacture of textiles, wearing apparel, leather and related products	25.9%	-10.8%	-2.4%	9.6%	48.5
TR			-39.7%	6.6%	70.4%	9.5%	30.6
US*			19.4%	19.7%	-13.5%	23.7%	28.8
CN			69.9%	76.2%	-45.0%	64.7%	29.2
MX*			-24.2%	-31.7%	75.6%	-9.0%	0.3
TR	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-28.2%	15.7%	82.1%	51.4%	0.0
US*			-1.9%	28.6%	-18.0%	3.4%	46.2
UK			34.2%	-26.7%	81.3%	78.3%	22.7
CN			82.3%	107.0%	-61.0%	47.0%	14.6
US*	C17	Manufacture of paper and paper products	20.0%	3.3%	-2.9%	20.4%	242.9
UK			42.7%	-9.3%	20.2%	55.5%	169.4
TR			-28.6%	25.4%	56.4%	39.9%	119.3
CN			83.1%	69.5%	-51.9%	49.3%	65.2
CN	C19_C21	Manufacture of coke, refined petroleum products, chemicals and chemical products, basic pharmaceutical products, and pharmaceutical preparations	27.7%	95.5%	-34.1%	64.5%	70.3
TR			-25.6%	3.4%	76.3%	35.7%	84.5
US*			-2.2%	8.6%	-5.1%	0.8%	47.4
UK			32.5%	-33.7%	16.2%	2.1%	33.0
CN	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-0.5%	130.0%	-32.5%	54.5%	31.5
UK			31.5%	-13.3%	-8.3%	4.6%	9.8
CN	C22_C23	Manufacture of rubber, plastic products, and other non-metallic mineral products	28.8%	93.2%	-47.3%	31.1%	142.6
TR			-6.1%	13.9%	-6.3%	0.1%	0.0
US*			1.6%	16.4%	-2.8%	15.0%	51.1
UK			21.6%	1.2%	-11.0%	9.5%	44.2
CN	C24	Manufacture of basic metals	43.6%	87.9%	-36.2%	72.2%	134.1

[102] To maximise the number of country-sector combinations, the decomposition analysis was also carried out using the time period 2011-2016. These results are added to this report and denoted with an asterix.
[103] It is important to recall that missing G20 coal and oil prices are filled-in using G20 averages. Therefore, results for country-sector combinations with missing price data and a high reliance on oil or coal should be treated with caution.

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Total effect	2016 Energy Intensity (toe **per million €)**
US*			9.9%	-4.5%	-3.4%	1.5%	115.8
TR			-10.3%	3.6%	20.2%	11.7%	0.0
UK			24.7%	-32.8%	7.9%	-9.6%	95.9
CN	C25	Manufacture of fabricated metal products, except machinery and equipment	20.6%	67.2%	-22.1%	57.0%	53.8
UK			25.8%	-0.7%	-9.4%	13.2%	14.5
UK	C26	Manufacture of computer, electronic and optical products	29.4%	-10.8%	8.0%	24.6%	15.5
CN			38.3%	57.6%	-23.2%	67.4%	12.1
UK	C27	Manufacture of electrical equipment	23.0%	-2.1%	3.6%	24.7%	22.0
CN			8.1%	62.7%	-25.1%	31.9%	14.1
TR	C28	Manufacture of machinery and equipment n.e.c.	-24.5%	51.2%	0.4%	14.7%	0.0
CN			57.1%	52.5%	-32.4%	62.0%	36.1
US*			7.7%	-7.0%	12.9%	13.0%	11.3
UK			26.8%	-8.4%	-2.3%	13.4%	8.3
MX			-64.6%	-27.6%	40.7%	- 63.9%	2.6
CN	C29	Manufacture of motor vehicles, trailers and semi-trailers	40.9%	79.1%	-52.6%	19.6%	16.7
UK			4.5%	33.4%	-11.0%	24.0%	11.9
UK	C30	Manufacture of other transport equipment	3.8%	30.6%	-10.0%	22.0%	9.6

*Source: Own estimates based on the LMDI methodology; Note: *Results for countries marked with an asterisk look at changes in energy costs between 2011-2016*

From estimating the energy costs from the individual components for a number of G20 countries, we see the drivers suggest an overall increase in energy costs across most manufacturing sectors. With increases in output and higher average industrial energy prices outweighing improvements in energy intensity.

Price effect

Across most of the G20 countries compared, the energy prices increased, driving energy costs upwards as was observed for the EU27. In the case of China and the UK, the increase in energy prices was generally much higher than in the EU27. Of the G20 countries reported, the United States saw more modest increases in energy prices close in magnitude to the EU. Turkey meanwhile saw a reduction in energy prices. The variation in energy prices across the G20 countries was largely driven by variation in the evolution of electricity prices with China and UK seeing increases in electricity prices of 35% and 65% respectively between 2010 and 2016 whereas Turkey had a reduction in electricity prices of 25%.

Output effect

Most of the G20 countries analysed saw an increase in output in the manufacturing sectors as observed for the EU27. China saw the largest growth across many manufacturing sectors. The notable exception is the UK which saw a reduction in output across most sectors except for a few key sectors such as Manufacture of motor vehicles and transport equipment.

Energy intensity effect

Across the G20 countries, most saw reductions in energy intensity as seen for the EU27. Of the G20 countries reported, China saw the largest reductions in energy intensity across most sectors. China's reduction in energy intensity come alongside substantial output growth suggesting economies of scale may have played a factor. Equally, China started the period from a much higher energy intensity than the EU in most sectors and so even with substantial reductions in energy intensity, the EU still has lower average energy intensity especially in lower Energy intensive sectors. Conversely, the only region to show increases in energy intensity over a number of sectors was Turkey. This may partly be explained by the fall in industrial energy prices over the period.

More detailed in comparing the drivers of energy costs for the G20 compared to the EU for each sector individually are available in Annex G.

4.4.4 Decomposition analysis of production costs

This section presents the decomposition of total production costs to show the extent to which changes in total production costs over recent years have been driven by changes in energy costs. The decomposition of production costs is carried out only for EU27 countries at the sectoral aggregation, summarised in Table 4-18 (due to limitations in the G20 data).

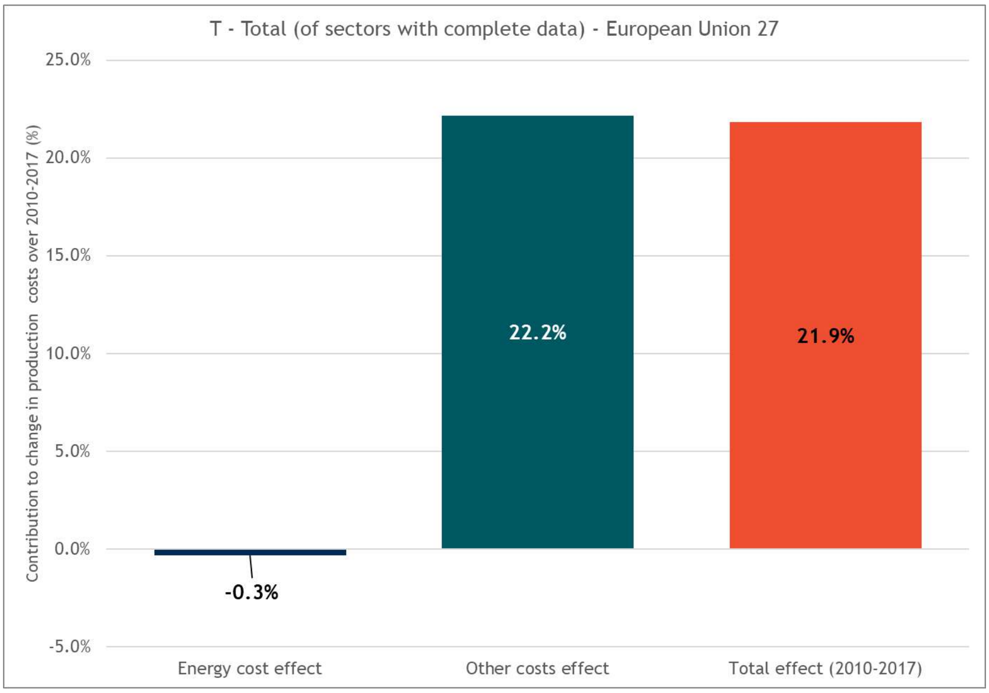
For EU27 country-sector combinations, the decomposition of production costs is based on Eurostat SBS data for energy purchases and total production costs and so, by definition, no residual term is left over.

$$Total\ production\ costs = Energy\ costs + Other\ costs\ of\ production$$

$$\Delta Total\ production\ costs = \Delta Energy\ costs + \Delta Other\ costs\ of\ production$$

Eurostat SBS 'purchases of energy products' data is used to represent energy costs. Other costs comprise of 'personnel costs' plus the 'total purchases of goods and services' less 'purchases of energy products', calculated from the Eurostat SBS data. The summation of energy costs and other costs make up total production costs for each country-sector combination. As shown in Figure 4-34, at an aggregate level, the increase in total industry production costs over the period 2010-2017 is almost entirely explained by increases in other (non-energy) costs. The energy cost effect reflects the extent to which changes in energy costs have affected total costs of production in each industry sector. At the EU27 level, energy costs have contributed to a very small, almost insignificant, reduction in total production costs.

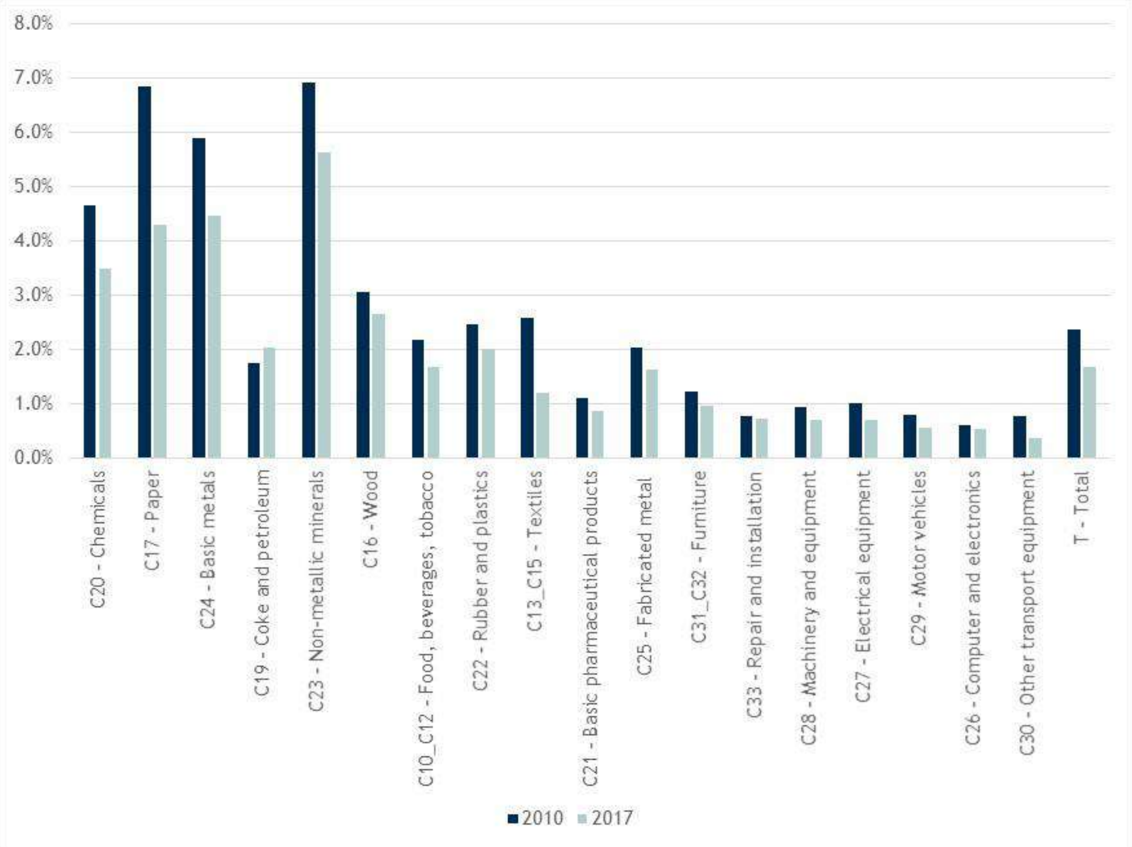
Figure 4-34 Breakdown of drivers of the changes in production costs over the period 2010-2017 (EU27 average across all industry sectors considered)



Source: Own estimates

Figure 4-35 presents the share of energy costs in 2010 and 2017 at the EU27-level. As expected, the figure shows that energy intensive sectors have a higher proportion of energy costs. In general, two main conclusions can be drawn from this figure. The first is that energy costs make up a small proportion of total production costs. In 2017, this was largest in the *Manufacture of other non-metallic mineral products (C23)* at only 5.6% of production costs. Energy costs only make up 1.7% of total industrial production costs at the EU27-level. The second conclusion is that the proportion of energy costs has decreased over time. This can mean that energy costs have fallen, other costs have increased, or a combination of both. Together, these two conclusions explain why a reduction in energy costs only contributed to a small reduction in total production costs in Figure 4-34.

Figure 4-35 Share of energy costs in proportion to total production costs - EU27-level



Source: Own estimates; Note: Ordered according to 2017 energy intensity

Table 4-19 Decomposition of production cost drivers at the EU27 level over the period (2010-2017)

Code	Description	Energy cost effect	Other costs effect	Total effect (2010-2017)	2017 EU27 Energy Intensity (toe **per million €)**
C20	Manufacture of chemicals and chemical products	-0.7%	14.8%	14.1%	190.8
C17	Manufacture of paper and paper products	-2.0%	15.8%	13.8%	182.3
C24	Manufacture of basic metals	-1.2%	7.7%	6.5%	174.1
C19	Manufacture of coke and refined petroleum products	-0.2%	-20.6%	-20.8%	158.8
C23	Manufacture of other non-metallic mineral products	-1.1%	4.0%	2.9%	158.2
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-0.2%	7.2%	7.0%	75.5
C10_C12	Manufacture of food products; beverages and tobacco products	0.0%	27.3%	27.3%	26.9
C22	Manufacture of rubber and plastic products	-0.1%	18.8%	18.8%	22.4

Code	Description	Energy cost effect	Other costs effect	Total effect (2010-2017)	2017 EU27 Energy Intensity (toe **per million €)**
C13_C15	Manufacture of textiles, wearing apparel, leather and related products	-1.3%	4.2%	2.9%	21.5
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-0.1%	13.5%	13.4%	19.3
C25	Manufacture of fabricated metal products, except machinery and equipment	-0.2%	15.6%	15.4%	17.5
C31_C32	Manufacture of furniture; other manufacturing	-0.1%	16.5%	16.4%	11.0
C33	Repair and installation of machinery and equipment	0.0%	12.5%	12.5%	10.1
C28	Manufacture of machinery and equipment n.e.c.	0.0%	34.2%	34.2%	9.5
C27	Manufacture of electrical equipment	-0.2%	18.9%	18.7%	8.3
C26	Manufacture of computer, electronic and optical products	-0.1%	2.7%	2.6%	6.5
C29	Manufacture of motor vehicles, trailers and semi-trailers	0.1%	52.6%	52.6%	6.1
C30	Manufacture of other transport equipment	-0.1%	83.6%	83.5%	4.3
T	Total (Of sectors with complete data)	-0.3%	22.2%	21.9%	50.6

Source: Own estimates sorted according to energy intensity in 2017

The table above presents the decomposition analysis of production costs results for each sector at the EU27 level. The results show that, in general, production costs have increased in the period between 2010 and 2017. The only exception is the *Manufacture of coke and refined petroleum products (C19)*. As discussed in the decomposition of energy costs, this sector has seen large reductions in production at the EU27 level. This explains why production costs have decreased by about 21% between 2010 and 2017. In fact, Figure 4-35 shows that although sectoral energy costs have decreased, the share of energy costs as a proportion to total sectoral production costs have increased between 2010 and 2017.

The industry sectors which have seen the largest increase in production costs are:

- Manufacture of other transport equipment (C30);
- Manufacture of motor vehicles, trailers and semi-trailers (C29);
- Manufacture of machinery and equipment n.e.c. (C28); and
- Manufacture of food products; beverages and tobacco products (C10_C12).

Three out of the four sectors which have experienced the largest increase in production costs are low energy-intensive sectors. These three sectors (C30, C29, and C28) correspond to the three sectors which have the largest relative increase in gross output in the period. This implies that at the EU27 level, low energy intensive sectors have increased economic activity at a much faster pace than higher energy-intensive sectors between 2010-2017. In fact, in all three of these sectors, the energy cost effect contributed to close to 0% of the increase in total production costs.

Overall, energy costs have contributed very little to change in production costs. The largest positive energy cost effect is seen in the *Manufacture of motor vehicles, trailers and semi-trailers* (C29) at a very small 0.1% out of a 52.6% increase in total production costs. In this section, the results show an increase in gross output, energy consumption, and energy costs. However, improvements in the sectors energy intensity over time has mitigated the impacts of the positive energy cost effect.

The sectors which have experienced the largest negative energy cost effect on total production costs are:

- Manufacture of paper and paper products (C17);
- Manufacture of textiles, wearing apparel, leather and related products (C13_C15);
- Manufacture of basic metals (C24); and
- Manufacture of other non-metallic mineral products (C23).

In these sectors, the energy costs effect ranges between -2% and -1.1% of total production cost changes. The three sectors that registered the highest cost savings due to a reduction in energy costs are high energy-intensive sectors (C17, C13_15, and C24). The results show similar characteristics in all three sectors, at an EU27 level. Firstly, total energy consumption falls in all three sectors. Secondly, the average price of energy increased over time. Thirdly, energy intensity has improved in all three sectors. This is paired with a substantial increase in gross output in both *Manufacture of paper and paper products* (*C17)* and *Manufacture of basic metals (C24*) and a small reduction in *Manufacture of textiles, wearing apparel, leather and related products (C13_C15)*. Therefore, two of these three highly energy-intensive sectors have managed to improve energy efficiency, reduce costs, and increase output while facing higher energy costs. The same conclusions apply to *Manufacture of other non-metallic mineral products (C23)*, a medium energy-intensive sector.

4.4.5 Decomposition analysis of the output effect

This section presents a further decomposition of the output effect reviewed in the decomposition of energy cost effects, where the output effect measures the impact of changes in industry output on industry-wide energy costs. Changes in industry output over time could be explained by changes in domestic demand versus changes in imports and exports at a sectoral level.[104]

Methodology

The decomposition of the output effect is mainly based on imports, exports, and gross output data collected from the OECD STAN database. This data is provided at the United Nations' ISIC 2-digit sectoral aggregation, which can be compared to the European NACE statistical classification at the 2-digit level. In fact, results are presented using NACE sectoral aggregation at the 2-digit level. For comparability between analyses, a similar sectoral aggregation to the one applied to the energy

[104] Of course, the extent to which domestic demand or net trade of certain products might change is, in itself, dependent on a number of different factors, including unit costs and competitiveness, quality and branding of products etc. But, for this exercise, we will not consider the impact of these factors on the output effect. Instead we will focus on explaining the role of imports, exports and domestic demand in affecting levels of production, and therefore energy costs.

decomposition analysis was applied to the decomposition analysis of output effects. The sectoral scope of the decomposition analysis of the output effect is presented inTable 4-20

Table 4-20 Sector scope of the output decomposition analysis - EU27 and G20 countries

Section	Code (NACE 2)	Description
C - Manufacturing	C10_C12	Manufacture of food products; beverages and tobacco products
	C13_C15	Manufacture of textiles, wearing apparel, leather and related products
	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	C17	Manufacture of paper and paper products
	C19	Manufacture of coke and refined petroleum products
	C20	Manufacture of chemicals and chemical products
	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	C22	Manufacture of rubber and plastic products
	C23	Manufacture of other non-metallic mineral products
	C24	Manufacture of basic metals
	C25	Manufacture of fabricated metal products, except machinery and equipment
	C26	Manufacture of computer, electronic and optical products
	C27	Manufacture of electrical equipment
	C28	Manufacture of machinery and equipment n.e.c.
	C29	Manufacture of motor vehicles, trailers and semi-trailers
	C30	Manufacture of other transport equipment
	C31_C32	Manufacture of furniture; other manufacturing

Note: The data used in this analysis is provided using the United Nations' ISIC classificaiton. This table, and all results, are presenting using the best matching NACE classificaiton.

To investigate the drivers of the output effects, industrial output in each country is decomposed as:

$$Output = \ Domestic\ demand + Exports - \ Imports$$

Since the OECD STAN database provides data for gross output, exports, and imports, the subject of the formula for the above equation can change to estimate domestic demand:

$$Domestic\ demand = \ Output - Exports + Imports$$

Once domestic demand is estimated, the changes to output can be decomposed into:

$$\Delta Output \ = \Delta Domestic\ demand + \ \Delta Exports - \Delta Imports$$

Where the changes to domestic demand, exports, and imports over the time period 2010-2017 are used to inform changes in output in the same time period. This relationship between the three variables leads to no residual term.

Prior to the estimation of country-industry specific domestic demand, the OECD STAN data was processed in the following manner:

1. The OECD STAN database provides current price gross output data in national currencies and current price trade data in US dollars (USD). Although the OECD trade data is complete, there are some gaps in the sector-country specific gross output data;
2. Using OECD exchange rate, all data were converted into Euros[105];
3. Some missing gross output data were filled in using Eurostat SBS data Turnover data downloaded at the NACE 2-digit level and used in the energy cost decomposition analysis. Eurostat SBS turnover data are applied directly in country-sector combinations where all gross output data are missing. SBS data growth rates are used to fill in the gaps when some of the gross output time series is missing;
4. Then, we attempt to fill in any other missing gross output data by using the Turnover data collected in Subtask 2.1 of this project. This filling technique only attempts to fill in gross output data where the sectoral aggregation in Table 4-20 matches the sectors in Table 4-21. Similarly, growth rates are used when some of the data in the time series are available;
5. The gross output, imports, and exports data are deflated to constant prices using country-sector level deflators (100=2015). As with the treatment of gross output in the energy cost decomposition analysis, this is not a perfect reflection of changes in physical output, but it is a close proxy. Constant price data controls for changes in sectoral price, therefore only reflecting changes in real production volumes;
6. The EU27 total was estimated for sectors that have complete data. The EU27 total data removes the effects of intra-EU trade to allow for a comparison between the EU and G20 countries;
7. National gross output growth rates for sectors with full time series were used to fill in G20 country-sector combinations with some missing gross output data;
8. Input-Output tables and key deflators prepared by the Asian Development Bank were used to fill the gaps for some G20 countries and sectors when additional data is available[106].

EU27 Results

This section presents the output decomposition results at the EU27-level. Table 4-21 presents the total change in EU27 sectoral output and the drivers of this change over the period between 2010-2017. At the EU27 level, these effects are estimated using data from Member States that had a full gross output, imports, and exports time series[107]. These sectors have been ranked based on their energy-intensity.

Table 4-21 Decomposition of output drivers at the EU27 level over the period (2010-2017)

Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)	Main factor driving output growth
C20	Manufacture of chemicals and chemical products	1.1%	4.8%	-5.1%	0.9%	No dominant effect
C17	Manufacture of paper and paper products	1.3%	0.7%	0.4%	2.3%	Domestic Demand
C24	Manufacture of basic metals	20.0%	1.3%	-6.9%	14.4%	Domestic Demand
C19	Manufacture of coke and refined petroleum products	-29.9%	-6.6%	7.6%	-28.9%	Domestic Demand

105 OECD (2020), Exchange rates, Available at: https://data.oecd.org/conversion/exchange-rates.htm
106 Asian Development Bank (2019), Input-Output Tables for 2010 to 2017, Accessed on 12 March 2019
107 EU27 results excludes intra-EU trade. In this case, domestic demand includes goods which are produced and consumed within the borders of the European Union.

Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)	Main factor driving output growth
C23	Manufacture of other non-metallic mineral products	1.2%	3.5%	-1.9%	2.8%	Exports
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-2.5%	3.0%	-0.4%	0.0%	No dominant effect
C10_C12	Manufacture of food products; beverages and tobacco products	3.3%	4.3%	-1.7%	5.9%	No dominant effect
C22	Manufacture of rubber and plastic products	15.0%	5.8%	-5.0%	15.8%	Domestic Demand
C13_C15	Manufacture of textiles, wearing apparel, leather and related products	6.9%	14.5%	-20.9%	0.4%	No dominant effect
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-8.4%	47.4%	-18.2%	20.8%	Exports
C25	Manufacture of fabricated metal products, except machinery and equipment	13.1%	3.5%	-3.3%	13.3%	Domestic demand
C31_C32	Manufacture of furniture; other manufacturing	-3.5%	10.5%	-8.2%	-1.2%	No dominant effect
C28	Manufacture of machinery and equipment n.e.c.	11.7%	6.3%	-4.3%	13.7%	Domestic Demand
C27	Manufacture of electrical equipment	3.8%	8.2%	-11.3%	0.7%	Imports
C26	Manufacture of computer, electronic and optical products	24.0%	22.7%	-35.4%	11.2%	Imports
C29	Manufacture of motor vehicles, trailers and semi-trailers	31.0%	13.5%	-8.5%	35.9%	Domestic Demand
C30	Manufacture of other transport equipment	10.1%	18.1%	-3.4%	24.8%	No dominant effect

Source: Own estimates sorted according to 2017 energy intensity estimated in the decomposition of energy costs

Since the main data source for gross output in this analysis (OECD STAN) is different from the main **data source used in the EU27's decomposition of energy costs (Eurostat SBS),** this may lead to some differences in total changes to gross output. However, for the sake of comparison between analyses, the sectors in this decomposition have been ranked using the 2017 energy intensities estimated in the energy cost decomposition analysis.

Although there is a chance of having small changes to output indicators in the two analyses, a striking similarity is the large reduction in EU27 gross output in *Manufacture of coke and refined petroleum products (C19)*. In the decomposition of output effects, the data for C19 show the largest relative reduction in gross output in the EU27. All other sectors except the *Manufacture of furniture (C31_C32)* see an increase in output at the EU27. Overall, the EU27 sectoral total results indicate that gross output changes are mainly driven by changes in domestic demand.

The domestic demand effect

The results show that thirteen out of seventeen EU27 sectors have had a positive domestic demand effect on changes in gross output over time. This shows that total output has increased as a result of higher demand for that product within the EU27[108].

The sectors with the highest domestic demand effect at the EU27-level are:

- Manufacture of motor vehicles, trailers and semi-trailers (C29);
- Manufacture of computer, electronic and optical products (C26);
- Manufacture of basic metals (C24); and
- Manufacture of rubber and plastic products(C22).

Three out of the four sectors with the large positive domestic demand effect on gross output are low energy-intensity sectors (C22, C29, and C26). In fact, the *Manufacture of motor vehicles, trailers and semi-trailers (C29)* has seen the largest increase in gross output driven by domestic demand. The results suggest that there has been a significant global increase in demand for EU motor vehicles. This is evident by a large increase in both domestic demand and exports and a negative imports effect on gross output. A negative imports effect implies that EU27 imports from non-EU countries have increased over the period 2010-2017. Since both imports and exports have increased, the EU has managed to mitigate the effects of higher imports on its trade balance. However, a large increase in the domestic demand effect suggest that consumers of these products within the EU have had a larger increase in appetite for products produced regionally than internationally.

The four sectors which have a negative domestic demand effect at the EU27-level are:

- Manufacture of coke and refined petroleum products (C19);
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21);
- Manufacture of furniture; other manufacturing (C31_C32); and
- Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16).

Sectors which have seen negative or small positive domestic demand effects are typically high energy-intensive sectors. Although they have experienced lower domestic demand, higher gross output growth in *Manufacture of basic pharmaceutical products and pharmaceutical preparations* (*C21)* and *Manufacture of wood and wood products (C16)* is driven by a positive exports effect. On the other hand, the imports effect is negative in both sectors as some of the demand over the period was reliant on additional imports either to meet domestic demand or support additional international demand. These results show that EU27 consumers have lost their appetite for goods in these industries, which are produced regionally but have increased their appetite for goods produced overseas. However, an expansion in export of these goods to non-EU countries has overtaken these two effects, resulting in higher gross output.

The exports effect

At the EU27-level, sixteen out of seventeen sectors analysed have seen a positive export effect on changes to gross output, meaning that there has been an increase in the demand for EU manufactured

[108] Since intra-EU trade has been removed and the EU is considered as a single region in this analysis. Therefore, the domestic demand effects capture trade between EU27 countries as well as changes to demand in the countries where the goods are produced.

goods in international markets. The only sector which has negatively affected the EU27's balance of trade when compared to 2010 is the *Manufacture of coke and refined petroleum products (C19)*. In this sector, there has been a reduction in demand both domestically and internationally suggesting weaker demand for refined fossil fuels over the period.

The industry sectors that have had the largest positive export effect on gross output growth are:

- Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21);
- Manufacture of computer, electronic and optical products (C26);
- Manufacture of other transport equipment (C30); and
- Manufacture of textiles, wearing apparel, leather and related products (C13_C15).

The export effect on gross output growth was highest in sectors, which are less energy-intensive. In the *Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)* both domestic demand and imports drove down gross output change. In fact, gross output increased only because a large exports effect overtook negative domestic demand and imports effects. While global demand for pharmaceutical **products has increased, the EU's demand has fallen over time.** However, EU manufacturers have managed to grow because of higher foreign demand. On the other hand, a high positive export effect in all other sectors exhibiting a large positive export effect is paired with a positive domestic demand effect and a negative import effect. In these sectors, both global and regional demand has increased. Furthermore, the results suggest that, within these sectors, the EU has remained competitive both internationally and within its borders.

The imports effect

In general, the import effect has driven down gross output, meaning that EU27 imports in most industrial sectors have increased between 2010-2017. Two sectors have registered a positive imports effect on gross output. This means that imports from non-EU countries have fallen over time. The two sectors with a positive imports effect on gross output are:

- Manufacture of coke and refined petroleum products (C19); and
- Manufacture of paper and paper products (C17).

Manufacture of coke and refined petroleum products (C19) results also shows a very large negative domestic demand effect, meaning that the EU27's overall demand for *coke and refined petroleum products* has fallen in between 2010-2017. The EU27-level results also show a negative export effect, suggesting that global demand, or at least global demand for EU27 petroleum products, has also fallen over time. Although the balance of trade effect is positive (less imports and more exports), massive reduction in domestic demand has resulted in a large decrease in sectoral gross output. In contrast, the *Manufacture of paper and paper products (C17)* has seen a positive gross output effect as imports have fallen. Showing that production has become more concentrated within the EU27.

The sectoral results show that international trade has not been a major determinant of changes in gross output over time and that an increase in domestic demand was the main driver of change.

The sectors with the largest negative imports effect at the EU27-level are:

- Manufacture of computer, electronic and optical products (C26);
- Manufacture of textiles, wearing apparel, leather and related products (C13_C15);
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21); and
- Manufacture of electrical equipment (C27).

Source: Study on energy prices, costs and their impact on industry and households

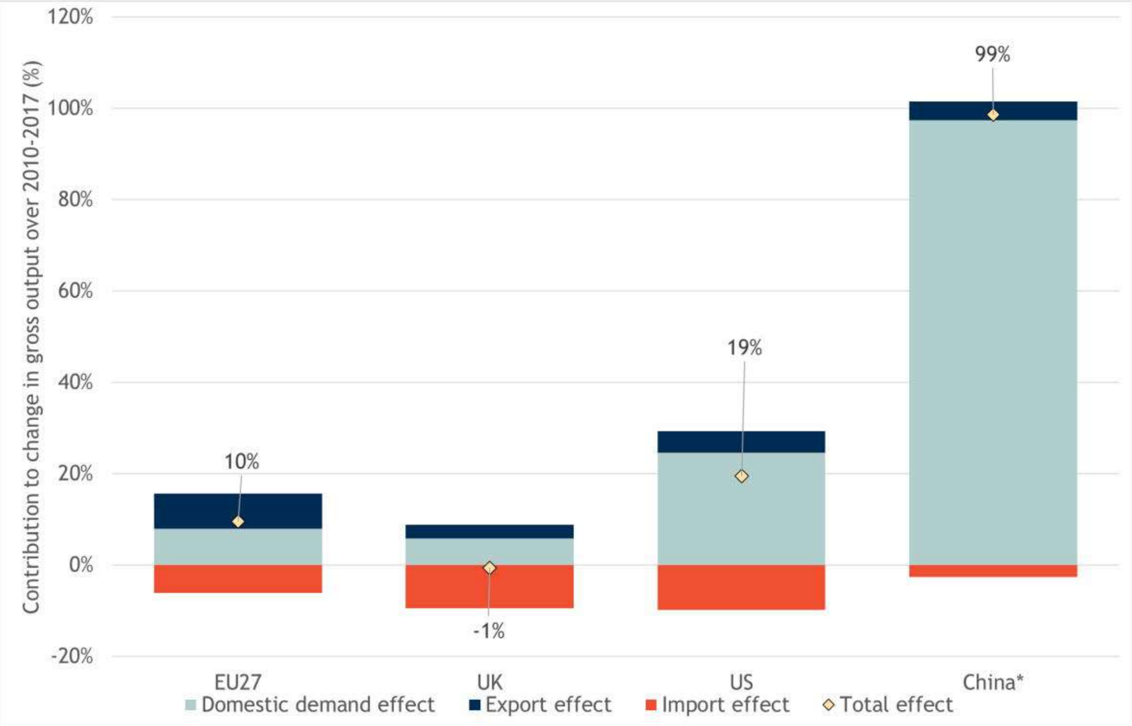
Sectoral EU27 gross output was mostly negatively affected by large increases in non-EU imports of products in industries which are less energy intensive. The large negative import effect (-35%) in *Manufacture of computer, electronic and optical products (C26) was* largely reflected in the need to meet large increases in demand domestically (+24%) and exports (+22%), suggesting that growth in demand outstripped EU production increasing the reliance on imports.

As described above, the *Manufacture of basic pharmaceuticals products and pharmaceutical preparations* (C21) has concurrently seen a substantial increase in non-EU exports and a reduction in domestic demand. This shows that while domestic demand has weakened, EU27 producers have made up for this by capturing more of international demand for basic pharmaceutical products.

G20 Results

This section presents the output decomposition results for three of the EU's main G20 trading partners (UK, US, and China) for sectors which consistently have a complete data set to determine the impacts of the domestic demand effect, the exports effect, and the imports effect on changes in gross output between 2010-2017. The EU27-level results (excluding intra-EU trade) are also presented for comparison.

Figure 4-36 Breakdown of drivers of the changes in gross output over the period 2010-2017 (EU27 and main G20 trading partners)



*Source: Own estimates; *China's data accounts for all sectors except C31_C32 due to a lack of complete data for this sector*

Figure 4-36 shows that the EU27, the US, and China have experienced increases in total industrial gross output over time. On the other hand, the UK has experienced a slight reduction in gross output over time. In the EU27, the US, and China, higher gross output was mainly driven by increased domestic demand.

Higher exports in all four areas have contributed positively to gross output. However, the positive exports effect is moderate. Finally, an increase in imports in all regions over time has driven down gross output between 2010 and 2017.

The results for the EU27, the UK, the US, and China show that higher demand for goods produced by industrial sectors listed in Table 4-21 was met by an increase in both domestic and foreign suppliers. However, UK consumers have increased consumption of imported goods at a higher rate than the increase in consumption of locally produced goods. Although UK exports and domestic consumption have increased, a negative imports effect on gross output (as a result of higher imports) has dominated the decomposition analysis, suggesting that the UK has lost some of its competitiveness in manufacturing over time.

In line with the results presented in Figure 4-36, the country-sector specific results presented in Table 4-22 show that all Chinese and UK sectors analysed and fifteen out of seventeen EU27 industrial sectors have seen increased gross output over time. On the other hand, only eight out of seventeen UK industrial sectors have registered an increase in gross output between 2010-2017. The following sub-sections reviews the results presented in in Table 4-22 on a sector by sector basis.

Table 4-22 Decomposition of output drivers for the EU27 and main G20 trade partners over the period (2010-2017)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C10_C12	Manufacture of food products; beverages and tobacco products	3.3%	4.3%	-1.7%	5.9%
UK			13.9%	4.2%	-6.6%	11.5%
US			34.6%	2.8%	-5.1%	32.3%
CN			171.8%	2.9%	-4.0%	170.7%
EU27	C13_C15	Manufacture of textiles, wearing apparel, leather and related products	6.9%	14.5%	-20.9%	0.4%
UK			-36.4%	12.3%	8.8%	-15.3%
US			98.6%	6.8%	-48.2%	57.1%
CN			118.7%	14.8%	-1.8%	131.7%
EU27	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-2.5%	3.0%	-0.4%	0.0%
UK			-28.3%	-1.7%	6.4%	-23.5%
US			67.7%	5.6%	-13.8%	59.5%
CN			175.2%	2.7%	-5.6%	172.3%
EU27	C17	Manufacture of paper and paper products	1.3%	0.7%	0.4%	2.3%
UK			-7.6%	-5.6%	15.2%	2.1%
US			26.5%	1.9%	-1.4%	26.9%
CN			122.6%	6.1%	-5.7%	123.0%
EU27	C19	Manufacture of coke and refined petroleum products	-29.9%	-6.6%	7.6%	-28.9%
UK			-33.7%	-22.7%	7.1%	-49.3%
US			17.0%	19.5%	-3.5%	33.0%
CN			123.1%	2.4%	-0.4%	125.1%
EU27	C20	Manufacture of chemicals and chemical products	1.1%	4.8%	-5.1%	0.9%
UK			-23.5%	-25.8%	24.9%	-24.5%
US			25.4%	6.0%	-5.6%	25.7%
CN			164.3%	7.0%	-7.4%	164.0%
EU27	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-8.4%	47.4%	-18.2%	20.8%
UK			16.4%	-8.0%	-21.6%	-13.2%
US			84.1%	5.7%	-23.8%	66.0%

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
CN			227.3%	2.8%	-11.2%	218.8%
EU27	C22	Manufacture of rubber and plastic products	15.0%	5.8%	-5.0%	15.8%
UK			8.6%	0.7%	-5.3%	4.0%
US			50.8%	6.4%	-13.1%	44.1%
CN			115.0%	14.3%	-1.0%	128.3%
EU27	C23	Manufacture of other non-metallic mineral products	1.2%	3.5%	-1.9%	2.8%
UK			12.0%	0.4%	-4.5%	7.9%
US			51.4%	2.9%	-9.1%	45.2%
CN			168.1%	5.5%	-1.5%	172.1%

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C24	Manufacture of basic metals	20.0%	1.3%	-6.9%	14.4%
UK			24.9%	41.1%	-92.2%	-26.3%
US			35.7%	10.0%	-20.0%	25.7%
CN			149.8%	2.2%	-4.9%	147.1%
EU27	C25	Manufacture of fabricated metal products, except machinery and equipment	13.1%	3.5%	-3.3%	13.3%
UK			2.6%	2.2%	-3.5%	1.4%
US			58.1%	3.2%	-8.5%	52.8%
CN			107.0%	12.1%	-1.2%	118.0%
EU27	C26	Manufacture of computer, electronic and optical products	24.0%	22.7%	-35.4%	11.2%
UK			0.5%	-10.6%	1.6%	-8.5%
US			65.8%	15.8%	-44.5%	37.2%
CN			111.1%	20.2%	-18.7%	112.5%
EU27	C27	Manufacture of electrical equipment	3.8%	8.2%	-11.3%	0.7%
UK			26.1%	11.6%	-37.8%	-0.1%
US			67.7%	21.5%	-59.3%	29.9%
CN			108.4%	14.5%	-2.0%	120.9%
EU27	C28	Manufacture of machinery and equipment n.e.c.	11.7%	6.3%	-4.3%	13.7%
UK			-0.1%	-10.9%	3.5%	-7.5%
US			51.9%	6.1%	-24.1%	33.8%
CN			101.1%	8.0%	-1.1%	107.9%
EU27	C29	Manufacture of motor vehicles, trailers and semi-trailers	31.0%	13.5%	-8.5%	35.9%
UK			38.6%	24.6%	-31.0%	32.2%
US			102.9%	12.5%	-35.8%	79.6%
CN			146.7%	5.1%	-5.9%	145.9%
EU27	C30	Manufacture of other transport equipment	10.1%	18.1%	-3.4%	24.8%
UK			18.8%	51.3%	-25.9%	44.2%
US			25.0%	26.2%	-10.9%	40.4%
CN			93.8%	-2.1%	-8.1%	83.5%
EU27	C31_C32	Manufacture of furniture; other manufacturing	-3.5%	10.5%	-8.2%	-1.2%
UK			40.6%	23.4%	-36.6%	27.4%
US			40.2%	13.1%	-27.7%	25.6%

Source: Own estimates;

4.4.6 Decomposition analysis of energy Intensity effects

From the decomposition of energy costs, the energy intensity effect is shown to be the key driver in reducing energy costs for the manufacturing industry. The drivers of this energy intensity effect can be grouped into three main drivers:

- Changes in industry structure;
- Changes in the fuel mix;
- (actual) energy efficiency measures and behavioural changes.

Analysis was carried out to look at how changes in industry structure and changes in fuel mix may have contributed to the overall energy intensity effect observed over 2010-2017.

Changes in industry structure

Industry structural change means the changes in the composition of industries within a sector. In relation to the energy intensity effect, this structural change effect refers to the change in energy intensity from industrial activity changing within in the sector.

Methodology & data limitations

To capture the extent of structural change on energy intensity, energy costs and output need to be available consistently at Nace 3 or 4-digit level. The Eurostat SBS data provides industry data down to that level for both Purchase of energy products and turnover. The level of detail available allows the calculation of an energy cost per unit of output measure (refer hence forth as energy cost share) for each subsector of the Nace 2-digit sectors used in the main decomposition analysis.

The main limitation of this measure is that this “energy cost share” measure does include within it changes in energy prices and so that can potentially distort the relative intensity between subsectors.

The impact of structural change on the energy cost share was calculated as follows:

1. The energy cost share for each Nace 3-digit sector using the 3-digit purchase of energy products divided by turnover. A reference energy cost share is defined for each subsector in 2017;
2. The reference cost share for each subsector was multiplied by turnover in each year to get an estimate of energy consumption for each subsector. This gives the implied energy costs share as if there had been no other changes in energy cost shares before 2017 (for example, through fuel switching or energy efficiency);
3. The energy consumption of the individual subsectors is summed up to get the energy intensity of the aggregate Nace 2-digit sector where the only change over time is the structural change;
4. The structural change effect is then the percentage difference in the structural change only energy intensity.

Table 4-23 shows an example for the two subsectors that make up the energy intensive C239 - Manufacture of abrasive products and non-metallic mineral products n.e.c.

Table 4-23 Example calculation for C239 - Manufacture of abrasive products and non-metallic mineral products n.e.c. subsectors for EU27

	Energy cost share		Turnover share	
Nace_code	2010	2017	2010	2017
C2391 - Production of abrasive products	0.0226	0.0193	19%	17%
C2399 - Manufacture of other non-metallic mineral products n.e.c.	0.0459	0.0461	81%	83%

C239 - Manufacture of abrasive products	2010	2017	% change
Actual energy cost share	0.0414	0.041	0.2%
Energy cost share (Structural effect only)	0.0409	0.0414	1.2%
Other energy cost share effects			-1.0%

If Energy intensity of the subsectors was the same in 2010 as in 2017, then energy cost share for C239 would equal (0.0193 * 19%) + (0.461 * 81%) = 0.409. This suggests that if there was no change other than the structural change effect then energy cost share in C239 – Manufacture of abrasive products would have increased over the period by 1.2% but the observed change was 0.2% suggesting that other effects on energy cost share (such as energy efficiency or fuel switching) reduced the energy cost share in the sector as a whole. In this example, the increase in energy cost share was driven by the relative increase in activity in the more energy intensive subsector C2399. This demonstrates that the structural change itself is driven by two factors:

- Relative difference in energy cost share between subsectors;
- Change in share of turnover of each subsector.

Structural change results

The analysis shows that the structural change in subsectors at a Nace 3-digit sector level, had a relatively small impact on overall energy cost share of the aggregate sector relative to other factors. This reflects that despite substantial variation in energy intensity between subsectors for some industries, there is no indication that there was a sufficient shift in production between subsectors to drive the changes in energy costs shares observed. Included in the Table 4-24 below are the key drivers of the structural change, the range of changes in shares of turnover and the range of energy cost shares for subsectors.

The differences in energy cost shares can be quite large for subsectors within a 2-digit sector. For example, in C23 - Non-metallic minerals, the least intensive sub sector is a fifth as intensive as most intensive sub sector. However, over the period, the change in turnover shares was only between -1.8% and 1% so the net structural change effect is only 2%. However, for other sectors where the difference in energy cost share in subsectors is very small which limits the scope of structural change to impact energy intensity. For example C15 - Leather and related products and C18 - Printing and production where even with a shift in shares of 4.9% and 3.2% respectively, the structural intensity effect is only 1% and 0% in these cases.

The largest structural change effect is observed for C30 Other transport equipment which shows a particularly large structural change effect in turnover between sectors to a lower energy intensive sector.

Table 4-24 Structure intensity effect for EU27 for Manufacturing sub sectors at 2 digit level

Nace code	Description	Structural intensity effect	Other energy intensity effects	Total energy intensity effect	Minimum change in turnover share	Maximum change in turnover share	Minimum Energy cost share	Maximum Energy cost share
C10	Food products	-1%	-21%	-22%	-1.2%	0.8%	1.1%	2.5%
C13	Textiles	-3%	-31%	-34%	-2.3%	3.8%	1.7%	4.9%
C14	Wearing apparel	-1%	-65%	-66%	-0.8%	0.9%	0.5%	1.0%
C15	Leather and related products	1%	-83%	-82%	-4.9%	4.9%	0.4%	0.5%
C16	Wood and wood products	0%	-15%	-14%	-1.9%	1.9%	2.3%	2.7%
C17	Paper and paper products	-1%	-37%	-38%	-1.4%	1.4%	2.0%	6.1%
C18	Printing and reproduction of recorded media	0%	-5%	-5%	-3.2%	3.2%	1.6%	1.8%
C19	Coke and refined petroleum products	0%	49%	49%	-0.1%	0.1%	0.0%	1.8%
C20	Chemicals and chemical products	0%	-27%	-28%	-0.4%	1.1%	0.7%	4.7%
C21	Pharmaceuticals	-1%	-24%	-26%	-0.8%	0.8%	0.6%	1.8%
C22	Rubber and plastic products	0%	-19%	-19%	-0.1%	0.1%	1.5%	2.0%
C23	Other non-metallic mineral products	2%	-22%	-20%	-1.8%	1.1%	2.6%	11.4%
C24	Basic metals	-1%	-25%	-26%	-1.7%	3.7%	1.6%	6.0%
C25	Metal products	2%	-24%	-22%	-2.4%	2.5%	0.7%	2.0%
C26	Computer, electronic and optical products	4%	-11%	-7%	-12.4%	8.6%	0.3%	1.0%
C27	Electrical equipment	1%	-29%	-28%	-2.5%	0.9%	0.5%	1.3%
C28	Machinery and equipment n.e.c.	-1%	-23%	-24%	-2.3%	1.0%	0.5%	0.9%
C29	Motor vehicles etc	0%	-30%	-30%	-0.3%	0.5%	0.3%	1.0%
C30	Other transport equipment	-14%	-36%	-49%	-7.8%	19.5%	0.3%	0.6%
C32	Other manufacturing	-1%	-25%	-26%	-1.7%	4.4%	0.4%	1.2%
C33	Repair and installation	1%	-7%	-6%	-2.4%	2.4%	0.5%	0.8%

However, when looking at individual Member States, the structural change effect can vary considerably suggesting that structural change is driven by changes in industry composition within Member States rather than broader industry changes at an EU level.

The Eurostat SBS data provides sufficient coverage of 4-digit subsectors that allows the structural change effect to be reported at the 3-digit level for the key energy intensive sectors. In most energy intensive sectors, the structural change makes only a small contribution to the change in energy cost share over 2010-2017.

For sectors where the structural change is smallest, this is due to the small difference in energy cost share between subsectors. Interestingly, the top three most energy intensive sectors (C235 - Cement, Clay building materials and Pulp and Paper), all have relatively small variations in the energy cost shares between the 4-digit subsectors. Of these three sectors, Cement, lime & plaster shows the largest change in turnover share between the two subsectors (C2351 - Cement & C2352 - Lime & plaster) but as the difference in energy cost share is so similar, the structural effect on energy intensity is very small. There are a few energy intensive sectors where the structural change is relatively large share of the change in energy cost share. This includes C234 - Other porcelain and ceramic products, C239 - Abrasive products and non-metallic mineral products n.e.c. and C244 - Basic precious and other non-ferrous metals.

Looking at these sectors in more detail, within these energy intensive sectors at the 4-digit level, there is a substantial difference in energy intensity between subsectors. Although from the relatively large changes in turnover, it is clear that the structural changes that are occurring are not between the extremes within these sectors.

This wide variation in energy intensity within subsectors does highlight that structural changes even at the 4-digit level have the potential to have a substantial impact on the energy intensity of the aggregate sector if there was a shift in production away from the most energy intensive subsectors toward the lower intensive sectors.

Table 4-25 Structure intensity effect for EU27 for Energy intensive manufacturing sub sectors at 3 digit level

Sector	Structural intensity effect	Other energy intensity effect	Minimum change in turnover share	Maximum change in turnover share	Minimum Energy cost share	Maximum Energy cost share
C235 - Cement, lime and plaster	-0.8%	-9.0%	-8.1%	8.1%	13.5%	15.0%
C233 - Clay building materials	-0.8%	-27.8%	-1.8%	1.8%	6.3%	9.8%
C171 - Pulp and paper	0.0%	-38.3%	-0.1%	0.1%	6.1%	6.7%
C231 - Glass	1.7%	-24.1%	-3.4%	5.1%	3.0%	7.9%
C245 - Casting of metal	-1.3%	-24.5%	-4.7%	9.7%	2.3%	6.0%
C239 - Abrasive products	1.2%	-1.0%	-1.9%	1.9%	1.9%	4.6%
C234 - Porcelain and ceramics	-3.0%	-8.5%	-2.8%	7.9%	2.4%	7.6%
C201 - Basic chemicals	-0.9%	-24.9%	-0.4%	1.1%	3.7%	14.3%
C244 - Non-ferrous metals	-1.5%	-6.8%	-1.0%	2.3%	0.3%	5.2%

Fuel switching

Fuel switching is considered potential driver of the energy intensity effect within industry sectors as switching from processed using more inefficient fuels such as coal to more efficient processed using electricity and gas are expected to lead to a net reduction in energy intensity. From the literature, the improvement in energy intensity is expected to come from the higher level of control that comes from using electricity and gas over coal and oil fuel use[109].

[109] Griffn et al 2016, Industrial energy use and carbon emissions reduction: a UK perspective, WIREs Energy Environ 2016

Data limitations

The true impact of fuel switching on energy intensity is difficult to isolate from the available statistics. While data are available to calculate the change in fuel mix over time, what cannot be derived from a top down approach is the specific energy intensity of individual fuels in industrial production.
Though a full decomposition cannot be carried out due to the lack of data, the changes in the fuel mix over time in industry subsectors can be explored and identify if there is any trend between fuel mix and energy intensity.

Fuel mix change over time

Looking at the changes in fuel mix over time across the manufacturing sectors, one can observe that the direction of change between fuels varies considerably between sectors but overall, the scale of the change in fuel shares is relatively small at less than 5% for most sectors and fuels.

- The share of coal in fuel consumption remains quite static for most sectors, but this also reflects relatively low shares of coal use in most sectors;
- For electricity, most sectors show increases in the share of electricity in energy consumption over the period;
- For natural gas, on average there was an increase in the share of gas in total energy consumption over the period;
- Overall oil consumption fell as a share of energy consumption across most sectors.

Overall, there is a clear trend across industry sectors towards higher shares of electricity or gas use and a corresponding substitution away from oil and/or coal use. This fuel switching trend towards these more efficient fuels suggest it could have potentially contributed to the reductions in energy intensity observed. However, the relatively small changes in shares over the period suggest the scale of the impact would be rather limited.

Looking at individual sectors, there are a few interesting cases to draw out. Among the energy intensive sectors, C24 – Iron & steel sector has seen a visible shift away from coal towards other fuels, mainly electricity. C16 - Wood & Wood products and C17 – Paper & Pulp show a reduction in all main fuels and a shift towards other fuels. This trend reflects that these sectors have the largest share of other in total consumption across the period and that share has increased further over time as they make use of biomass, waste products for energy.

Figure 4-37 Absolute Change in fuel shares 2010-2017 by subsector for EU27

Estimating impact fuel switching on energy intensity

To explore the relationship between energy intensity and fuel shares, a simple regression was estimated of energy intensity against fuel shares for the 4 main fuels and a time trend to capture general energy efficiency trend.

The specification of the equation to be estimated is, in its simplest form:

$$Energy\ intensity = \beta_0 + \beta_1\ Coal + \beta_2\ Electricity + \beta_3\ Gas + \beta_4\ Oil + \beta_5 Year + \varepsilon$$

Where:

- Energy intensity is the natural logarithm of energy consumption per million euros of Turnover (taken from Eurostat SBS database);
- Coal is the natural logarithm share of coal consumption in total energy consumption from multiple sources (see 4.42);
- Electricity is the natural logarithm share of electricity consumption in total energy consumption from multiple sources (see 4.42);
- Gas is the natural logarithm of the share of gas consumption in total energy consumption as constructed from multiple sources (see 4.42);
- Oil is the natural logarithm of share of oil consumption in total energy consumption from multiple sources (see 4.42);
- Year is the year of observation in levels to capture the time trend.

There are limitations to the simple regression estimated with the largest one being the omitted variable bias. As highlighted, energy intensity should also be driven by changes in structural change and other energy efficiency measures and behavioural trend. The time trend is expected to capture this but there is still a risk that the parameter estimated are capturing other factors.

Results

Overall, the regressions results do not find a significant relationship between energy intensity and fuel mix shares for many combinations of fuels and sectors. The exception is electricity which shows the a statistically significant relationship for half of the industry sectors. Where significant, the coefficient on electricity share is consistently negative.This aligns with the theory, suggesting that as industries switch to using more electricity as a share of energy use, energy intensity falls..

For coal, the evidence of a relationship is weak looking across sectors, but this is not unexpected given the relatively low share of coal use across most industry sectors. The sector with the largest coal share of generation (C24 - Iron & Steel) does show a significant positive coefficient suggesting that energy intensity falls as coal use falls. However, as we saw in Figure 4-37, the overall change in fuel share across the EU27 of 2010-2017 has been quite small which limits the potential magnitude of the impact.

For both oil & gas, the mixture of signs and low statistical significance does not suggest any clear impact on energy intensity .

The time trend captured by the year variable, is not always consistent across sectors in terms of direction and not always significant suggesting this is not effectively picking up the general energy efficiency effect. However, where the time trend is clearly significant such as for C24 – Iron & steel, the sign is the expected direction of energy efficiency reducing energy intensity over time.

The regression results are mixed across sectors and there are very few sectors where all variables are significant suggesting limitations to this simple equation to isolate this effect. However, in the case of C24 - Iron & steel and C10_C12 - Food Drink & Tobacco where the fuel shares are significant and the appropriate sign provides evidence that fuel switching has impacted energy intensity over the period 2010-2017 for those sectors. However, the scale of the impact of fuel switching is likely to be limited as the change in shares between fuel types is relative small at less than 4% for any individual fuel.

Table 4-26 Regression results for Energy intensity regressed against fuel shares for each manufacturing subsector

Sector	Coal	Electricity	Natural Gas	Oil	Year
C10_C12 - Food, Drink & Tobacco	-0.03**	-0.48***	-0.05	0.09***	0.01**
C13_C15 - Textiles & leather	-0.02	-0.74***	0.31	-0.07*	-0.02***
C16 - Wood etc	-0.01	-0.33	-0.04	0.01	0.01
C17 - Paper and paper	0.01	-0.17	0.2	0.03	0
C19 - Coke & Petroleum	0.34	-1.63	-1.15*	-1.04	0.19**
C20 - Chemicals	-0.01	-0.59***	0.01	0.04	0
C21 - Pharmaceuticals	0.24**	-0.55	-0.5**	0.21*	-0.03
C22 - Rubber and plastic	-0.01	-1.22**	0.34	-0.14	-0.01
C23 - Other non-metallic	0	-0.8***	-0.08	-0.03	0
C24 - Basic metals	0.08**	-0.61***	-0.12	-0.13***	-0.02**
C25 - Metal products	-0.02	-0.39*	-0.01	-0.13	-0.03***
C26 - Computer and electronics	0.09	-0.6	0.43	0.18	-0.01

Sector	Coal	Electricity	Natural Gas	Oil	Year
C27 - Electrical equipment	-0.06**	-0.26	-0.09	-0.06	-0.04***
C28 - Machinery and equipment	0.01	-0.44	0.14	0.06	-0.01
C29 - Motor vehicles	0.01	-0.59**	0.35**	0.11	-0.05***
C30 - Other transport equipment	0.06	1.22	0.7	0.47	-0.09***
C31_C32 - Other manufacturing	-0.5**	0.34	-1.15***	0.2	-0.03
C33 - Repair and installation	-0.11	-1.55***	0.7	-0.19***	-0.02

Source: Own calculations
*Note: * 1% significance level, ** 5% significance level and *** 10% significance level*

Conclusion on drivers of the energy intensity effect

The analysis of energy intensity effect has shown that industry structural change and fuel switching have not provided a significant contribution to the observed reduction in energy intensity for the EU27 across various manufacturing sectors. This suggests that the main driver of energy intensity was actual energy efficiency improvements.

Structural change was found to have had a negligible impact on energy intensity across almost all manufacturing subsectors. Though there is substantial variation in energy intensity in manufacturing subsectors, there was little evidence of substantial shifts in production towards less energy intensive activity

Impact of fuel switching on energy intensity was not statistically significant for most industry sectors and fuel sectors. This suggests that fuel switching did not have a substantial impact on the reductions in energy intensity over the period. Only shifts in electricity use were found to be significant in explaining energy intensity among a number of manufacturing sectors. Suggesting that increasing electrification may have had a small contribution to reducing energy intensity over the period. The impact for other fuels was mixed showing no clear relationship.

This lack of a significant contribution from either structural change or fuel switching suggests that actual energy efficiency improvements have driven this reduction in energy intensity effect.

5 Task 3 - Analysis of impact of realised' prices and support interventions on profitability and investments across power generation technologies in the power market in the EU and EU major trading partners

5.1 Methodology and data

5.1.1 Objective and scope

The aim of this task is to collect, monitor and organise hourly data (prices and generation by type) on organised power markets in G20 countries, along with information on subsidies and investments, to assess the impact of realised prices (power generation weighted average market price) and support interventions on the profitability of investments in different power generation technologies and fuel types.

5.1.2 Data gathering

The following data types are collected and processed as part of Subtask 3.1:

1. Electricity hourly data:
    a. The electricity prices in at least hourly time resolution observed on organised markets (e.g. day-ahead prices reported by power exchanges) for countries and (where applicable) price zones within countries;
    b. The hourly power generation level of different technologies and fuel types (e.g. 'natural gas fired combined cycle') in countries and (where applicable) zones within countries matching the price zones.
2. The amount of government support that complements/replaces sales of electricity on organised markets received by each power generation technology and fuel type;
3. Investments in new power generation units (in capacity and monetary terms) per power generation technologies and fuel types for countries and (where applicable) price zones within countries.

1. Electricity hourly data

General approach for Europe

For Europe, ENTSO-E Transparency Platform gathers hourly data relative to power generation and power prices. The first year fully covered by this data source is 2015. Therefore, a country-oriented data collection has been carried out to gather additional data between 2008 and 2014. The main available sources have the following contributions/limitations:

- ENTSO-E:
    - Main contribution: good coverage of prices and power generation per technology;
    - Main limitation: data from 2015 onwards only.
- Individual TSOs:
    - Main contribution: power generation data can be available before 2015;
    - Main limitation: not all MS TSOs provide data, heterogeneity.

- Power market operators:
  - o Main contribution: power prices and power generation for main markets;
  - o Main limitation: EEX data are not available free of charge; in general power generation data replicates ENTSO-E data with no data before 2015.
- Power prices sent by EC:
  - o Main contribution: power prices available for main markets and MS;
  - o Main limitation: no data for 2008 and 2009.

Based on the above contributions and limitations, we have used the following approach to get a comprehensive database of hourly power prices and power generation per technology in Europe:

- Power generation per technology:
  - o Data after 2015 (included): ENTSOE;
  - o Data before 2015: data collection from individual TSOs (depending on availability)

Table 5-1 Power generation data from MS TSO implemented in the database

Country	TSO	Date of availability	data integrated	Time granularity source
France	RTE	2012	2012-2014	30 min
Belgium	Elia	2012	2012-2014	15 min
Czech Republic	CEPS	2010	2010-2014	60 min
Spain	REE	2008	2008-2014	10 min
Denmark	Energinet	2011	2011-2014	60 min
Romania	Transelectrica	2008	2008-2014	10 min
United Kingdom	Elexon	2009	2009-2014	30 min
Germany	PF Bach, from TSOs	2009	2009-2014 (wind)	60 min
Austria	APG	2013	2013-2014 (wind)	60 min
Sweden	Svenska kraftnät	2008	2008-2014	60 min
Ireland	PF Bach, from TSO	2009	2009-2014 (wind)	60 min

Table 5-2 Initial review of MS TSO data

Country	TSO	Link	Status
AT	Austrian Power Grid AG	APG	Implemented in database
DE	Vorarlberger Übertragungsnetz GmbH	VUEN	No data found
AL	OST sh.a - Albanian Transmission System Operator	OST	No data found
BA	Nezavisni operator sustava u Bosni i Hercegovini	NOS BiH	No data found
BE	Elia System Operator SA	Elia	Implemented in database
BG	Electroenergien Sistemen Operator EAD	ESO	No data found
CH	Swissgrid ag	Swissgrid	No data found
CY	Cyprus Transmission System Operator	Cyprus TSO	No data found
CZ	ČEPS a.s.	ČEPS	Implemented in database
DE	TransnetBW GmbH	TransnetBW	Implemented in database
DE	TenneT TSO GmbH	TenneT DE	Implemented in database
DE	Amprion GmbH	Amprion	Implemented in database
DE	50Hertz Transmission GmbH	50Hertz	Implemented in database
DK	Energinet	Energinet.dk	Implemented in database
EE	Elering AS	Elering AS	No data found

Country	TSO	Link	Status
ES	Red Eléctrica de España S.A.	REE	Implemented in database
FI	Fingrid Oyj	Fingrid	No data found
FR	Réseau de Transport d'Electricité	RTE	Implemented in database
UK	National Grid ESO	National Grid ESO	Implemented in database
UK	System Operator for Northern Ireland Ltd	SONI	Implemented in database
UK	Scottish Hydro Electric Transmission plc	SHE Transmission	Implemented in database
UK	Scottish Power Transmission plc	SPTransmission	Implemented in database
GR	Independent Power Transmission Operator S.A.	IPTO	No data found
HR	HOPS d.o.o.	HOPS	No data found
HU	MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság	MAVIR ZRt.	No data found
IE	EirGrid plc	EirGrid	No data found
IS	Landsnet hf	Landsnet	No data found
IT	Terna - Rete Elettrica Nazionale SpA	Terna	No data found
LT	Litgrid AB	Litgrid	No data found
LU	Creos Luxembourg S.A.	Creos Luxembourg	No data found
LV	AS Augstsprieguma tīkls	AST	No data found
ME	Crnogorski elektroprenosni sistem AD	Crnogorski elektroprenosni sistem	No data found
NL	TenneT TSO B.V.	TenneT NL	No data found
NO	Statnett SF	Statnett	No data found
PL	Polskie Sieci Elektroenergetyczne SA	PSE S.A.	No data found
PT	Rede Eléctrica Nacional, S.A.	REN	No data found
RO	C.N. Transelectrica S.A.	Transelectrica	Implemented in database
SE	Svenska Kraftnät	SVENSKA KRAFTNÄT	Implemented in database
SI	ELES, d.o.o.	ELES	No data found
SK	Slovenská elektrizačná prenosová sústava, a.s.	SEPS	No data found

- Power prices:
  - o Main source to be used: data sent by EC covering 2010-2018. It matches with the series we would have obtained from market operators.

Table 5-3 Power markets covered in EC data

EEX-DE	APX-NL	PNX-FR	BPX-BE	EXAA-AT
EPEX-CH	OMEL-ES	OMEL-PT	GME-IT	PolPX-PL
OTE-CZ	OTE-SK	HUPX-HU	BSP-SI	OPCOM-RO
DESMIE-GR	NP-SYS	FI	DK1	DK2
SE1	SE2	SE3	SE4	
NO-Oslo	NO-Kr.sand	NO-Bergen	NO-Molde	NO-Tr.heim
NO-Tromsø	EE			

General approach for countries/zones outside Europe

Outside Europe we rely on data from TSOs and market operators. Main improvement from the inception report is the integration of additional zones for the US and an almost complete implementation of available data in the database.

- Power generation per technology:
    - o Most zones/countries have been implemented. The remaining countries to be covered are Brazil, Russia, Argentina and Japan.

Table 5-4 Power generation data outside Europe implemented in database as of 24/04/2020

Country	TSO-Zone	Date of availability	Time granularity source
Turkey	Epias	2012	60 min
Mexico	CENACE	2016	60 min
US	Southwest Power Pool	2011	5 min
US	MISO	2013	60 min
US	PJM	2016	60 min
US	CAISO	2018	60 min
US	ERCOT	2007	15 min
US	NYISO	2015	5 min
US	New England ISO	2014	day
Canada	AESO	2012	60 min
Canada	IESO	2015	60 min
South Korea	EPSIS	2002	1 Month
South Korea	EPSIS	2018	1 Month
Australia Wa- Western Australia (WA)	AEMO	2006	30 min
Australia	AEMO	2019	5 min

- Power price per technology:

Table 5-5 Power price data outside Europe implemented in database as of 24/04/2020

Country	TSO-Zone	Date of availability	Time granularity source
US	MISO	2006	60 min
US	PJM	2000	60 min
US	ERCOT	2013	60 min
US	NYISO	1999	60 min
US	Southwest Power Pool	2013	60 min
US	New England ISO	2013	60 min
US	CAISO	2017	60 min
Canada	AESO	2000	60 min
Canada	IESO	2002	60 min
Turkey	Epias	2012	60 min
Mexico	CENACE	2016	60 min
South Korea	EPSIS	2001	60 min
Australia	AEMO-WA	2012	30 min
Australia	AEMO	2008	30 min

2. Government support that complements/replaces sales of electricity

The goal of this sub-task is to gather information on the various types of public financial supports to power generation technologies deployed on the organised power markets identified in the two previous sub-tasks. The data collection focuses on available and usable data from different support schemes (mainly Feed-in tariffs, Feed-in premiums, Contract-for-Difference, Renewable obligation with green certificates and auctions). The main focus will be simple Feed-in Tariff.

To gather such data, we rely on the EMOS lot 2 study from DG Ener which provides in the "Renewable Energy Support Policies in Europe" report a list of support policies per technology, per MS and per year of contracting. Below an extract from the latest available EMOS report for Germany for solar.

Table 5-6 Extract of Feed-**in tariffs for solar energy in Germany (€c/kWh) until March 2012**

Technology	Capacity	Aug. 2004	2005	2006	2007	2008	2009	2010*	2011	Jan.-March 2012
Rooftop systems	≤ 30 kW	57.4	54.5	51.0	47.7	46.8	43.0	36.3	28.7	24.4
	30-100 kW	54.6	51.9	48.5	45.3	44.5	40.9	34.6	27.3	23.2
	100 kW-1 MW	54.0	51.3	48.0	44.8	44.0	39.6	32.7	25.9	22.0
	> 1 MW	*n.r.*				44.0	33.0	27.3	21.6	18.3
Ground-based sytems	Protected areas	*n.r.*								18.8
	Other areas	45.7	43.4	40.6	38.0	35.5	31.9	28.4	21.1	17.9
Duration		20 years								

*: *annual average*

Table 5-7 Feed-**in tariffs for solar energy in Germany (€c/kWh) between April 2012 and June 2018**

Scheme	Technology	Capacity	April-Dec 2012*	2013*	Jan.-July 2014*	Aug.-Dec. 2014*	2015*	2016*	2017*	2018*	2019*	2020 01	2020 02	2020 03	2020 04
Feed-in tariffs	Building-mounted systems	≤ 10 kW	18.6	15.3	13.3	12.7	12.4	12.3	12.2	12.0	10.7	9.87	9.72	9.58	9.44
		10-40 kW	17.7	14.5	12.7	12.3	12.1	12.0	11.9	11.7	10.4	9.59	9.45	9.31	9.18
		40-100 kW	15.8	12.9	11.3	11.0	10.8	10.7	10.6	10.5	8.39	7.54	7.42	7.31	7.21
		100-500 kW							*n.r. (auctions)*						
		0.5-1 MW				*n.r. (auctions)*									
		> 1 MW	12.9	10.6	9.24										
	Ground-based systems	≤ 100 kW	12.9	10.6	9.24	8.77	8.59	8.53	8.47	8.33	7.40	6.80	6.70	6.60	6.50
		0.1-10 MW						*n.r. (auctions)*							
Premiums	Rooftop systems > 500 kW	≤ 10 kW	Variable premiums on top of the market price to match the feed-in level			13.1	12.8	12.7	12.6	12.4	11.1	10.3	10.1	10.0	9.84
		10-40 kW				12.7	12.5	12.4	12.3	12.1	10.8	10.0	9.85	9.71	9.58
		40-750 kW				11.4	11.2	11.1	11.0	10.9	8.79	7.94	7.82	7.71	7.61
		0.75-1 MW							*n.r. (auctions)*						
	Ground-based systems	≤ 750 kW				9.17	8.98	8.91	8.87	8.73	7.80	7.20	7.10	7.00	6.90
		0.75-10 MW							*n.r. (auctions)*						
Duration			20 years												

*: *annual average.*
**: *semester average.*

Methodology

A two steps methodology, based on EMOS data, has been implemented:

1. Collect data from EMOS per technologies and year and process it in the database;
2. Convert the technology mapping from EMOS data into a usable mapping. For a given technology it requires to calculate the weighted average support from the sub-technology subsidies based on installed capacities. In the case of the above table, it will require estimating the capacity distribution per sub technology (rooftop, ground based etc.) and capacity size. We collected this information in the PVPS reports[110], published by IEA.

[110] https://iea-pvps.org/national-survey-reports/ and https://iea-pvps.org/trends-reports/

3. Investments in new power generation units

This sub-task aims at collecting data on both capacities (MW) and investments (€) related to new power generation units commissioned between 2008 and the latest available year (2018 or 2019).
The main sources used are:

- Data on capacities (MW):
  - Global Energy & CO_2 Data (GED)[111]: Enerdata's in-house energy and CO_2 database covering more than 180 countries (including G20 and EU Member States), with annual data from 1970 onwards. This robust and recognised database is based on more than 400 premium processed sources;
  - Power Plant Tracker: Enerdata's in-house power plant database covering more than 85% of the world's power capacities including G20 and EU Member States. This database provides detailed information at the power plant level, including capacity, commissioning and decommissioning dates and could be used to complete and benchmark information from the GED database. Eurostat database on Electricity production capacities by main fuel groups and operator: used as a primary source for EU MS, available here;
  - Both Global Energy & CO_2 Data and Power Plant Tracker databases use national and regional TSOs, power market operators and statistical bodies as primary sources.
- Investments (€)

  As they are a main driver of the Internal Rate or Return, CAPEX and OPEX values have been carefully reviewed. We have made an exhaustive review of all sources, collected by the consortium or provided by the EC, and selected the most coherent ones for each energy.
  - Main sources for Solar (all countries):
    - IRENA: Renewable Power Generation costs (also used in the Cost & Tax EC study);
    - IEA: PVPS - Country Reports & PVPS - Trends;
    - EC assumptions: PRIMES scenario, combined with IEA WEO to interpolate CAPEX data points for each year.
  - Main sources for Wind (all countries):
    - IRENA: Renewable Power Generation costs.
  - Main sources for Coal & Gas:
    - Power Plant Tracker[112], Enerdata's in-house power plant database provides detailed information at the power plant/renewable park level including capacity, commissioning and decommissioning dates, investment (CAPEX);
    - National sources, such as EIA (US), BEIS (UK), Fraunhofer Institute (DE).

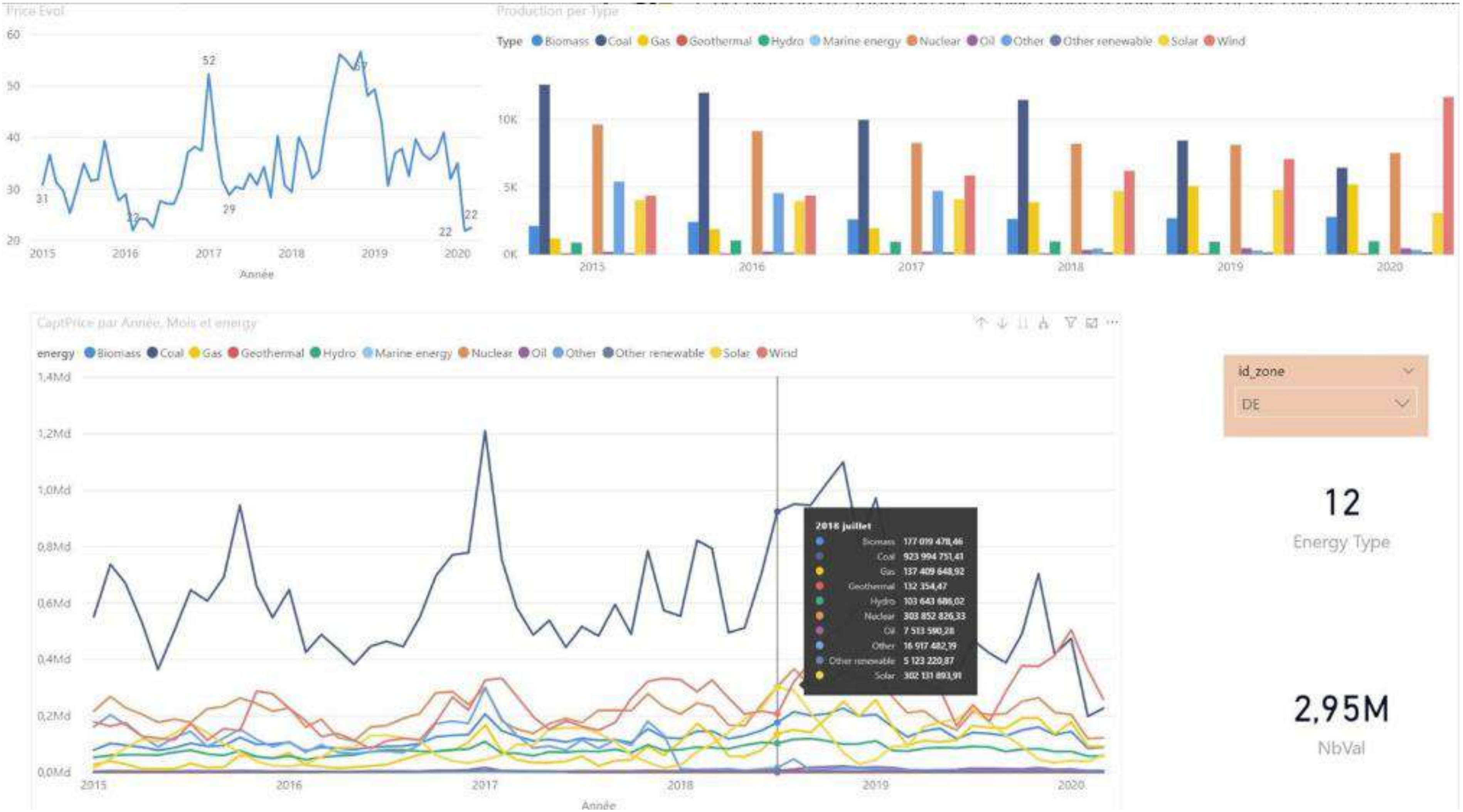
5.2 Database

The main purpose of the database is to deal with a huge amount of data coming from hourly power generation and prices datasets. More than 50 individual sources for power generation and prices have been implemented.

In parallel, we have worked on database extractions and business intelligence tools that allow us to efficiently manage the significant amount of data. A specific dashboard has been developed (for internal use in relation with the study at Enerdata) which includes, for a given zone, the visualization of the power price, power generation per year per technology and realised price per technology.

111 https://www.enerdata.net/research/energy-market-data-co2-emissions-database.html
112 https://www.enerdata.net/research/power-plant-database.html

Figure 5-1 Database dashboard



5.3 Assessment of the impact of realised prices and support intervention on the profitability of investments in different power generation technologies and fuel types

The aim of subtask 3.3 is to use the databases identified and accessed in subtask 3.1 (the hourly databases on power generation and prices, the database about support intervention in the electricity sector and the one about investments), to calculate the annual profitability of investments in different power generation technologies and fuel types.

5.3.1 Introduction

The main objective of the task is to assess profitability of different power generation technologies and fuel types by taking into account price erosion or cannibalization and support intervention in the EU and major EU trading partners. The main drivers of profitability are:

- The power generation costs depending on CAPEX, O&M costs, fuel costs, CO_2 costs and the efficiency or load factor;
- The annual revenues obtained by different power generation technologies and fuel types from the sales of electricity on organized markets according to the annual 'realised' prices
- Additionnal revenues from system services;
- And/or the annual revenues from support intervention in the electricity sector.

Wholesale electricity Markets

Besides revenues from support intervention (see Government support section) and system services (see Revenues from system services section), the main source of revenues for power suppliers is the sales of electricity.

The main market places for traded products are power exchanges and over the counter 'OTC' operations. On both market places different products can be traded depending on the time horizon as shown below.

Table 5-8 example of power generation traded contracts

Traded contracts on the French electricity wholesale market		
	Powernext	**French OTC market as assessed by platts**
day-ahead	24 single hours and 11 different blocks of hours	base & peak
week-end	-	base
week-ahead	-	base & peak
months	3 consecutive months, base & peak	3 consecutive months, base & peak
quarters	4 consecutive quarters, base & peak	2 consecutive quarters, base & peak
years	3 consecutive years, base & peak	2 consecutive years, base & peak

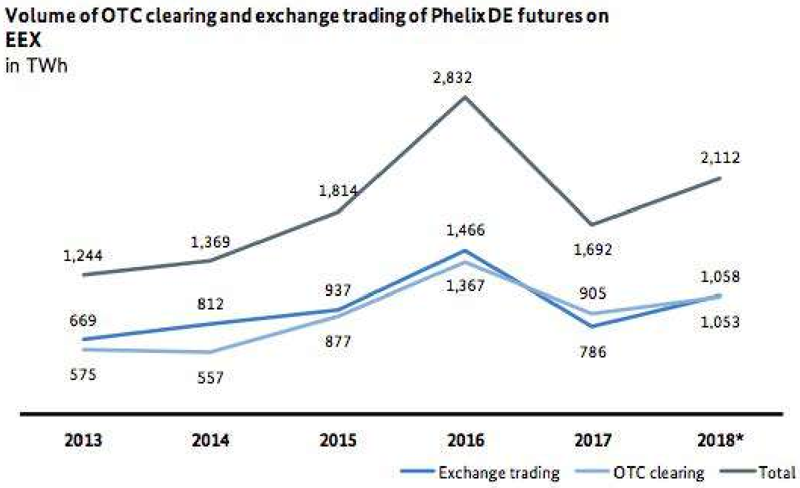
Source: Platts[213]*, Powernext*

From the point of view of electricity generators, the electricity wholesale markets can be used to sell their power generation output, optimize the operation of their generation portfolio, but also perform arbitrage deals or take speculative positions.

Power exchanges are organised market places with a central counterparty. The main ones in volumes in EU are Nord Pool, EEX, APX in the Netherlands, OMEL in Spain and GME in Italy.

OTC transactions are carried out bilaterally and counterparty risk is born by the market participants. Shown below is an example for Germany where volumes traded on future exchanges and OTC are quite similar. Traded volumes on both power exchanges and OTC can be relatively similar as we see in the German example.

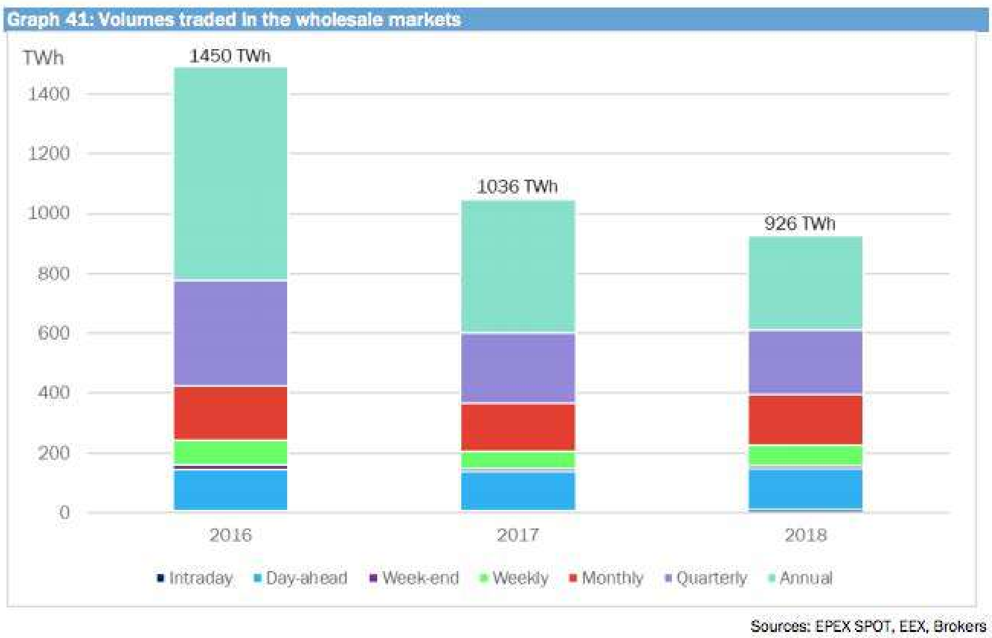
Figure 5-2 Volume of OTC clearing and exchange trading of Phelix DE futures on EEX for Germany (2013-2018)



The core market elements are the forward market, the day-ahead market, and the intraday market. The intraday market aims to secure real time supply, the day ahead market serves to optimize scheduling of resources, and the forward market allows participants to exchange weekly, monthly, quarterly, and yearly products. All products can be used to sell generation outputs, procure electricity, and for speculative or hedging purposes. Exchanged volumes per product type can vary between countries/markets.

Shown below is an example for France, where annual products are the most traded followed by quarterly, monthly, and then day-ahead products. Intraday products are the least traded. Traded volumes accounts for around 2-3 times the total physical power generation.

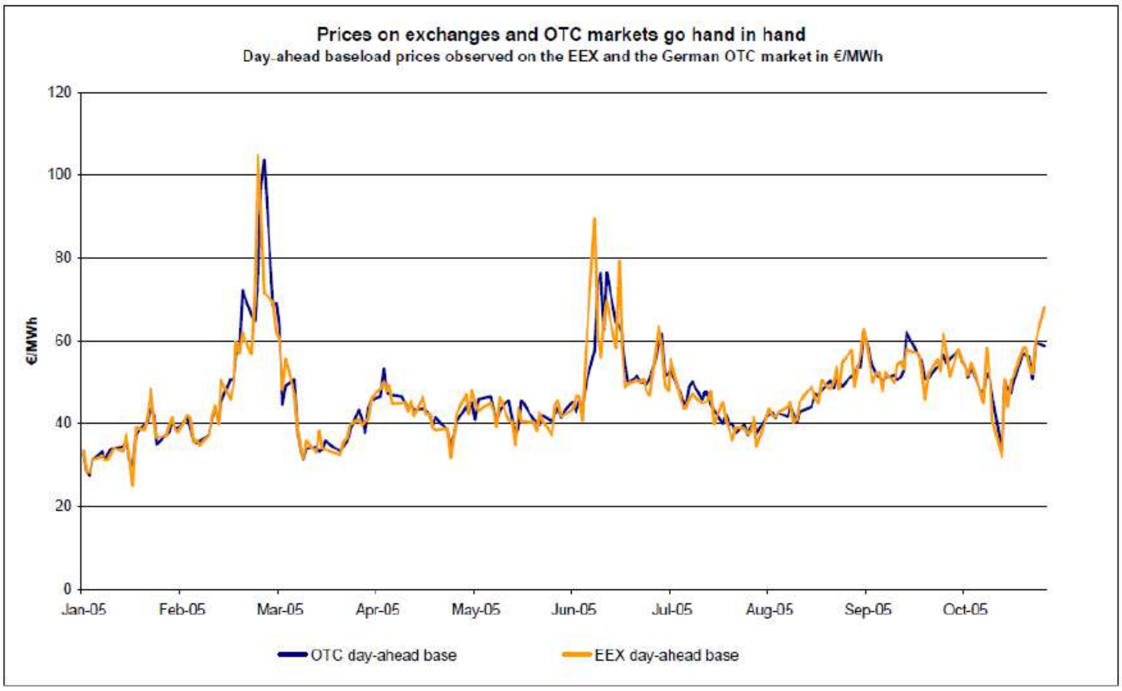
Figure 5-3 Volumes traded in the wholesale markets in France (2016-2018)



Source: CRE, Functioning of the wholesale electricity and natural gas markets (Report 2018)

We will now explain why day ahead power prices, easily available from power exchanges, are a good proxy to take into account all the above revenues and operations. First of all, the DG Competition report on energy sector inquiry [113] clearly states (paragraph 37) that there is a convergence between power exchanges prices and OTC prices for equivalent products as shown below. It means that we can use power exchanges prices to cover both power exchange and OTC revenues.

Figure 5-4 Convergence power exchange and OTC prices



Source: EEX, Argus Media

The question is, whether the day ahead price is a good proxy for all the operations made on products based on different time horizons. Depending on the delivery period, bulk electricity can be traded on spot or forward markets. Spot markets are mainly day-ahead markets on which electricity is traded one day before physical delivery takes place. On forward markets, power is traded for delivery further ahead in time

Spot/day ahead prices are set by the short run marginal cost of the plant producing the last unit of electricity required to meet demand at that time of day. However, while future markets prices are influenced by supply-demand fundamentals that are expected to prevail in the future, spot prices are determined by the short variations of these fundamentals. The DG Competition report on energy sector inquiry states that "forward prices can give an indication of the overall market expectation about future spot prices" which means that in average, over a power plant lifetime, forward prices should be relatively close to spot prices. The main difference come from a risk premium since sellers and buyers engage in forward contracts because they prefer price certainty to unknown spot prices in the future. If we exclude risk management and focus only on revenue from power generation output, day ahead price can be considered as a good proxy for the revenues from all traded products (except for ancillary services).

[113] https://ec.europa.eu/competition/sectors/energy/2005_inquiry/full_report_part2.pdf

Apart from physical sales of electricity, potential additional revenues from trading practices monetizing the optimality value of power plants are not accounted for in this analysis.

5.3.2 Methodology

The primary metric that we will use for assessing the profitability of investments is the internal rate of return (IRR), which is defined as the discount rate at which the net present value (NPV) equals zero (see formula below). The benefit of using the IRR (as opposed to the NPV) is that the figures are expressed as percentage values which are easier to compare and interpret than absolute Euro figures.

$$NPV_{t,y} = 0 = \sum_{k=y}^{Lifetime} \frac{RM_{t,k} + RS_{t,k} - C_{t,k}}{(1 + IRR)^{k-y}} - I_t$$

With $NPV_{t,y}$ the Net Present Value for the investments made in year y for technology/fuel t; $RM_{t,k}$ the revenues from the sales of electricity on organized markets in year k for technology/fuel t; $RS_{t,k}$ the revenues from support intervention in year k for technology/fuel t; $C_{t,k}$ the variable costs in year k for technology/fuel t, I_t the overnight investment costs.

The proposed methodology and data sources were discussed and validated as part of stakeholder webinar that took place on the 20th of May 2020. Academic experts, EU electricity associations or regulators emphasized the importance of capturing or estimating the complexities of power market and to focus on data quality rather than on wider time, technological and geographical series.

Given the disaggregation of input data (hourly power generation, technological costs, and parameters), the profitability assessment focuses on the following technologies which provide a good balance between data quality and technology coverage:

- Solar PV;
- Wind onshore and offshore turbines;
- Gas fired power plants;
- Coal fired power plants;
- Hydropower plants;
- Nuclear power plants.

Solar PV and wind benefit from the extensive data sets collected on both revenues (power generation, realised price, support intervention) and costs (e.g. use of PVPS reports) which results in detailed IRR calculations per country. Regarding gas and coal fired generation, the main challenge is to capture the different sources of revenues. Therealised day ahead price is used as a proxy of power generation market revenues and a premium has been estimated for ancillary services and other sources of revenues (see next section for more details). For hydro and nuclear, a simple regional approach is implemented to account for less detailed input data and a low amount of commissioned projects between 2008 and 2018 compared to other technologies.

5.3.3 Scenario and sensitivities

The profitability analysis relies on several estimates and assumptions to deliver an expected, average profitability for already installed capacities. Hence, the calculated profitability would be different if, for instance, different assumptions on future electricity prices were made, and a scenario/sensitivity analysis is useful to better understand the sensitivity to different assumptions. The challenge with delivering a useful scenario/sensitivity analysis is that evaluating the sensitivity to different values for all parameters would lead to a very high number of different profitability estimates, which become overwhelming and difficult to properly appreciate. Therefore, choices need to be made with respect to the parameters for which an analysis will be performed, and for which not.

The parameters on which a scenario/sensitivity analysis can be performed can be subdivided into estimates with respect to already incurred costs/revenues and assumptions for future costs/revenues. The key difference between those is that for already incurred costs and revenues (e.g. investment costs, historical realiseded prices), as well as for already allocated incentives (e.g. feed-in-premiums), there is not so much uncertainty but rather variance to account for. For future costs/revenues on the other hand, there is real uncertainty as there are many unknown developments that influence those. To keep the scenario/sensitivity analysis comprehendible, we have chosen to focus on evaluating the impact of uncertainties affecting future costs and revenues.

For the estimates of past costs and revenues, the approach is to take the capacity-weighted average value, be transparent on the values used, and be clear that the resulting profitability estimate concerns an average plant. Since we only consider already installed capacities, the same approach is taken for subsidies and other incentives (i.e. assuming those are not uncertain), as the incentives have already been allocated before construction in most cases. Note that we will evaluate the profitability without any incentives as part of the analyses in the factsheet, however.

The main uncertainties to consider for the scenario/sensitivity analysis include a wide range of developments that affect electricity prices and price volatility, including the future penetration of renewables and what the overall electricity mix will look like, the impact of energy storage and demand response technologies, and the rate of electrification of transport, industrial processes, heating and cooling. The net effect of these developments on the profitability of power plants materialises through influencing the effective sales price (realised price) that results for the different technologies and will be evaluated as such in the first analysis. Furthermore, the future development of fuel and carbon prices can pose significant uncertainties for the profitability of power plants. These will be evaluated in a second analysis.

Scenario: Fuel, carbon prices and realised prices

The profitability analysis relies on IRR calculations that require assumptions for the whole lifetime of the projects commissioned between 2008 and 2018. It means some projections are needed for the next 30-40 years. For such time horizon the main uncertainties for the future of global and EU energy systems come from energy and policy measures and to a lesser extent technological and sociological changes.

For these reasons, the profitability analysis relies on a central scenario that will be in line with existing 2030 & 2050 EU objectives and existing energy and policy measures. We have used extractions (for 2030 and 2050) from a METIS[114] based studyof an energy system that is greenhouse gas neutral in 2050. This approach ensures a coherent set of data for the central scenario used in IRR calculations.

[114] METIS is a mathematical model used by the European Commission providing analysis of the European energy system for electricity, gas and heat. It simulates the operation of energy systems and markets on an hourly basis over a year, while also factoring in uncertainties like weather variations.

For this central scenario a set of coherent projection variables are extracted to be used in the IRR calculations for EU countries:

- Fuel costs;
- CO_2 costs;
- Realised price per technology.

For countries outside the EU, those variables are estimated from GECO[115] projections and EU projections.

Sensitivity analysis

A sensitivity analysis carried out, based on two complementary approaches:

- The first approach takes into account the following METIS's scenario sensitivities describing a future with
  - Less heat pump penetration in industry compared to baseline – NoIndusHP (METIS' 2050_LTS_15TECH_NoIndusHP);
  - Less flexibility around EV smart charging compared to baseline – EVnoFlex (METIS' 2050_LTS_15TECH_EVnoFlex);
  - Less hydrogen demand from local production and more imports – LowH2Demand (METIS' 2050_LTS_15TECH_LowH2Demand).

  Those sensitivities allow exploring different level of flexibility and power demand in the system, which results in different level of renewable penetration and realised prices.
- The second approach is a sensitivity analysis around key parameters:
  - Lower CAPEX for renewables to be more in line with recent observed trends – LowCAPEX;
  - Lower realised price to reflect the 2020 drop in power market price and to assess a potential impact of long lasting low prices – LowPrices.

Box 5-1 Background on price erosion for intermittent RES

Background on price erosion for intermittent RES

Based on Trinomics' (forthcoming) Study on the Macroeconomics of the Energy Union: Deliverable D4.1 - Report on literature review and stakeholder interviews regarding the representation and implications of the financing challenge

The concept that high penetration levels of intermittent energy sources such as wind and solar lead to price erosion for these energy sources has been proven in several studies. , Recent contributions show that the number of hours in which wholesale electricity prices drop below €1/MWh could reach 500 up to 2,000 hours/year for countries with large solar capacities (20-50% of demand) and 700 to 1,400 hours/year for countries with large wind capacities (15-25% of demand). In other words, sales prices for wind and solar PV may decline to less than 25% of average wholesale electricity prices for 25% of the time, underlining the significance of this effect. The overall magnitude of its impact is in the order of a reduction in average sales prices of 1% (wind) and 4% (solar) for each 1% increase in market share of the respective technology. With current penetration levels of 14% (wind) and 4.5% (solar PV) , which are expected to increase to more than 20% (wind) and 10% (solar PV) in 2030 , the effect of price erosion may result in sales prices that are 20% up to 40% lower than average wholesale prices. It should be noted that part of this effect may be offset by increased flexibility of the system (including flexible generation, storage, interconnections and demand response), but how effective flexibility measures will be is hard to foresee.

[115] Global Energy and Climate Outlook

5.3.4 Revenues from system services

In addition to revenues from electricity sales and subsidies, power producers may generate revenues from the provision of system services. While those revenues are generally small compared to the revenues from electricity sales and subsidies, their impact on the profitability (IRR) may be significant given the small margins in the electricity sector. System services (or "Ancillary Services") are needed for the operation of a transmission or distribution system. System services are generally remunerated by Transmission System Operators (TSO) and reported as *costs* in annual reports of National Regulatory Authorities (NRA) and ACER. System service costs typically include[116]:

1. Balancing costs: payments to providers of balancing services (capacity and energy) used to ensure, in a continuous way, the maintenance of system frequency within a predefined stability range[117];
2. Grid losses: payments for energy required for the compensation of technical power losses;
3. Redispatching and countertrading costs: payments to power producers to reduce/increase their feed-in to avoid overloading of power lines. Generally, only conventional power plants can be subject to redispatching due to priority dispatch for renewables;
4. Grid reserve contracting and use (including capacity remuneration mechanisms): payments for reserve power plants, in particular for safeguarding sufficient electricity supply during the winter period;
5. Feed-in management: compensation payments for curtailment of renewable energy and combined heat and power installations. Can only be applied if the congestion management measures for conventional power plants have been exhausted;
6. Other: other services with limited costs, including reactive power, black start capability, and interruptible loads.

To evaluate the significance of those revenues for power plants, we analyse how these costs compare to revenues from electricity sales in wholesale markets. The analysis is performed based on three sources:

1. Bundesnetzagentur - Monitoring Report (2019): German market only;
2. Trinomics et al. (forthcoming) - Energy costs, taxes, and the impact of government interventions on investments: Provides sufficiently accurate information for several EU markets, including Belgium, Germany, Hungary, Ireland, Italy, Slovakia, and Spain;
3. ACER - Market Monitoring Reports, 2017 and 2018 editions.

Germany - based on Bundesnetzagentur - Monitoring Report (2019)

The total costs for system services in Germany amounted to €1.9 billion in 2018.[118] An overview of the costs per service and the main beneficiaries in terms of technologies is provided below.

[116] Breakdown based on categories of services distinguished in Trinomics et al. (forthcoming) - Study energy costs, taxes and the impact of government interventions on investments, and in Bundesnetzagentur - Monitoring Report (2019)

[117] This system services category refers exclusively to services remunerated in balancing markets - other services to equate the short-term electricity supply and demand are not included here, as they are remunerated in e.g. intraday markets.
For definitions on balancing, see the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing.

[118] Bundesnetzagentur - Monitoring Report (2019)

Table 5-9 Overview of costs per service, and their main beneficiaries in terms of technologies.

Service	Costs for system services (M EUR)	Primary beneficiaries
Balancing	123	Conventional power plants, storage, demand response
Grid losses	273	Mix of power plants
Redispatching and countertrading	388	Conventional power plants
Grid reserve contracting and use	416	Conventional power plants
Feed-in management	635	Renewables, CHP
Other[119]	18	Mix of power plants + storage
Total[120]	1 853	

To evaluate the impact of these payments on the profitability of the main technologies and judge whether or not these need to be accounted for in the profitability analysis, we compare these revenues to the revenues from electricity sales on wholesale markets. Here we apply the following assumptions and simplifications:

- Balancing, redispatching, grid reserve payments, and other system costs (reactive power, blackstart, countertrading) are exclusively realised by coal, gas, nuclear, and hydro power plants. This assumption will lead to slightly overestimated revenues for the concerned power producers as biogas, battery storage, and demand response also capture part of the revenue[121]. The results should therefore be seen as the upper bound of these revenues for coal, gas, nuclear and hydro producers;
- Payments for energy procured to compensate grid losses are not taken into account as all electricity generated is remunerated through wholesale market sales in the profitability analysis. Adjusting for those revenues would lead to double counting;
- Payments for feed-in management are effectively compensations for curtailed electricity. As we assume that no curtailment occurs in the profitability analysis, these payments are not relevant and would probably amount to a similar revenue as if there would be no curtailment needed;
- All generation technologies sell their electricity at the average wholesale spot (day-ahead) market price (2018: 45 €/MWh[122] - assumption required for estimating revenue from electricity markets).

Table 5-10 Results of the system services revenue assessment based on Bundesnetzagentur data

Technology	Electricity production (TWh)[123]	Revenue from electricity markets (M EUR)	Additional revenue from system services (M EUR)	Average mark-up on electricity market revenue
Coal	239	10.763	535	5,0%
Natural gas	84	3.796	189	5,0%
Nuclear	76	3.420	170	5,0%
Hydro	23	1.052	52	5,0%
Wind	112	5.022	-	0,0%
Solar	46	2.079	-	0,0%

[119] Includes reactive power and black start capability
[120] Interruptible loads are excluded as those payments are not for power producers but for consumers
[121] However, by May 2020 multiple balancing markets did not include storage technologies (especially other than pumped hydro) and loads as balancing service providers. ENTSO-E (2020) Survey on ancillary services procurement, balancing market design 2019.
[122] Consistent with average price reported in ACER - Market monitoring report 2018
[123] Source: Enerdata

Multiple countries - based on Trinomics - Study on energy costs, taxes, and the impact of government interventions on investments

In the 2020 study on energy costs, taxes, and the impact of government interventions on investments, Trinomics collected information on system costs from TSOs. This data collection resulted in a dataset with system costs for all EU and G20 countries. Data quality varied substantially, however, and not all cost estimates are considered accurate and/or complete. In this analysis we focus only on the countries with the most reliable data, which are Belgium, Germany, Hungary, Ireland, Slovakia, and Spain. Italy has been added to this list because stakeholders remarked that this country may have a particularly high relevance of system costs and would therefore be an interesting case to consider, even though the data quality is not optimal.[124] The results of the analysis are summarised in the table below.

Table 5-11 **Results of the system services revenue assessment based on Trinomics' costs & taxes study data**

	Belgium	Germany	Hungary	Ireland	Italy	Slovakia	Spain
Electricity produced by coal, gas, nuclear, and hydro (TWh)	56	423	28	21	210	24	190
Average wholesale price (€/MWh)	€ 55	€ 45	€ 51	€ 61	€ 61	€ 49	€ 57
Revenue from electricity markets (M EUR)	€ 3.056	€ 19.030	€ 1.427	€ 1.297	€ 12.835	€ 1.187	€ 10.805
Revenue from system services (M EUR)	€ 305	€ 973	€ 316	€ 838	€ 1.571	€ 175	€ 1.744
Average mark-up on electricity market revenue	10%	5%	22%	65%[125]	12%	15%	16%

Sources: Electricity production: Enerdata, average wholesale prices: ACER Market Monitoring Report 2018, revenues from system costs: Trinomics - Energy costs, taxes and the impact of government interventions on investments.

Multiple countries - Based on ACER Market Monitoring Report 2018

ACER reports on several system costs in their annual market monitoring report. Relevant figures that ACER reports for several EU markets include:

- Balancing costs, split into costs for activating balancing energy and costs for balancing capacity. Important to note is that the costs for balancing energy are calculated as the additional payments on top of the revenues that would be incurred when selling at the average wholesale price, so there is no risk of double counting with revenues from energy sales on wholesale markets;
- Redispatching and countertrading costs;
- Capacity mechanism costs;
- Average day ahead wholesale prices.

[124] The data for Italy is publicly available but is difficult to interpret and match accurately to the different types of system costs, and validation with the National Regulatory Authority did not occur due to the impact of COVID-19. Hence, a relatively large category of 'other system costs' exists in the dataset (approximately one third of all system costs). We assumed all those costs are realised by gas and coal-fired power plants. It could be that feed-in management costs are included, but according to input by our Italian country expert, feed-in management costs in previous years were only a small amount (less than 5% of 'other system costs').

[125] The exceptionally high system service costs in Ireland are primarily due to the high costs for the capacity remuneration mechanism. This is partly due to the challenging circumstances of the Irish market with high intermittent RES penetration and limited interconnections, but probably also due to expensive prices for capacity.

The balancing, redispatching, and countertrading costs are reported in the 2017 market monitoring report but not in the 2018 edition. Hence, the analysis below is conducted for 2017.

While the balancing and capacity mechanism costs are reported as costs per unit of demand (EUR/MWh), they cannot be compared directly to the average wholesale prices as part of the demand is fulfilled by intermittent renewables which do not earn revenues from these system services. So, a correction needs to be made for the share of demand that is fulfilled by intermittent renewables (PV and wind). The results of the revenue assessment based on the values collected by ACER is provided in the table below.

Table 5-12 Results of the system services revenue assessment based on ACER data

	Avg wholesale price	Balancing (EUR/MWh)	Redisp. & countertr. (EUR/MWh)	Capacity mechanism (EUR/MWh)	Share PV and wind	System cost revenues for conventional generators (EUR/MWh)	Mark-up on avg wholesale price
AT	34,19	1,27	1,13	0,00	10%	2,66	8%
BE	44,58	1,95	0,02	0,29	11%	2,53	6%
DE	34,19	0,53	1,95	0,80	23%	4,23	12%
ES	52,23	1,20	1,32	0,97	23%	4,54	9%
FI	33,19	1,22	0,02	0,10	5%	1,41	4%
FR	44,96	0,74	0,01	2,03	7%	2,98	7%
HU	50,35	3,98	0,06	0,00	2%	4,13	8%
NL	39,31	0,72	0,40	0,00	10%	1,25	3%
PT	52,48	1,60	0,00	0,52	25%	2,83	5%
SI	49,52	3,84	0,01	0,00	2%	3,92	8%

Sources: Wholesales prices, balancing, redispatching, and countertrading costs from ACER Market Monitoring Report 2017. Capacity mechanism costs from ACER Market Monitoring Report 2018. PV and wind shares from Eurostat SHARES 2018.

Conclusion

The assessment of revenues from system services indicates that conventional power plants typically realise additional revenues that amount to values between 5 to 15% of the revenues from electricity sales on wholesale markets. For the profitability analysis we assume that conventional power producers generate additional revenues equal to the average value of the last analysis above which has the broadest scope of countries, based on the ACER report: 7% mark-up on average wholesale prices.

5.3.5 Assumptions

In this section we detail the main assumptions used in IRR calculations. More technology specific assumptions are described in the technology profitability sections.

Table 5-13 Summary of main assumptions for IRR calculations

Section	Assumptions/estimation description	Methodology
Revenues	Government support (e.g FiT) are often given by project size or type whereas the analysis is done at an aggregated level (e.g: Solar PV). It is required to estimate a weighted average support	For solar PV, use of IEA "PVPS Trends" reports to get a detailed split between centralized and distributed systems. For wind: on-shore / off-shore split
Revenues	Support scheme duration	If there isn't any specific information: equals project lifetime
Revenues	Projection of realised price	Baseline scenario (METIS) for EU countries and Enerdata's Enerfuture EnerBlue[126] scenario for non-EU countries
Yearly decommissioned capacities	Used to calculate new installed capacities per year. Total installed capacities data are available but is more difficult to find data about decommissioning capacities	No wind or solar PV capacities decommissioned at this stage of the study. Enerdata's assumptions for Coal and Gas.
Costs	CAPEX	Costs & Taxes study values (historical) for solar PV and wind
Costs	Need for a fine weighted average capex per project size and subtype for a given technology	For solar, use of IEA-PVPS National Survey Reports. For wind: onshore / offshore split
Costs	O&M	Costs & Taxes study values (historical)
Costs	Fuel cost, CO_2 cost	GECO for historical values, METIS extractions if available for projections
Technological parameter	Lifetime	EC
Technological parameter	Load factor	Estimated from power generation and capacities from Eurostat for historical period. PRIMES values in projections. Enerdata in house database for countries outside EU

[126] https://www.enerdata.net/research/forecast-enerfuture.html

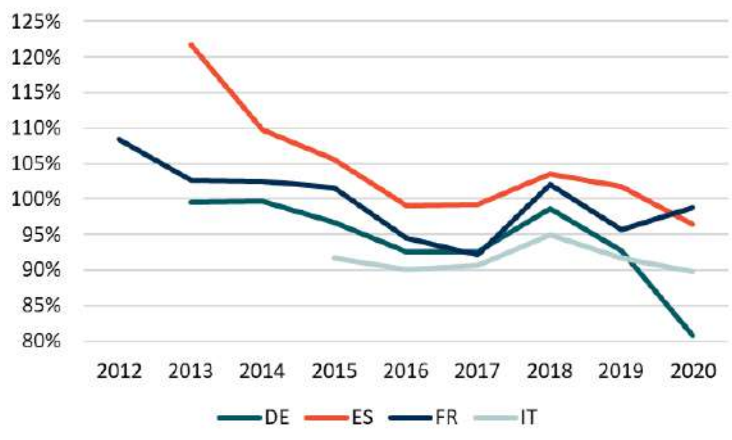
5.3.6 Realised prices and market value

Historical values

The largest part of the data collection was allocated to hourly data (price and power generation per technology) with the objective to build the realised price per technology. Realised price is a key indicator to measure the impact of intermittent penetration on market price. In the case of wind and solar, realised price is also a good indicator to assess price erosion and “cannibalization”: market value declines as penetration of wind and solar increases.

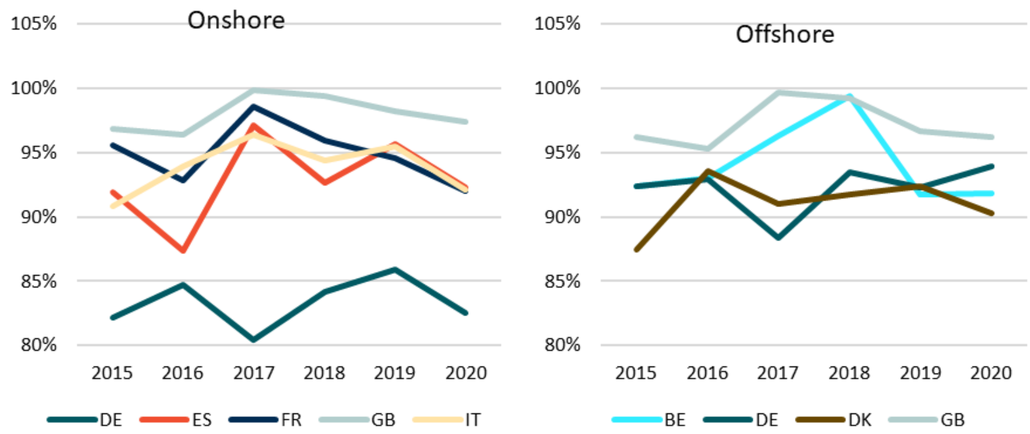
The following figures show the market value of solar and wind power generation which is computed as the ratio of the realised price and the market price. A level below 100% indicates a lower market value compared to a technology generating a stable power output such as baseload power generation.

Figure 5-5 Market value of Solar PV power generation from historical observed data for top EU producers



For Solar PV, high penetration as in Germany and Italy (around 8% market share of solar PV in 2019) results in a relatively low market value, significantly below 100%. In the case of Germany, the increasing share of Solar PV is also linked to decreasing trend for the market value.

Figure 5-6 Market value of Wind power generation for top EU (+UK) producers



Wind market value is significantly below 100% for all EU countries with large wind power capacities. Overall, those observations are in line with existing studies and literature. Solar and wind market values are expected to decrease as penetration increases both on actual observation (existing data) and modelling data (projections). As mentioned in Hirth (2016)[127] the market value erosion with higher RES penetration depends on the overall power mix and more specifically on hydro flexible capacities.

Figure 5-7 Market values from Hirth (2016)

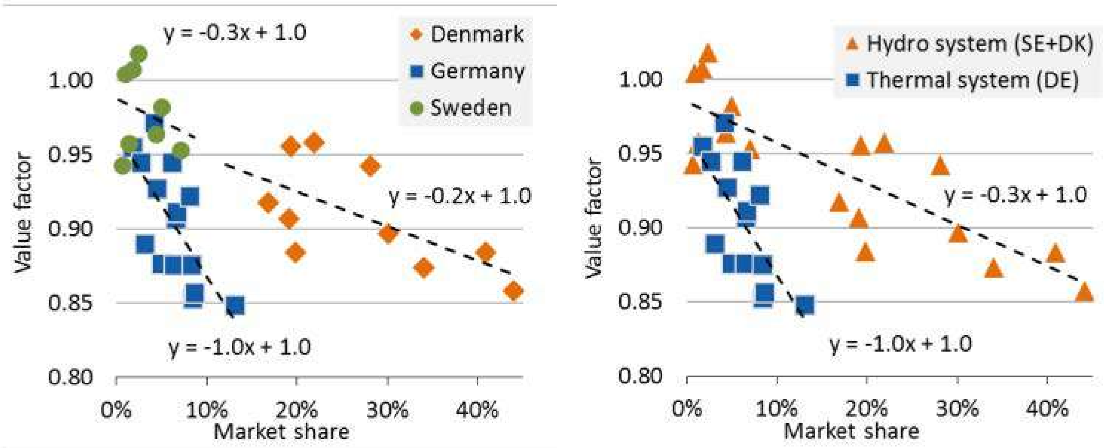


Figure 6. The wind market value in Germany, Denmark and Sweden 2001 to 2015. Own illustration based on data from IEA electricity statistics, TSOs, EPEX Spot, and Nordpool Spot.

Figure 7. Denmark and Sweden grouped. Own illustration based on data from IEA electricity statistics, TSOs, EPEX Spot, and Nordpool Spot.

Projection values

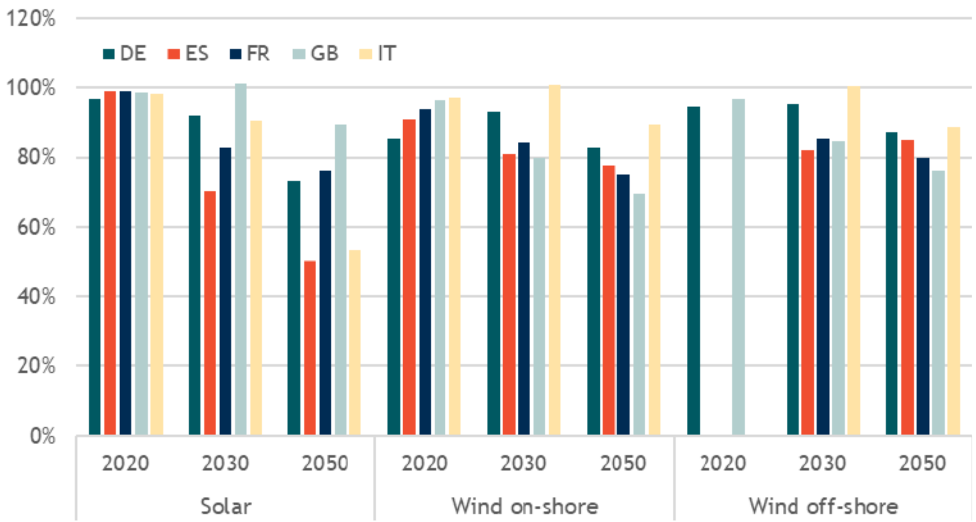
Realised prices projections used in this study and the IRR calculation come from the Baseline scenario - METIS as mentioned in the previous section. Market values derived from those realised prices clearly show a decreasing trend for wind and solar as the penetration of these technologies in the power mix increases. Price erosion for intermittent renewable technologies is significant and will impact negatively profitability over time.

This is especially the case for solar PV in sunny countries, Spain and Italy with a market value dropping at around 50% in 2050. Onshore wind market value decreases significantly as well, between 70%-80% in 2050 except for Italy. Offshore wind market value remains higher than solar PV and onshore wind, at around 80% in 2050.

[127] *The market value of wind energy*

Source: Study on energy prices, costs and their impact on industry and households

Figure 5-8 Market value from projection data (Baseline scenario - METIS)



5.3.7 *Government support*

In order to increase the shares of renewables (RES) in the countries' electricity generation mix, all EU Member States (MS) and EU trading partners have supported RES generators with various public support schemes over the past decades. Energy markets alone would not have driven this development due to an insufficient market maturity of RES-E sources.

The USA and Germany pioneered the use of RES support policies in 1978 and 1990, respectively. Today, most EU MSs and trading partners have set out public support schemes which take different forms depending on the RES technologies, dedicated national budgets levels and market maturity. Public supports can be allocated through direct upfront investment grants, promotional loans, in the form of tax credits and exemptions or direct support to the electricity prices and thus revenues to power generators and investors. This price-based support scheme is the most common mechanism used by the countries as it gives a predictable regulatory framework that reduces the market risk for investors and thus the cost of capital.

Price-based support schemes are distinguished according to two main design components:

- The *market exposure,* i.e. the exposure of public supports to wholesale electricity market prices and their volatility. If foreseen by legislation and granted by the regulator, RES power generators will receive a feed-in-tariff (or FiT) , typically a 15-20 years purchase agreement for the sale of RES electricity at a pre-determined fixed price, irrespective of the market variations. FiTs levels are usually based on RES generations costs (e.g. LCOE approach) and may be timely adjusted to decline during the purchase agreement term. Alternatively, policy designers may connect the price-based public supports with more market integration opting for so-called feed-in-premiums (or FiP) granted to RES generators on top of the electricity market price. FiP may be fixed or variable (aka. sliding) with or without cap and floor prices adapting to market prices variations and so limiting price volatility risks for RES plant generators and subsidized windfall profits at the same time. Sliding FiP are calculated on a continuous basis as the difference between the average technology-specific market price and a predefined reference tariff level, usually defined as the average electricity market value of plants in the same technology category over a given period;

- The *support allocation mechanisms*, which either follow administrative procedures set by the national energy regulator (e.g. registration lists) or competitive bidding procedures where RES generators compete through auctions to set price levels of the FiT or FiP and control the allocated RES volumes. In RES auctions, the competitive price building mechanism implies a high cost-effectiveness of the system, so long as sufficient competition was created with demand for support higher than the auctioned volume. Most RES auctions are reverse multi-unit auctions where multiple items of a product (i.e. RES power) are sold by several competitors to a sole buyer. To guarantee a high realization rate of RES projects, the design of auctions often includes pre-qualification criteria (e.g. permits, etc.) for participants to meet and penalties in case of delays or project failings.

Since the introduction of RES support schemes and as the RES technologies are more and more mature, we observe an underlying trend towards a better market integration of the price-based public supports via the use of sliding feed-in-premiums allocated by auctions and tendering procedures. Indeed, if administratively based feed-in-tariffs are highly effective, they are not market-oriented and may unduly distort price competition between project developers and thus reducing RES cost effectiveness. FiT policies were usually the first RES support schemes introduced before gradually being supplemented or replaced by sliding feed-in premiums and RES auctions. This is in line with the *European Commission Guidelines on State aid for environmental protection and energy 2014-2020*[128] advocating in favour of market-based instruments. Today, FiTs and FiPs often coexist where FiPs combined with RES auctions are dedicated to large-scale RES projects and accessible to mature developers, whereas administrative FiTs are dedicated to smaller RES projects and developers, which may not afford to take part in complex large scale RES project tendering procedures.

Next to price-based support schemes, a few EU MS (e.g. Belgium, Italy, the UK, Sweden, etc.) and trading partners (e.g. the USA at federal level, etc.) used or are using RES quotas obligations based on tradeable green certificates (i.e. TGC). This is a volume-based support scheme with a RES target expressed in RES-share in final electricity consumption or in volume of produced electricity. Market participants (e.g. power producers, suppliers or grid operators) are statutory obliged to buy and cancel green electricity certificates. The number of green certificates to buy corresponds to the RES quota obligations multiplied by the volume of electricity supplied annually to the final consumers. RES quotas systems are either technology-neutral, meaning one overall quota obligation is set for all the different RES technologies or technology-specific.
Selling the green certificates constitute a complementary source of revenues for RES generators in addition to wholesale market price of the final energy sold. Green certificates are market-driven and enable a competitive price determination through the interplay of demand and supply for TGCs. But they fully expose the RES generators to market price volatility. To limit the market risk, some states applied hybrid systems with minimum guaranteed prices for the quotas (e.g. Belgium). Besides, to ensure a demand for TGCs, a penalty mechanism is set out when participants do not meet the legally annual required number of certificates.
The recent substitution of the RES quotas systems in the UK, Italy and Poland with price-based support mechanisms suggests a trend side-lining the green certificates among the EU MSs.

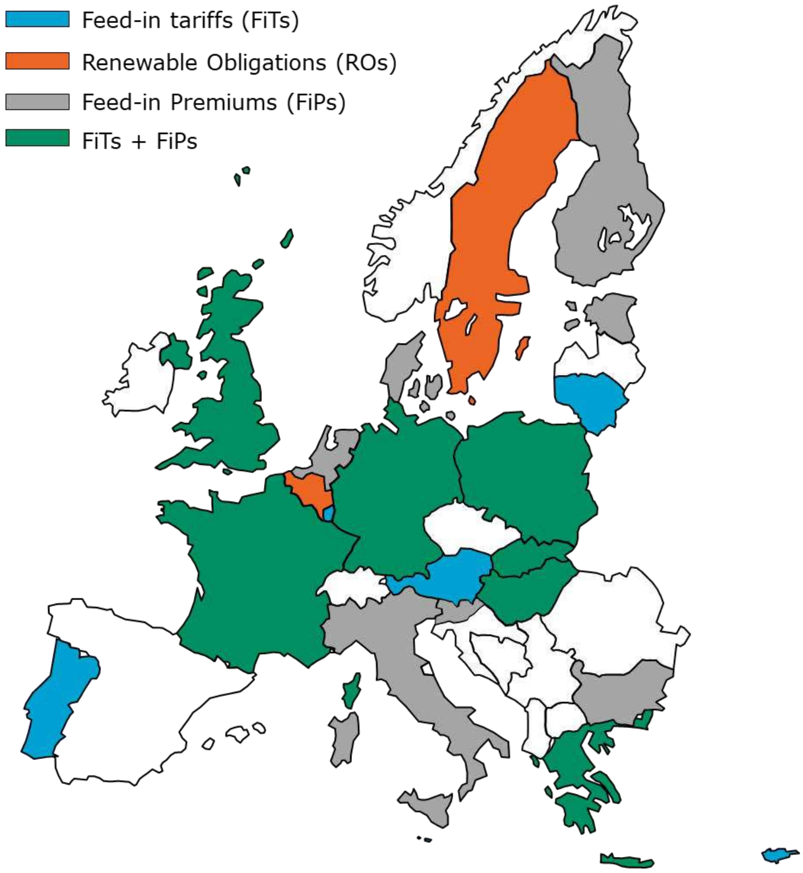
[128] Cf. Available here : https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014XC0628%2801%29

Source: Study on energy prices, costs and their impact on industry and households

Figure 5-9 Schematic illustration of main RES support schemes and their relation to electricity market price.

Source: Banja M., et al (2017).

Figure 5-10 Illustrative map of the RES support schemes applied in EU in 2019



5.3.8 Profitability per technology

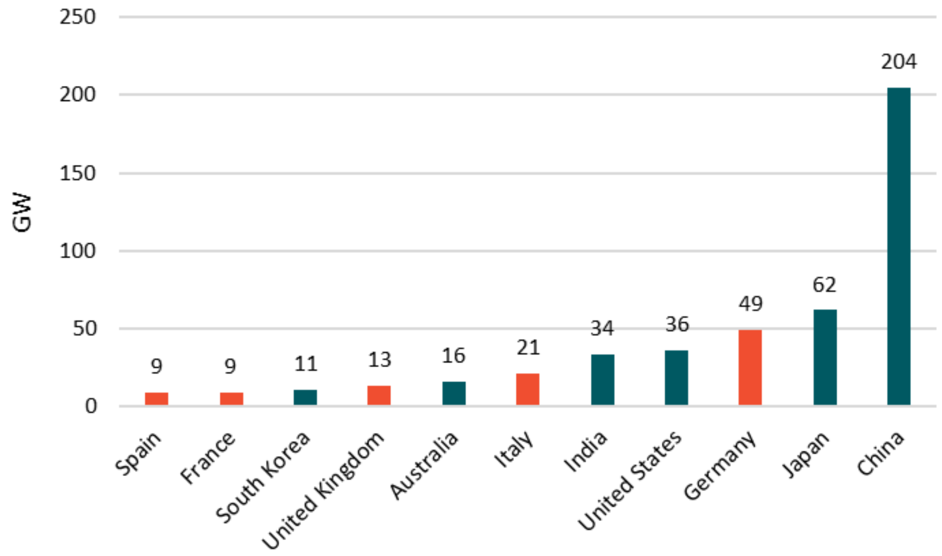
The selection of countries presented in this section is mainly based on the top EU27+UK and G20 countries in terms of installed capacities. Selected countries per technology may vary in function of raw data availability used to compute profitability indicators.

Solar PV

Solar PV power generation has been almost doubling every year in EU28 between 2005 and 2011 before progressively converging at around +8% annual growth in 2019. At the world level, annual growth has been relatively stable for the past 5 years at around +30% and it is the technology that accounts for the third highest additional power generation for the past 5 years behind gas and wind.

As of 2019, China has by far the highest solar PV capacities, more than 204 GW, followed by Japan (62GW) and Germany (49 GW). EU28 as a whole has 128 GW installed and Germany, Italy, the UK, France and Spain account for 80% of the total EU28 solar PV capacities.

Figure 5-11 Countries with the highest Solar PV capacities in 2019 (EU28 countries in orange)



Solar PV accounts for 4% of the EU28 market share in terms of power generation as of 2019 and is expected to play a key role in the power mix decarbonization (11% market share in 2050 in the EC Reference scenario 2016, 10% in WEO SDS 2019).

The profitability analysis will help assess competitiveness of Solar PV both in terms of revenues and costs (in line with the first two bullet points above).

Specific assumptions

The main difficulties in assessing the profitability of PV come from the broad range of installation types and sizes, all having a large impact both on CAPEX and support interventions. Tariffs granted depend on several parameters, including the type of installation (e.g. for solar: rooftop / ground-mounted), and the net capacity of projects. As profitability is calculated at the technology level (e.g. solar PV), it is required to calculate the weighted average support from the sub-technology subsidies. It requires estimating the capacity distribution per sub technology (rooftop, ground based etc..) and capacity size.
For these reasons, additional data regarding the distribution of solar PV system per size and type have been collected.

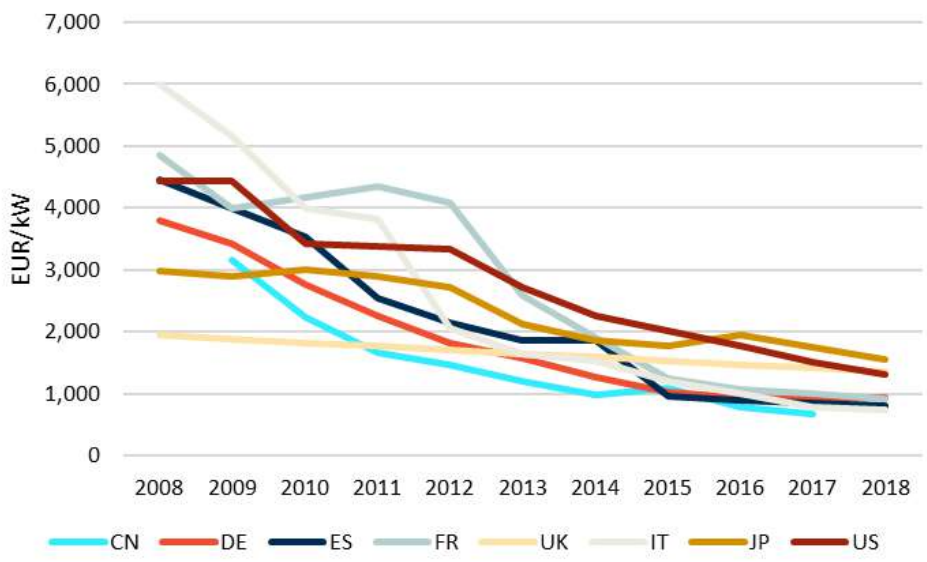
Projected realised prices and load factors come from the Baseline scenario (METIS).

The selection of countries included in the Solar PV profitability analysis is based on the share of Solar PV capacities at global and EU levels and data availability. The selection covers 75% of global Solar PV capacities and 80% of EU27+UK.

Costs

The power generation cost from Solar PV can be measured with the levelized cost of electricity (LCOE). In the case of Solar PV it is mainly driven by CAPEX values and the load factor (power output per unit of MW). Across similar regions or even at the global level CAPEX is not expected to change a lot for a given year. The main factor then is the distribution between system size and type, which can be estimated with the share of centralized/distributed installations.

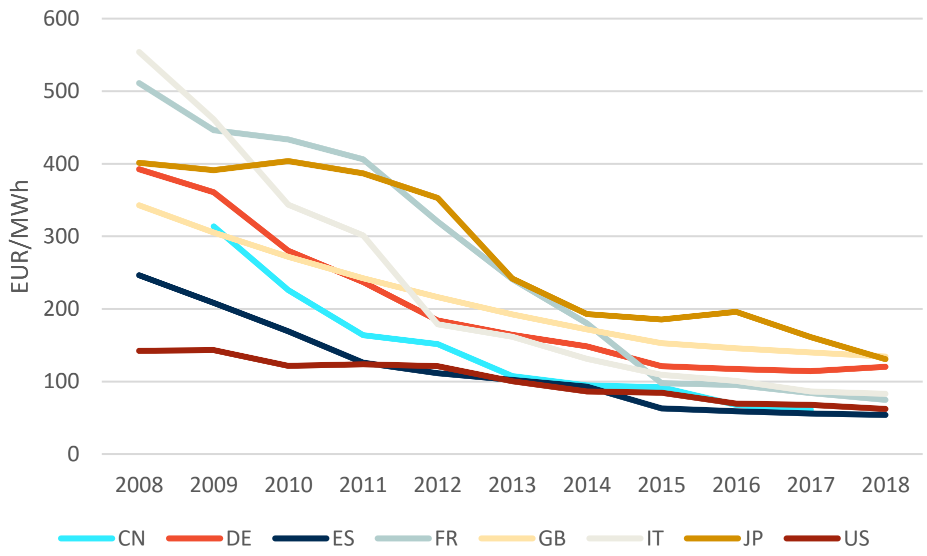
Figure 5-12 Centralized solar PV CAPEX per country



CAPEX for centralized system has dropped by a factor of three between 2009 and 2018 and now stand below 1 000€/kW for most selected European countries and around 1 500 €/kW for the US and Japan.

LCOEs follow this decreasing trend to range in 2018 between 55 €/MWh and 135 €/MWh. With highest LCOEs in 2008, Italy faced the sharpest decrease over the 2008-2018 period (16%/year). China, the USA and Spain registered the lowest LCOEs driven by high share of centralized systems for China (70%) and the USA (60%) in the global solar PV power generation and good load factors for Spain due to relatively high solar irradiation. Conversely, in Japan the share of centralized systems is relatively low (34%) which may explain higher LCOE. Germany has lower solar irradiation potential compared to France, Italy, and Spain.

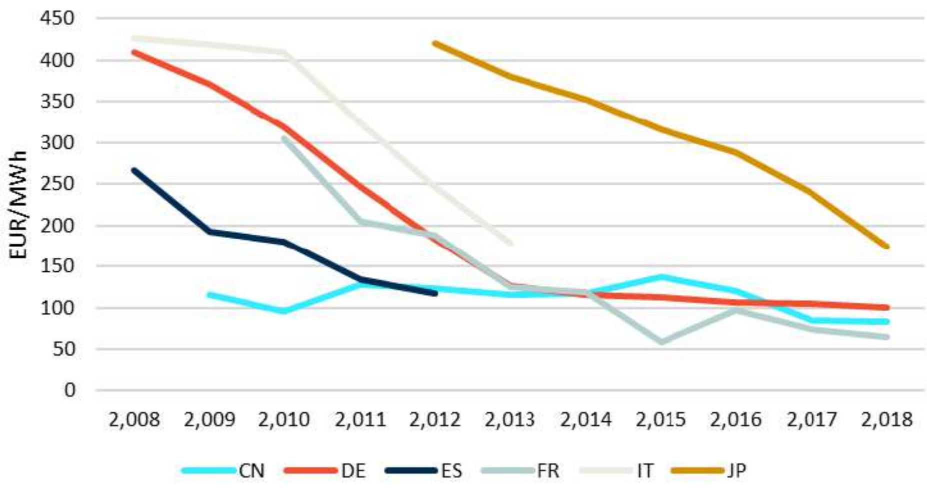
Figure 5-13 Average LCOE for solar PV systems per country



Revenues

Revenues for Solar PV systems come from support intervention, tenders, and competitive markets as the technology is getting more mature. In the following analysis, we use the data collected in the first part of this task and we focus on simple FiT scheme and realised prices.

Figure 5-14 Support scheme revenues for solar PV per country



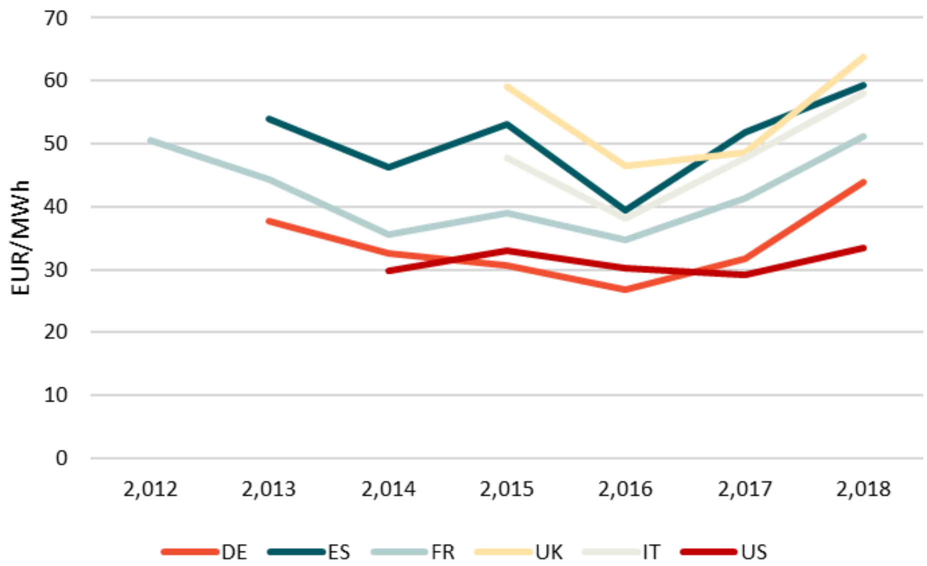
At first sight, FiT-based support schemes in all selected countries provide very high revenues compared to what is expected from the wholesale market (realised price). Furthermore, we observe an overall decreasing trend of the FiT allocated to Solar PV projects over the 2008-2018 period, of which sharpest reductions concern the countries with the highest level starting from 2008, i.e. Germany, Italy and the UK. Very high FiTs level positions Japan separately from its peers while Chinese FiTs levels remained relatively low and stable during the period.

The UK registers the lowest level of FiT in 2018 following scheme overhaul in 2016 introducing dramatic reduction of rates as from February 2016 and a quarterly “default degression” mechanism, which led to tariffs falling automatically overtime, independently of other factors. The FiT support scheme fully closed in March 2019.

In Spain, the scheme stopped earlier in 2012, in order to prevent the the tariff deficit and debts[129] held by utilities from escalating. The scheme was finally removed in 2013 (Law 24/2013). In Italy, the subsequent *Conto Energia 1,2,3,4 & 5* were specifically designed for FiT-allocated solar PV systems until they reached the capacity targets and financial caps of subsidies in July 2013.

The German FiTs support scheme is set out by the EEG law (last amendment in 2017) for solar PV systems. Since April 2012, a monthly regression rate is applied on feed-in tariffs and updated every quarter based on the additional installed capacity recorded during the previous quarter. In France the development of the solar photovoltaic energy is supported through a mix of feed-in tariffs and tender-based financial supports. FiTs scheme for photovoltaics installations was introduced in 2006 and is still in effect for small installations. In March 2011, the Government further revised down feed-in tariffs for solar PV installations. Since then, feed-in tariffs have been constantly cut on a quarterly basis. Since May 2017, feed-in tariffs are reducing by 5%/year when registration for new installations meet the expected target of 350 MW of additional solar PV capacity per year.

Figure 5-15 Realised price for solar PV per country



As seen in the section about market value, the realised price tends to decrease with increasing solar PV market share. The realised prices in Germany, France, and Italy are significantly below the average market prices from 2015. Apart from this price erosion, the variations of the realised price are linked to the average market price which increased from 2016. Eventually, the main differences between countries come from the structure of the power mix, electricity demand, and integration with neighbouring markets.

The 2030-2050 Baseline scenario (METIS) anticipates a significant decrease in solar market value for Spain and Italy as capture prices would durably stand below the average projected market prices. Spain

[129] Please see *the EC's Economic Papers 534 - Electricity Tariff Deficit : Temporary or Permanent Problem in the EU ? October 2014* for further information

would report the most significant decrease in market value from over 100% in 2018 to 50% in 2050. It is linked to the fact that market prices are expected to rise while realised prices would decrease from 2030. German and French solar market values would slightly decrease to around 85% in 2030 and around 75% in 2050, while the market value in the UK would remain stable to 100% until 2030 before diminishing to 90% in 2050 following a regular decrease in both realised and market prices. In terms of trends, market prices are expected to slightly vary within a +/- 20 €/MWh - price corridor, with an overall downward trend for the UK, France, and Spain until 2050 and upward trend for Italy and Germany until 2030 and then downwards until 2050.

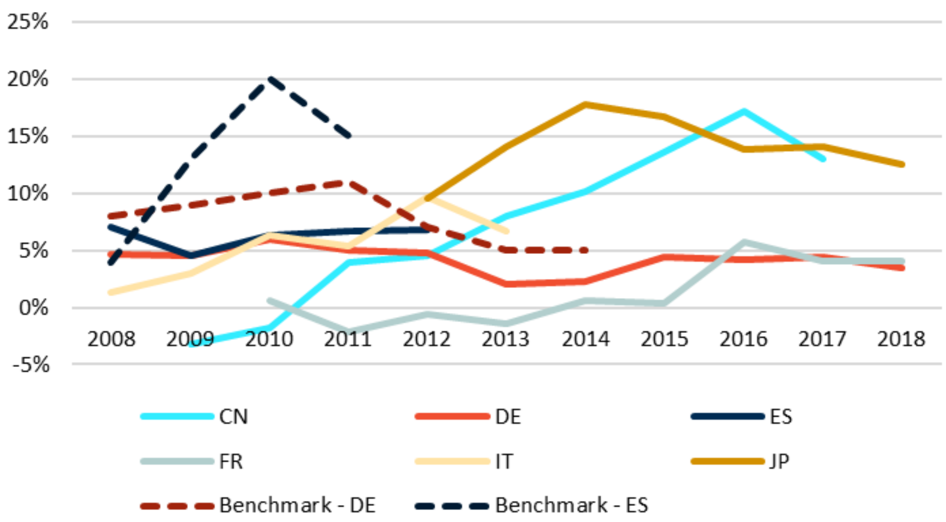
Profitability

The past two sections assessed the main drivers of solar PV profitability: costs and revenues. This section focuses on the IRR which convert costs and revenues cashflow into a key metric of profitability.

The first IRR calculation is based on support intervention and more precisely on FiT schemes. Japan and China report the highest subsidized IRRs, exceeding 10%. They are driven by high levels of FiT revenues and low levels of CAPEX Centralised for China. European countries register lower IRRs varying between -10% and +10%. German, Italian and Spanish subsidized IRRs remained positive during the period while French IRRs became positive from 2014 as costs plunged faster than FiTs revenues did. UK Fit-based IRR fell below zero after 2015.

The benchmark[130] study provides higher IRRs for Germany due to slightly lower CAPEX (and IRR high sensitivity to CAPEX) in this benchmark and an assumption about a 2%/y escalation realised price which is taken into account at the end of the scheme duration (20 years) when revenues are coming from market. In Spain, the large gap in 2009-2010-2011 is coming from a massive decrease in CAPEX from the benchmark whereas it is decreasing in a more progressive pace in our assumptions (IRENA from Cost & Tax ongoing EC's study).

Figure 5-16 IRR from support intervention and comparison with benchmark

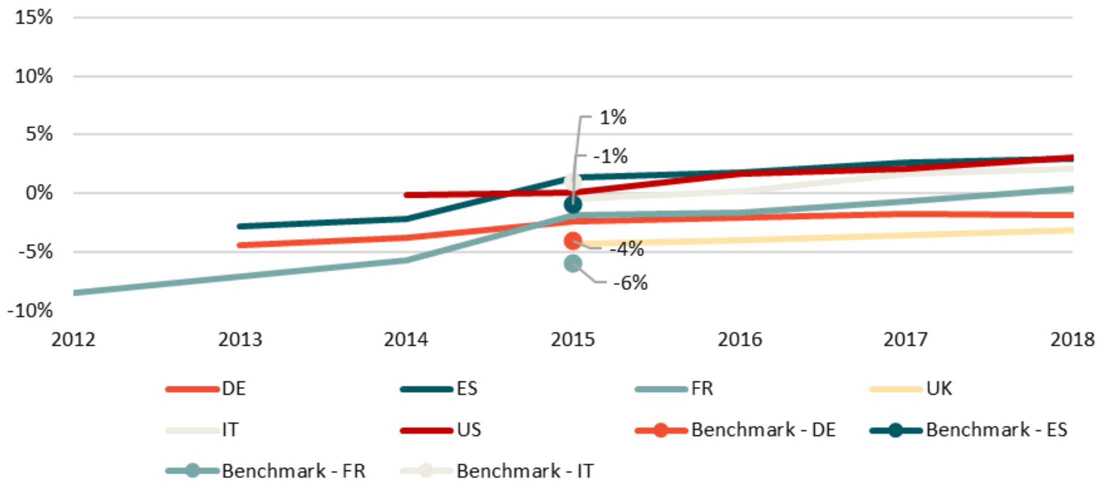


[130] Regulation, profitability and diffusion of photovoltaic grid-connected systems: A comparative analysis of Germany and Spain, Javier López Prol

IRR calculation based from market revenues, that is to say realised price, are well below the ones from FiT. This is consistent as Solar PV is not competitive enough on the 2008-2018 period. However, IRRs are progressing steadily for all selected countries as CAPEX are getting lower and realised prices are not showing explicit trends on the period. With further decreases in CAPEX expected in the coming years, IRR from market revenues should reach significant positive values in the short-medium terms.

France reports negative IRRs from support intervention over 2011 and 2013 mainly because of high CAPEX levels during this period. Profitability levels turned positive from 2015 thanks to sharp decrease in CAPEX levels.

Figure 5-17 IRR from market revenues and comparison with benchmark



Benchmarks source: Bertsch et al. (2018) 131

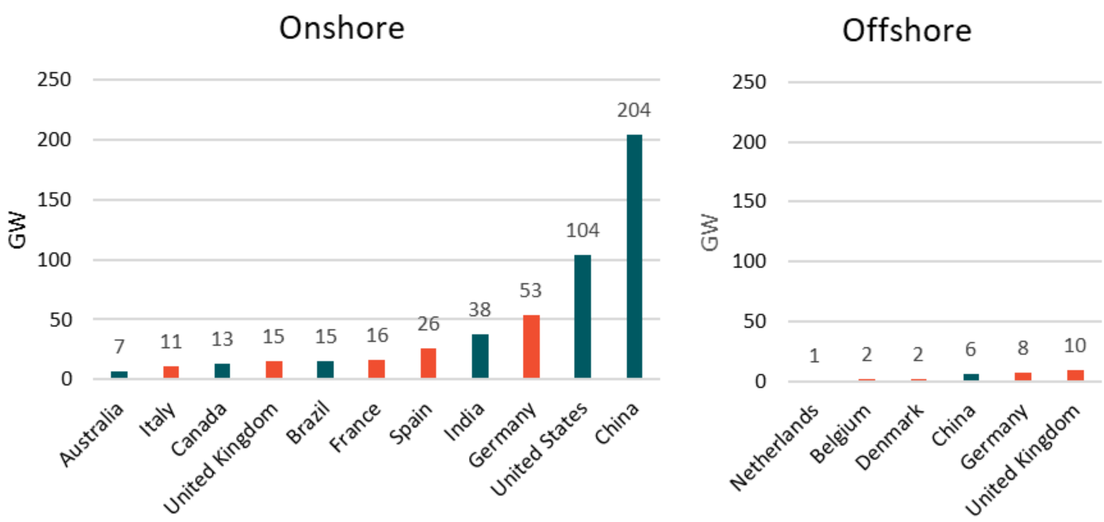
Wind

Wind power technology is one of the fastest-growing renewable energy sources together with solar PV. Wind power capacities have been growing at around 10% since 2010 in EU before slowing down to 6%-7% in 2018-2019. At global level the growth rate has been even higher, around +20% per year between 2010 and 2015 and +10% since then. Wind accounts for the second highest additional power generation for the past 5 years behind gas ahead of solar PV. EU28 total wind capacities reached 193 GW in 2019 of which 22 GW are offshore capacities.

China dominates the total wind onshore capacities with 204 GW installed in 2019, followed by the US and Germany. In the EU, wind offshore accounts for 11% of installed capacities in 2019 (5% at the world level), up from only 2% in 2008. Many regions of the world have high wind speeds, but the best locations for generating wind power are sometimes remote from consumption centres. Five out of six top wind offshore capacities countries are located in the EU.

[131] Are renewables profitable in 2030? A comparison between wind and solar across Europe, Bertsch, Valentin; Di Cosmo, Valeria; 2018

Figure 5-18 Countries with the highest wind capacities in 2019 (EU28 countries in orange)



Specific assumptions

Wind is split between onshore and offshore sub technologies. At this stage of the study we use onshore generation and realised price only when the split is directly available from hourly data. For EU countries, ENTSO-E data is only available from 2015. Before 2015, we collected TSO or market-operator data. For some countries the split between onshore and offshore is not available before 2015. In this case, we used estimations based on 2015-2018 data and power generation from Eurostat to get a split before 2015.

Projected realised prices and load factors come from the Baseline scenario (METIS).

The selection of countries included in the wind onshore profitability analysis is based on the share of capacities at global and EU level and data availability. The selection covers 77% of global wind onshore capacities and 68% of EU27+UK.

Regarding wind offshore, the selection covers 97% of global wind onshore capacities and 98% of EU27+UK.

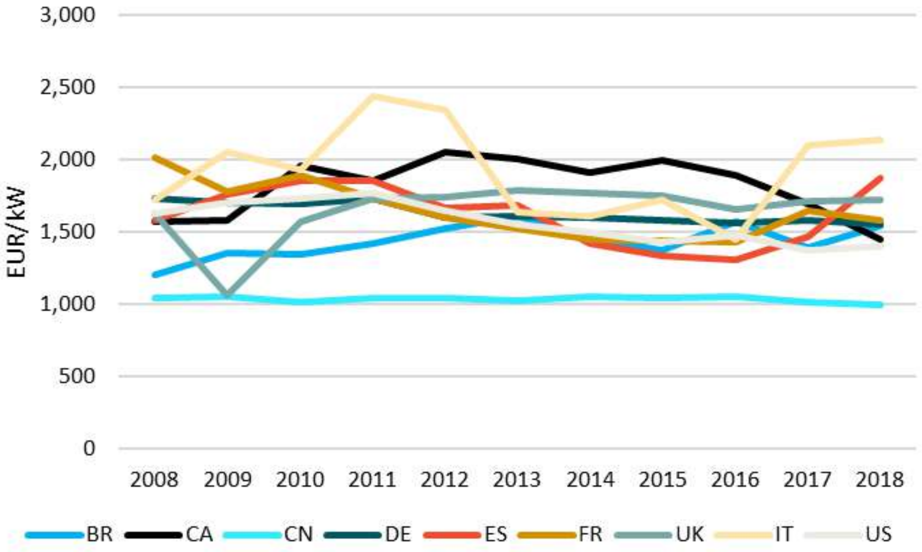
Wind onshore

In this section, we show the profitability analysis for wind onshore. We analyse costs, revenues and IRR for the selected EU countries quoted hereafter: Germany, France, Spain, the United Kingdom and Italy and the following countries outside EU: China, the USA, Brazil and Canada.

Costs

Wind onshore costs over the lifetime of the project can be measured with the Levelized Cost of Electricity (LCOE). CAPEX levels and O&M fixed costs are the main determinants for LCOE, with the capacity factor (also referred to as load factor) which is the relation between how much electricity a plant produces and how much it would produce if it operated a full capacity 100% of the time.

Figure 5-19 CAPEX for wind onshore per country



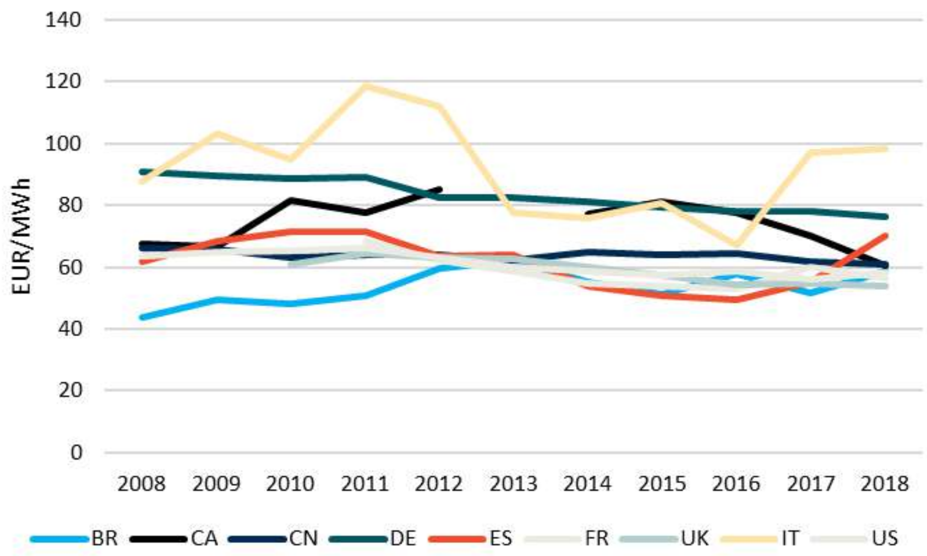
First observation shows a decrease in overall CAPEX levels over the 2008-2016 period before a rebound from 2017 but without any clear significant trends. China shows significantly lower CAPEX levels than the other countries. We observe higher levels of CAPEX on average in Italy and Canada but with a significant decrease over the last years. The year on year variation in CAPEX values come from the use of sources (IRENA and *Cost and Tax* ongoing EC study) which are based on CAPEX from actual projects.

Apart from CAPEX, EU countries have similar levels of O&M fixed costs except for Italy, which experienced higher O&M fixed costs, on average 1.3 times the value of Germany, France, Spain and the UK (IRENA, from Cost and Tax ongoing EC study). O&M fixed costs of non-EU countries are relatively higher than EU ones, especially in the US where they are more than two times higher.

Another key driver of LCOE and power generation cost for wind is the capacity factor. It is relatively high between 2008 and 2018 in the US and Brazil (around 30%) and Canada, Spain (24%), France and the UK (around 22%) and rather low in Germany, Italy and China (around 19%). For all these reasons the LCOE is significantly higher in Italy, at around 90 €/MWh, compared to Spain and China (around 60€/MWh).

Regarding long-term trends, the major drop in costs for this technology happened before 2008, more recent decreases seem to be driven by mild changes in turbine costs and balance of project costs, and strong increases in capacity factors (led by metereological conditions, technology advancements and higher towers).

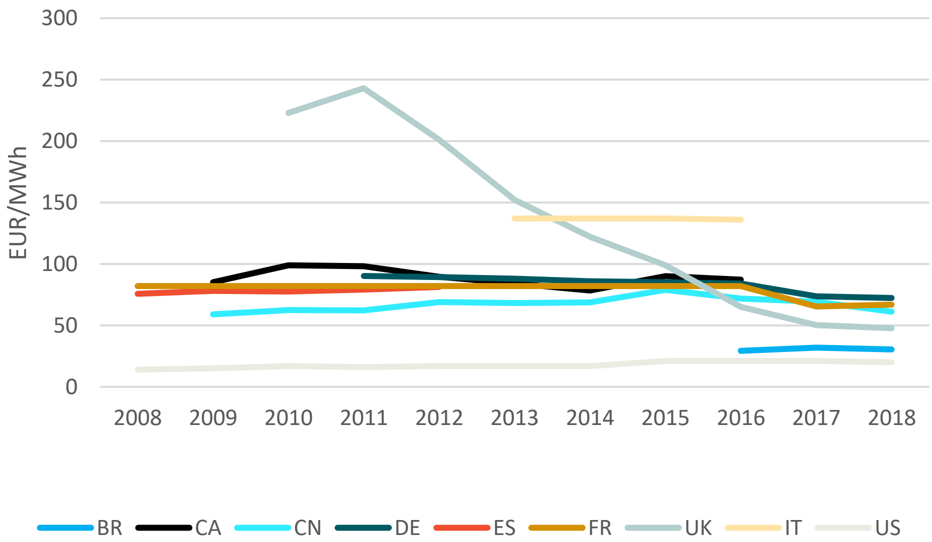
Figure 5-20 LCOE for wind onshore per country



Revenues

Revenues from wind onshore come from support (e.g. feed-in-tariffs, feed-in-premiums, with or without competitive bidding procedures, etc.) and markets as wind onshore technology is gaining cost competitiveness. In this analysis, we focus on public support schemes and realised price. The values illustrated in the graph below are based on feed-in-tariffs support schemes only and completed with auction bids results in the analysis when relevant.

Figure 5-21 Support scheme revenues for wind onshore per country



We observe that FiT support schemes in both the UK and Italy provide high revenues compared to what is expected from the wholesale market (realised price). In Italy, feed-in tariffs are almost twice higher than in France or Germany between 2013 and 2016. Parallel to the Italian *Tariffa Omnicomprensiva* FiT system, two auctions were held in 2014 and 2016 setting an average awarded bid price for > 5 MW wind onshore projects to 93 €/MWh and 66 €/MWh, respectively.

The UK shows a specific trend, starting with high support at the beginning of the period and then decreasing to the lower level of support compared with other countries. Indeed, the FiT scheme was overhauled in 2016 introducing dramatic reduction of rates as from February 2016 and a quarterly "default degression" mechanism, which led to tariffs falling automatically overtime, independently of other factors. The FiT support scheme fully closed in March 2019. Parallel to FiTs scheme, the UK launched two Contracts for Differences based on multi - RES technology auctions in 2015 and 2017; Average bid price of the 2015's awarded onshore wind projects amounted to 60.3 €/MWh.

The US Federal Government incentivizes renewable energy projects principally through tax credits mechanisms. Wind technologies are eligible to receive either the Production Tax Credit (PTC) or Investment Tax Credit (ITC). We consider here the PTC rates, which can be translated as feed-in-tariffs for any kWh generated by wind onshore producers.

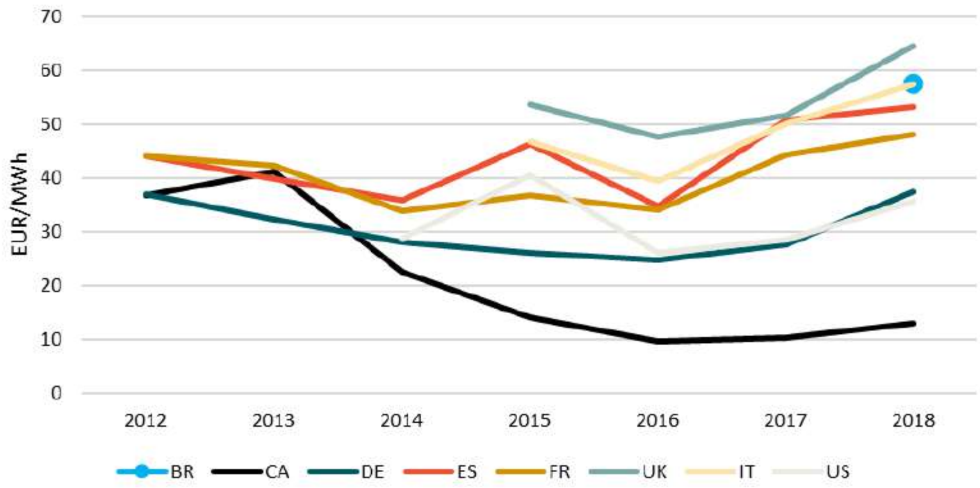
In Brazil, the FiT support scheme is determined through a reverse auction system, where all energies compete with each other. These specificities in the support scheme design may explain why the support levels are lower in the US and Brazil than in other selected countries.

In China, feed-in tariffs remained overall stable with a slight decrease from 2015 to align with the equivalent level of French, German, Spanish and Canadian support values. Government FiT support revenues for Germany and France are approximately at the same level and follow a similar trajectory. Both countries introduced project-specific tenders with sliding FiP remuneration scheme from 2017. The weighted average awarded bid price for the French and German auctions in 2017 amounted to 65.4 €/MWh and 45.3 €/MWh, respectively.

In 2013, the Spanish government decreed a temporary halt of feed-in tariffs in order to prevent the tariff deficit and debts held by utilities from escalating before removing it completely. Since the Royal decree 413/2014, sliding FiP granted by competitive bidding procedures were introduced with the completion of three auctions in 2016 and 2017 for a weighted average awarded price at around 32.0 €/MWh.

In the Canadian province of Ontario, the feed-in-tariffs were on average stable. The observed bump in 2010 is due to the exchange rate. In 2017, the FiT program stopped under a directive from the Minister of Energy, the final FiT application period was held in 2016. In Alberta, three Contracts for Difference through auction procedures were held between 2017 and 2018 resulting in a weighted average award price of 25.5 €/MWh.

Figure 5-22 Realised price for wind onshore per country



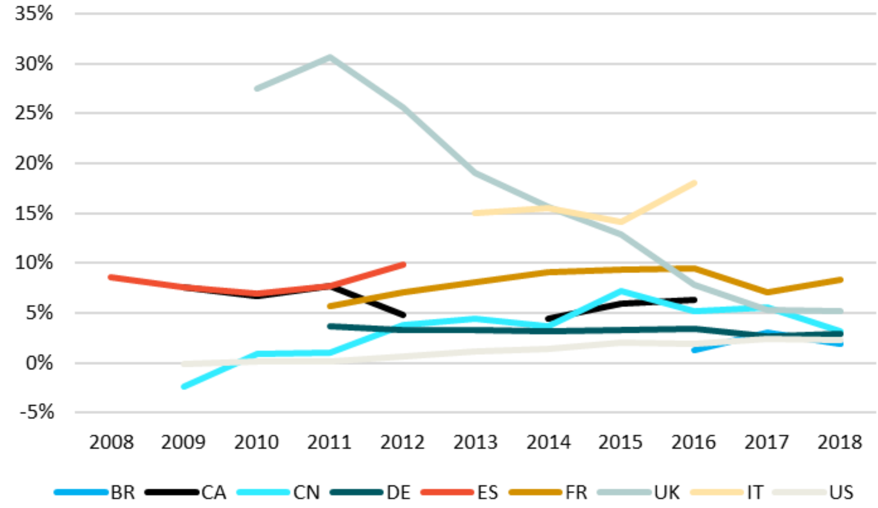
As described in the section about market value, the realised prices are significantly below the average market price with a market value below 100%. In particular, wind experienced relatively lower market values in Canada, Germany and in the US, which may be explained by higher market penetration of the wind onshore during the 2008-2018 period. The variations of the realised price are linked to the average market price which notably increased from 2016 for most selected countries. The main differences between countries come from the electricity demand, the power mix (variable RES penetration, flexibility) and the power exchanged with cross-border countries.

The 2030-2050 Baseline scenario (METIS) projections anticipate an overall decrease in wind onshore market value for the selected European countries. German and Italian wind onshore market values would only decrease from 2030 after a +10 pp and + 5 pp increase between 2018 and 2030, respectively. They follow the trends of their realised and market price projections, varying similarly. On the contrary, French, British and Spanish market values would decrease faster between 2018 and 2030 (-14 pp on average) before slowing down until 2050 (-8 pp on average) following the trends of their realised and market prices. In terms of trends, market prices are expected to slightly vary within a +/- 20 €/MWh - price corridor, with an overall downward trend for the UK, France until 2050 and upward trend for Italy and Germany until 2030 and then downwards until 2050. After a decreasing phase, Spanish market price is expected to slightly increase from 2030 to 2050.

Profitability

After assessing costs and revenues, this section focuses on the IRR for the selected countries, which is a profitability key metric based on costs and revenues cashflow calculation. The following figure shows the profitability of wind onshore based on IRR calculated with revenues from support intervention.

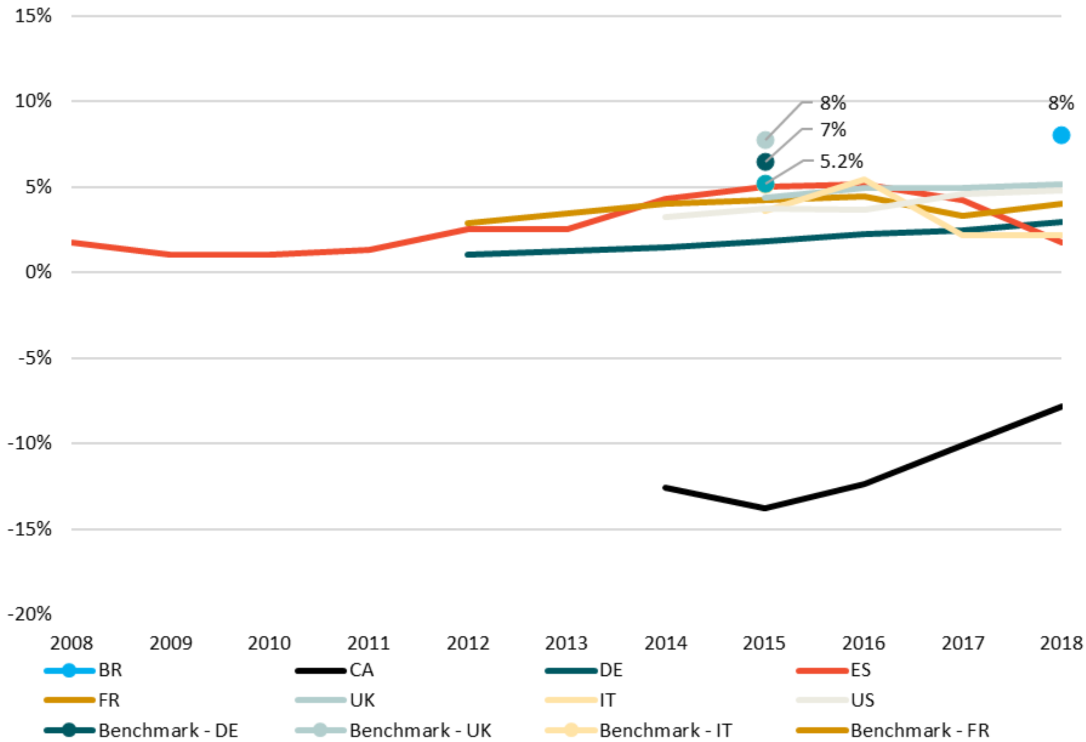
Figure 5-23 IRR from support schemes revenues for wind onshore



Except for Germany, IRR from support schemes are relatively high in the EU countries, at around 16% in in the UK and Italy on average, 8% in Spain and in France. In other countries, IRRs are lower standing between 0% and 6% and varied slightly upward on average.

In the UK, the IRR decreases and follows the trend of the support scheme. In Italy, the high IRR is driven by the high FiT revenues distributed between 2013 and 2016. In Germany, the support scheme does not offset low load factors, realised prices and high O&M costs.

Figure 5-24 IRR from market revenues for wind onshore and comparison with benchmark



Benchmarks source: Bertsch et al. (2018) [132]

[132] Are renewables profitable in 2030? A comparison between wind and solar across Europe, Bertsch, Valentin; Di Cosmo, Valeria; 2018

A long-term trend takes shape where positive market-based IRRs slowly increased over the period for all selected countries except for Canada. Highest IRR is attributed to the UK exceeding 5% from 2016 and Brazil (8.2% in 2018) while Canadian IRRs remain significantly negative, mainly driven by low levels of realised prices.
The main benchmark[67] study provides different IRRs that come from different assumptions in capacity factor and realised price while CAPEX values are relatively close.

The main differences with the benchmark are observed for Germany and the UK. In Germany, it is coming mainly from lower CAPEX and O&M costs in the benchmark. In the UK, CAPEX and O&M are also lower but we can also assume that the benchmark has used significantly higher realised prices (values not provided in this study). It mentions that investments in wind onshore seem generally profitable in Northern European countries but also in some countries on the Mediterranean or Atlantic coast, the latter having favourable conditions for wind onshore.

Wind offshore

In this section, we address the profitability analysis for wind offshore with analysis of costs, revenues, and IRR. The selected countries for the analysis are Belgium, Germany, Denmark, the UK, Netherlands, and China.

Costs

Costs depend on projects and vary with location, distance from shore, depth of installations, etc. There is no significant trend observed in CAPEX values for the observed EU countries. The variation observed from one year to another is mainly due to the low number of actual projects, which do not provide a meaningful average. The other factor is the nature of projects: distance from shore, depth of installations, location, etc. A project far from shore will require higher investments than a project close to shore. In addition, projects tend to be installed in deeper waters and further away from the shore as the best locations are already used which impacts negatively costs and profitability.

Figure 5-25 CAPEX for wind offshore per country

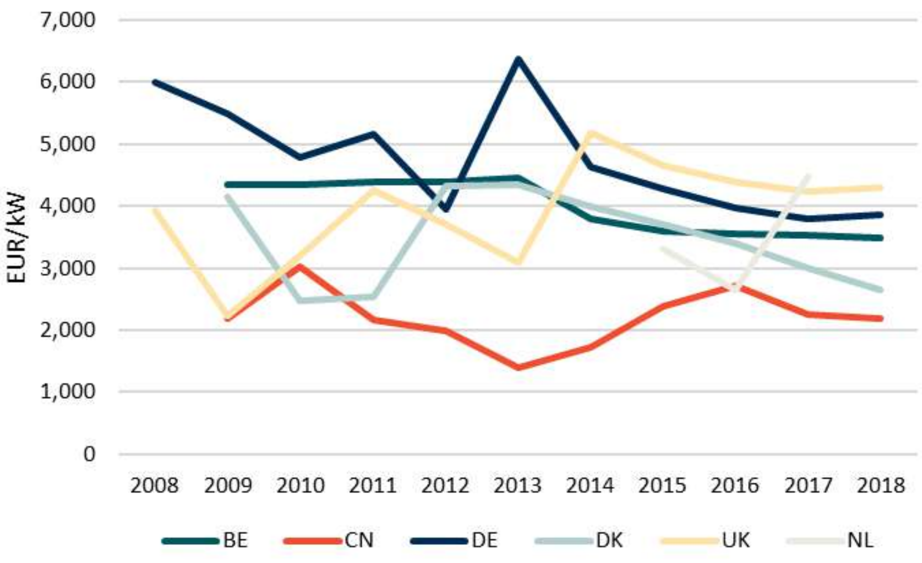
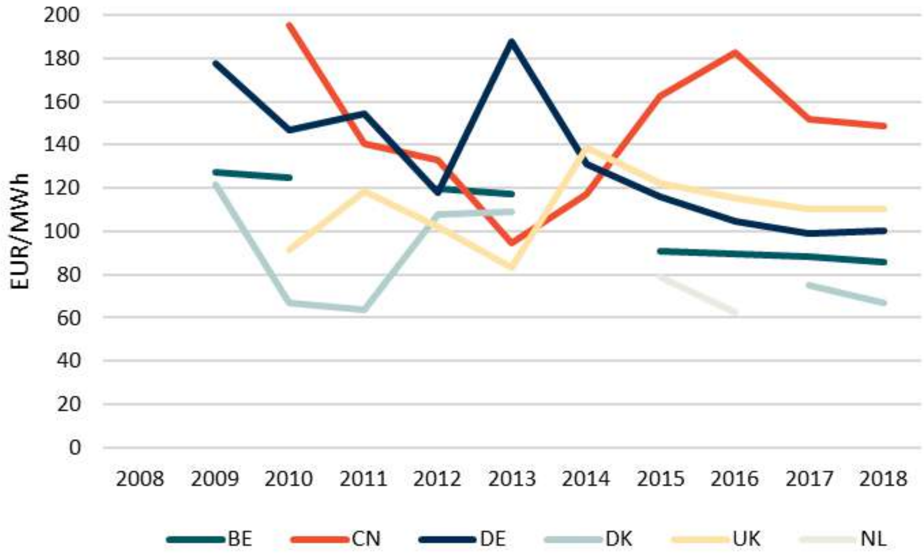


Figure 5-26 LCOE for wind offshore per country



As capital-intensive industry, wind offshore LCOEs follow the same trend as CAPEX. In the last two years of the period, costs ranged between 65 and 150 €/MWh. The highest LCOE values on the 2008-2018 period are observed in China (with an average of 147 €/MWh), where low CAPEX levels do not offset lowest load factor (19% on average) comparatively with other countries. Indeed, capacity factor was relatively high between 2008 and 2018 in the Netherlands (37%), Denmark (34%), the UK (34%), Belgium (32%).

Denmark displays the lowest LCOE in 2018 at 67 €/MWh thanks to a reduction of CAPEX, O&M fixed costs and a relatively high load factor.

Box 5-2 Comparison of LCOE with recent auction results for offshore wind

Comparison of LCOE with recent auction results for offshore wind

The calculation of the levelised cost of electricity (LCOE) conducted as part of this study yields results that may appear high compared to recent auction results of renewable energy projects, which indicate that even offshore wind projects can be realised without subsidies. There are several caveats when interpreting auction results, however, which may point to a higher cost and subsidy requirement if properly accounted for. In this section we analyse the main differences between our LCOE calculations and the recent auction results for offshore wind and discuss how this should be accounted for in the interpretation of the analysis.

The main caveats when interpreting auction results include :

1. The costs and risks for the bidders may differ depending on the auction scheme. Costs and responsibilities for grid connection, land lease and site development may be borne by the contracting authority. Also, responsibilities and risks for permitting and environmental impact assessments may already be addressed by the contracting authority;
2. The awarded contract for difference (or similar) may leave the upside for additional revenues at times of high market prices to the bidder or, alternatively, may require the bidder to pay back excess revenues to the contracting authority. If the bidder gets the upside, the bid price is not fully reflective of the expected revenues and cannot be directly used as an estimate of the project's costs;

3. There may be a significant time lag between the auction date, construction date and the operational start date. Hence, current auction results may indicate the expected costs for projects constructed a few years from now. And costs of projects recently commissioned may represent the cost level of a few years ago (at the start of the construction phase) and the auction results of even further ago;
4. The duration of the support may differ, leading to differences in the period in which the bid price applies and the market risk is (partially) covered by the contract for difference;
5. Auction schemes may or may not update the bid price to account for inflation during the operational phase.

As a result, one should be careful when comparing auction results to LCOE calculations. In a recent study , the auction results for offshore wind were analysed and harmonised to deliver an estimate of the project costs that can be compared to LCOE calculations. Table 5-14 provides a summary of the cost estimates based on both sources for the most recent years (2017 and 2018) and lists the underlying assumptions. It shows that both studies estimate the costs of offshore wind to be in the same range around 100 EUR/MWh. Whereas this study calculated the costs through the LCOE formula, the study on the auction results calculates an expected revenue of the auctioned offshore wind capacities. The authors state that the expected revenues can be compared to the LCOE as they should be enough to cover the costs (estimated by the LCOE) but will not be much higher due to the competitive nature of the auctions. Both studies also apply the same discount rate to indicate the cost of capital for the project and arrive at similar realised price estimates although those are not used in the LCOE calculation. Hence, we conclude that the offshore wind LCOE calculated in this study is consistent with auction results and therefore probably a realistic estimate of the costs of offshore wind technology.

Table 5-14 Comparison of study results to recent auction results

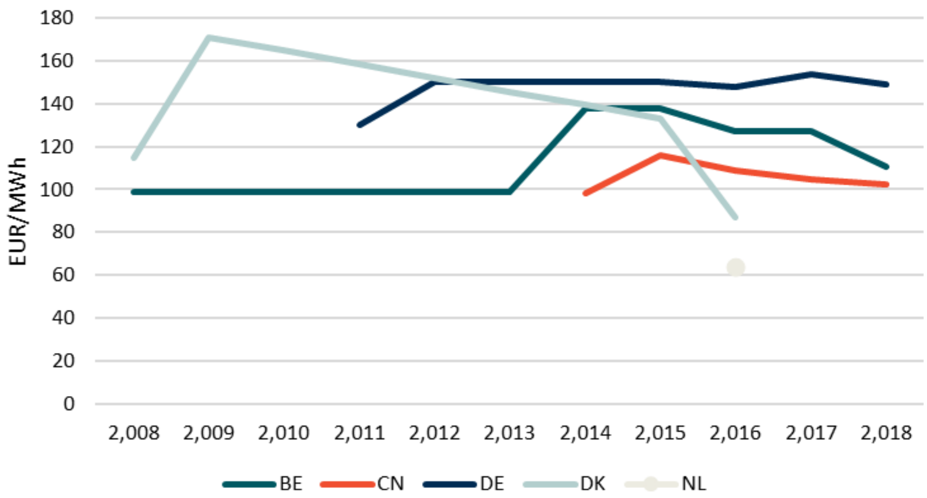
Offshore wind: 2017 - 2018	Study results	Auction results (Jansen et al. (2020))
Cost	LCOE: 70 - 150 EUR/MWh	Expected revenue: 110 - 150 EUR/MWh (actual projects) 90 - 120 EUR/MWh (regression)
Realised price	20 - 64 EUR/MWh (for information only - not used for LCOE calculation)	91 - 97% (current) 82 - 90% (2030)
Discount factor	7%	6.2% - 7.9%

The main reason for the apparent inconsistency with recent auction results is the time lag between auctioning and operation of the wind farm. The same study on auction results also provides insight on the expected revenues (and costs) of projects recently auctioned which are due to be delivered between 2020 and 2025. This shows that steep cost reductions are underway and offshore wind projects that enter the market in 2025 will be realised at a cost level around 50 EUR/MWh, which should be (close to) subsidy-free.

Revenues

Revenues for wind offshore come mostly from state support schemes. As for wind onshore, there are different schemes determined either through competitive bidding procedures or not. The analysis focuses on support scheme with available data and recent auctions results.

Figure 5-27 Support scheme revenues for wind offshore per country per year of commissioning



FiT-based support schemes in the UK for wind offshore (similarly to wind onshore) provided very high revenues in the first years compared to other countries before reducing dramatically and passing below the others because of the statutory "default degression" mechanism applied to FiTs. Parallel to FiTs, the UK launched two Contracts for Differences based on multi - RES technology auctions in 2015 and 2017; Average bid price of the awarded offshore wind projects amounted to 86.0 €/MWh in 2015 and 46.3 €/MWh in 2017.

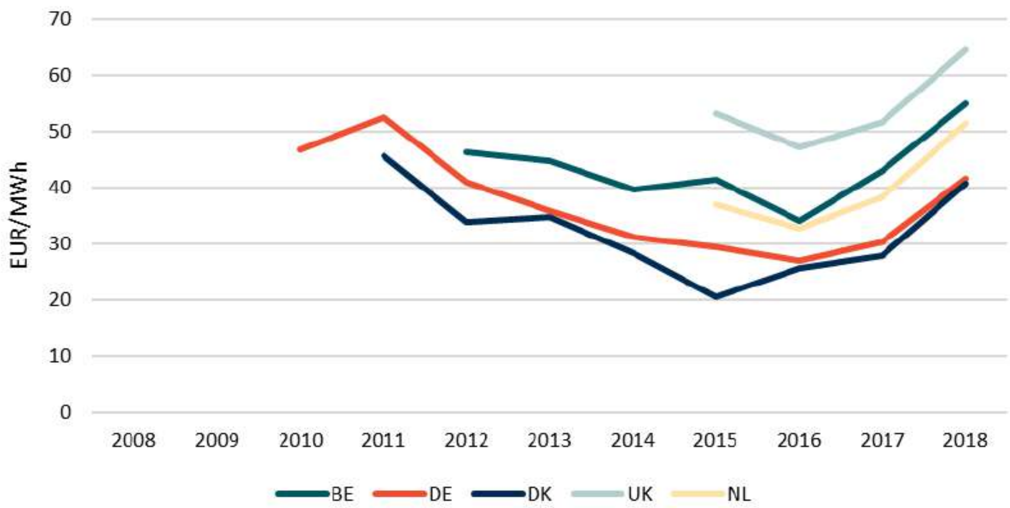
In the Netherlands, the government implemented an auction allocated FiP support scheme in 2008 on top of the wholesale price basis called SDE (Sustainable Energy incentive Scheme). It was replaced in 2012 by another tendering-based support scheme, the SDE+, which also provided sliding feed-in-premiums guaranteed for 15 years. Unlike SDE, rather than being allocated to individual technologies, the financial support is provided through an overall subsidy platform on which all the technologies compete for funding.. Premiums are allocated on a price only basis, the lowest request wins, and there were two auctions per year. As part of the SDE+ scheme, specific tenders for wind offshore are organised: Borsselle Wind Farm Zones I &II, III & IV, V between 2016 and 2017, Hollandse Kust Zuid & Noord between 2018 and 2020. Awarded bid prices for Borssele sites are below the revenues from subsidies for the other countries. From 2018, Hollandse Kust Zuid & Nord tenders resulted in a "subsidy-free" auction as awarded developers competed with a 0 €/MWh bid, meaning they anticipated sufficient cost reduction of wind offshore technologies (i.e. cost gains in larger wind turbines) not to require public support (cf. section on LCOE / Auction results comparison for further analysis).

In Germany, FiT support scheme is currently in effect, where owners of offshore installations receive a fixed payment that was globally stable in the period. Besides, two sliding FiP-based auctions were held in 2017 and 2018 enabling the development of 1.5 GW and 1.6 GW at an average awarded price at 4.4 €/MWh and 46.6 €/MWh, respectively. The 2017's average subsidized price is dramatically low as auction winners proposed a "zero-premium" bid, such as in the Dutch wind offshore auctions.

In Belgium, offshore wind technology is eligible to the federal support scheme based on green tradable certificates combined with a guaranteed minimum tariff, equivalent to a feed-in-tariff until 2014, before moving towards Contract for Differences (CfDs) system. In Denmark, the support scheme was set out as a fixed FiP with guaranteed bonus settled by tender procedures before being transformed into a sliding FiP with maximum price assigned through tenders.

In China, feed-in-tariffs for offshore wind were introduced in 2014 with a five-year bonus offered for projects offshore in Shanghai.

Figure 5-28 Realised price for wind offshore per country



As described in the section about market value, the realised prices were below the average market price with a market value below 100% over the 2008-2018 period that may be linked to a higher market penetration of wind offshore during the analysed period.

Realised price for wind offshore were relatively low in Denmark and Germany compared to other countries. The variations of the realised price are linked to the average market price which increased from 2016. The main differences between countries come from specific power mix, electricity demand and border exchanges.

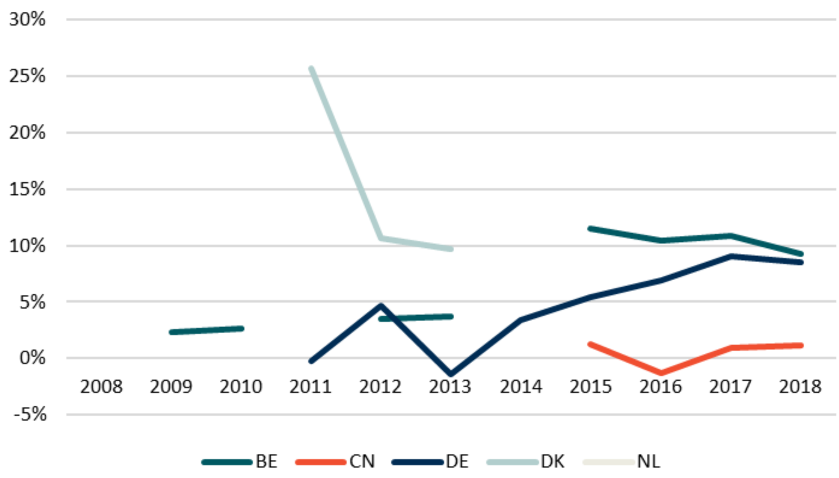
The 2030-2050 Baseline scenario (METIS) projection anticipates an overall decrease in wind offshore market value for the selected European countries from 96% in 2018 on average to 93% and 83% in 2050, meaning realised price declining faster than average market price. Projected trends of realised and market prices are similar for each country with an increase in prices for Belgium, Germany, Denmark and the Netherlands between 2018 and 2030 and then a greater decrease until 2050. Projected realised and market price in the UK would decline as of 2018. In terms of trends, market prices are expected to slightly vary within a +/- 30 €/MWh - price corridor, with an overall upward trend for the Denmark, Germany, and the Netherlands until 2030 and then a downward trend until 2050. British market prices are expected to mildly decrease from 2018 and 2050 while Belgium prices would increase for the next decades.

Source: Study on energy prices, costs and their impact on industry and households

Profitability

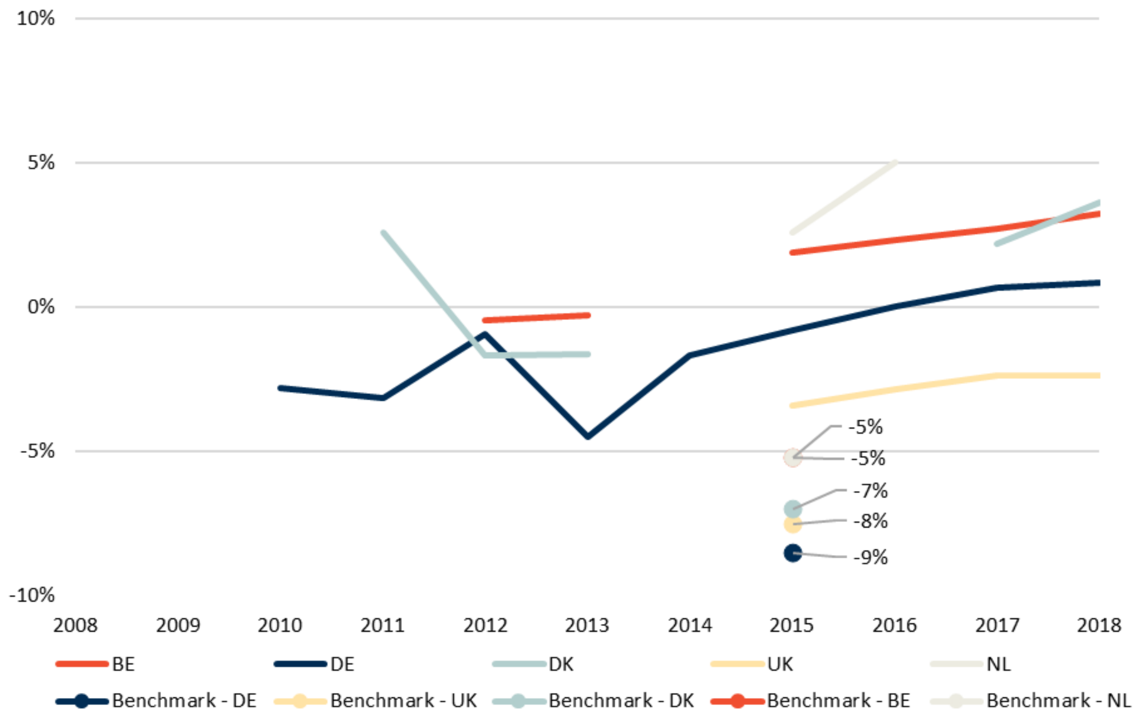
The profitability for wind offshore is presented below. First with IRR from subsidies revenues and then from market revenues.

Figure 5-29 IRR from support schemes revenues for wind offshore



In Denmark, IRRs were very high between 2011 and 2013 driven by low LCOEs while German IRRs increased from 2013 as CAPEX values decreased and FiT levels remained stable.
IRRs in Belgium were the highest (around 10%) over the 2015-2018 period compared to other countries, following the trend of support schemes. Chinese FiT-based IRRs were positive but stayed below the 5% threshold.

Figure 5-30 IRR from market revenues for wind offshore and comparison with benchmark



Source: Bertsch et al (2018). [133]

[133] Are renewables profitable in 2030? A comparison between wind and solar across Europe, Bertsch, Valentin; Di Cosmo, Valeria; 2018

IRRs from support scheme revenues were overall higher than IRRs from market revenues (realised price), which turned positive over the last years for Germany, Belgium, Netherlands, and Denmark. This upward trend is mainly explained by the combination of increasing realised price from 2016, relatively high load factors (35% on average) and decreasing LCOEs.

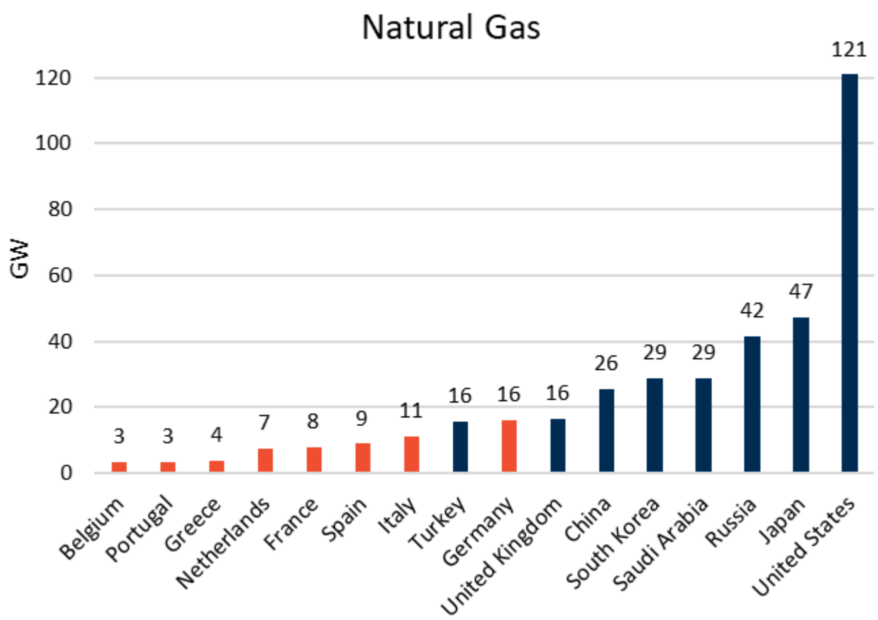
Despite the highest realised prices, the UK market-based IRRs remained negative, held back by high levels of CAPEX.

The benchmark[68] study provides lower IRRs that come from different assumptions in capacity factor, realised price and CAPEX values. It is coming mainly from higher CAPEX in the benchmark. In the UK, CAPEX values are a little higher, but the difference is mainly coming from O&M costs that are lower in the benchmark. Another significant driver may be realised prices (values not provided in this study).

Gas

In recent years with the drop in gas prices, gas-fired installed capacity increased significantly, and this trend can be expected to continue. The US has the largest gas-fired power plant fleet among the G20 countries with 546 GW of installed capacity in 2019. In Europe, Italy has the largest gas fleet, at 45 GW, followed by the UK (34 GW), and Spain (32 GW). Gas represented 20.5% of the EU power mix in 2018 (from 23.8% in 2008). In the period studied (2008-2018) the US commissioned almost 121 GW of gas-fired power generation capacity. Meanwhile, Russia added over 41 GW, and China 26 GW. In the EU27 Italy and Spain registered the largest amount of commissioned at 11 GW and 9 GW, respectively. Other countries which registered major gas development are the UK (16 GW) and Turkey (15 GW).

Figure 5-31 Countries with the highest gas added capacities 2008-2018 (EU countries in orange).



The gas boom witnessed in the US was pushed by stronger emissions standards, and the availability of cheaper shale gas from its growing tight oil production. As indicated on section 3.2.2, from 2010 onwards, US prices have diverged from around the same level as EU average prices (around €15/MWh) to around half of EU average levels, at less than €10/MWh. For reference purposes European prices were around €18/MWh in the last four years.

The gas expansion also led to strong decreases in coal consumption for power generation. On the other side of the globe, China is also turning to gas to decrease air pollution from burning coal although the country still relies heavily on coal. China's 13th Five-Year Plan states targets to increase the share of natural gas in the primary energy mix to 15% in 2030[134].

Specific assumptions

Installed added capacity of thermal power plants were estimated using data from Enerdata's Power Plant Tracker (PPT) and the Global Energy and CO_2 database. For a specific year, if added capacity from PPT is greater than the difference between total installed capacity from one year to another, than PPT data is used. If the opposite is true, the difference between total installed capacity from one year to another calculated using Global Energy and CO_2's data was taken as the added installed capacity. This exercise was necessary for mature technologies plant where decommissioning must be considered. Conversely for young RES technologies, the development in recent years is substantial enough to render decommissioning insignificant.

Load factor in projection for a given year of commissioning is estimated as the observed average load factor between 2008-2018 and derived from Eurostat (EU) and Enerdata's Global Energy and CO_2 (outside EU) databases. Projected realised prices and load factors come from the Baseline scenario (METIS).

For this technology, IRR evaluations will be presented in detail for the following countries[135]:

- Belgium;
- France;
- Germany;
- Greece;
- Italy;
- The Netherlands;
- Portugal;
- Spain;
- The UK;
- Turkey;
- The United States.

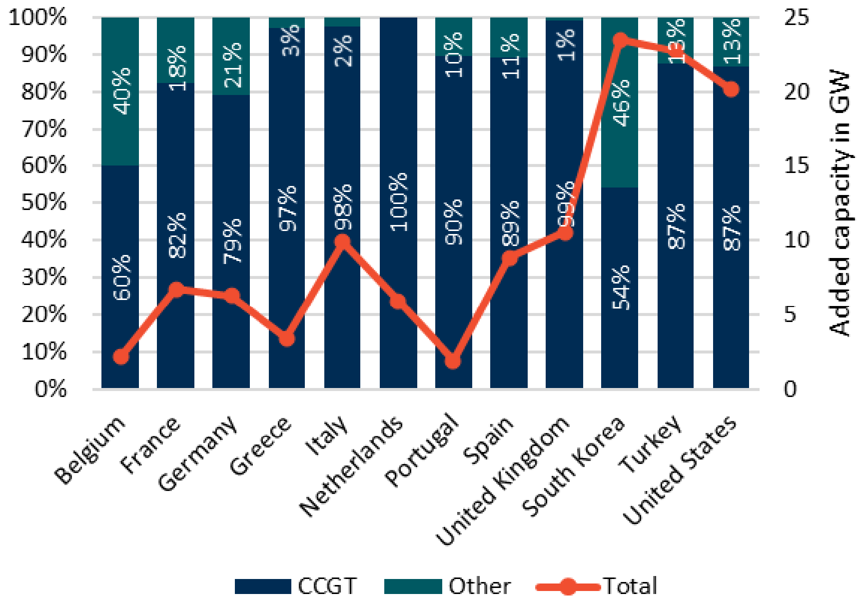
It accounts for countries where realised prices are available (requiring both hourly power market price and gas power generation) and with significant CCGT capacities installed on the observed period.

Added installed capacity structure

There were around 67 GW of gas-fired power capacity commissioned in Europe between 2008 and 2018. Over the total, 90% of the capacity was for CCGT power plants. Of the countries studied in detail, only Belgium has significant commissioning of non-CCGT power plants, i.e. steam and gas turbines (40% of the total while CCGT represented 60%). Outside Europe (for selected countries) commissioning of CCGT power plants represented 73% of the total. Based on these data we consider all commissioning to be CCGT.

[134] Enerdata (2019): Does the Gas Boom in the US and China Change the Market?
[135] Additional costs analysis will be provided for China, Saudi Arabia, Japan, and Russia

Figure 5-32 Technological structure of gas commissioning between 2008-2018: Selected countries.



O&M and other variables

In Europe fixed O&M costs and Efficiency rates are considered based on ASSET (2018) and data from IEA's WEO publications from 2009 until 2017. The linear variation of variables between 2009 and 2017 from the WEO publications were applied to 2020 data ASSET (2018) to generate estimates of variables between 2009 and 2017 based on the PRIMES model. For 2008 and 2018 the closest available rates were used as proxy.

For other countries O&M costs are provided by IEA's WEO publications. Variable O&M for European countries and other countries were based on estimates from ASSET (2018).

Costs

Fuel and Carbon Costs

Thermal power generation technologies are very sensitive to fuel costs as opposed to renewables and nuclear that are mainly impacted by the initial investment costs of the power plant. Regarding fuel costs of gas-fired power generation, we have considered the prices of gas used for power generation from Enerdata's Global Energy and CO_2 database. Most European countries were provided with country specific costs but some needed to be estimated. For Greece data from Italy were used as proxy due to proximity, while for Spain, Portugal was used as proxy for the same reason. Country specific gas prices were not available for China and Saudi Arabia. For these countries we used gas prices from the US's Henry Hub[136].

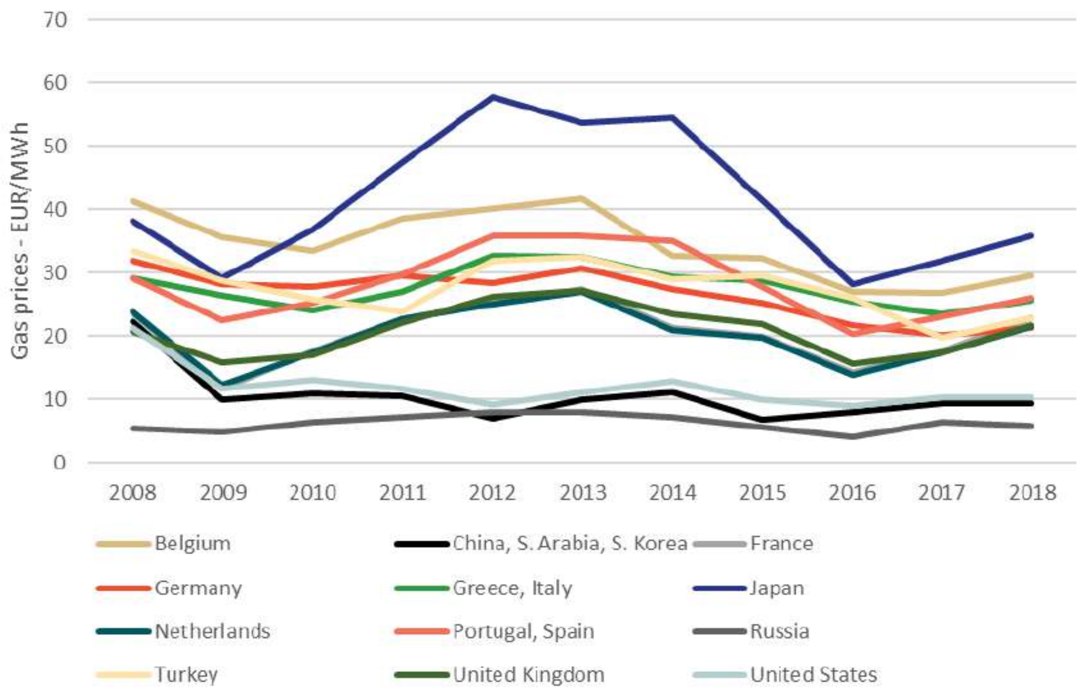
The US production of domestic affordable shale gas pushed for an increase of this energy source in the energy mix in recent years. The country's natural gas production increased by 5%/year on average since 2006 and has soared since 2017, increasing by 20% to reach 951 bcm in 2019. For reference purposes, US gas prices are around 60% lower than the OECD average for industry customers.

[136] international gas prices-Henry Hub from Yahoo Finance

Another important cost factor for this technology are prices for emission allowances although this dimension of cost was only applied to European countries in this study. Actual carbon prices were obtained from the EU Emissions Trading Scheme (ETS) from 2008 to 2018. Carbon prices for power generation assets were calculated using an emission factor by technology. The so-called "emission factor" is the amount of emissions generated per MWh of power output.For gas-fired power plants, the registered emission level from gas-fired power generation (from Enerdata's GED database) was divided by the power output of the gas-fired power plant fleet, leading to an emission factor of around 0.44 tCO_2/MWh[137].

Thus, from the graph below, we can observe that European carbon costs for gas-fired power generation have dropped significantly between 2008 and 2013 (-15%/year) and remained relatively stable until 2017 to then triple to 6 €/MWh in 2018. Gas prices in most analysed countries dropped between 2008 until 2010 to then increase in 2010 and drop below 2008 levels in 2016. Since 2016 prices have been increasing with overall European prices reaching 23 €/MWh in 2018 (+30%/year since 2016). Most non-EU countries registered prices in the lower spectrum of the graph with Russia registering the lowest rates.

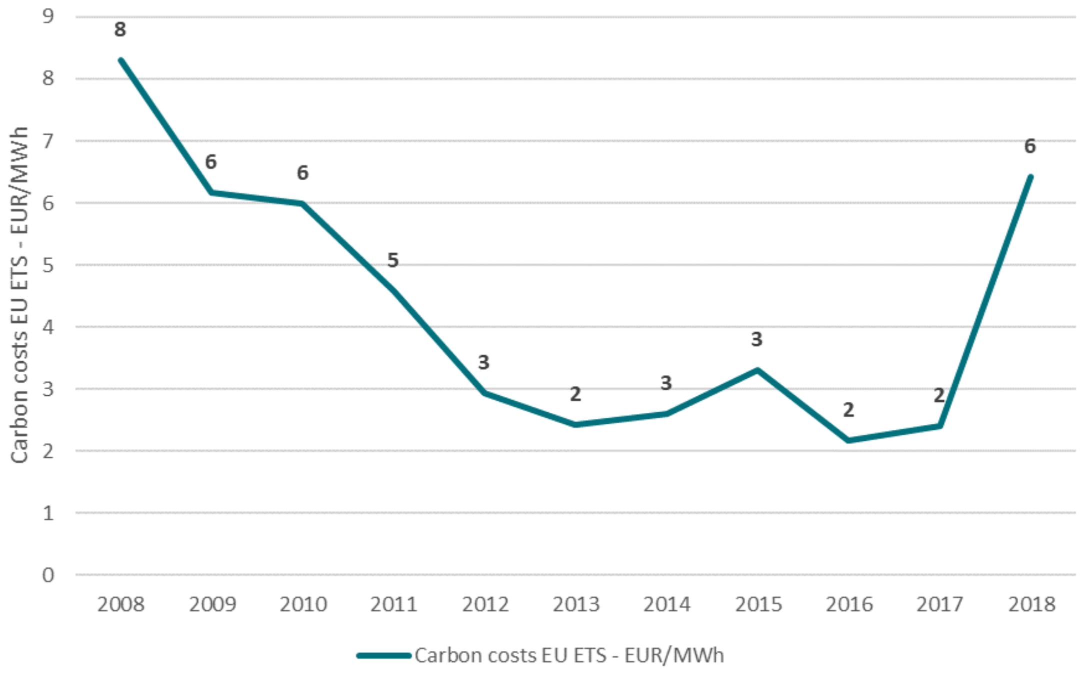
Figure 5-33 Gas prices (for all countries) 2008-2018.



[137] Data for calculation was provided by Enerdata's GED database

Source: Study on energy prices, costs and their impact on industry and households

Figure 5-34 Carbon Costs (EU ETS for gas power generation) 2008-2018.



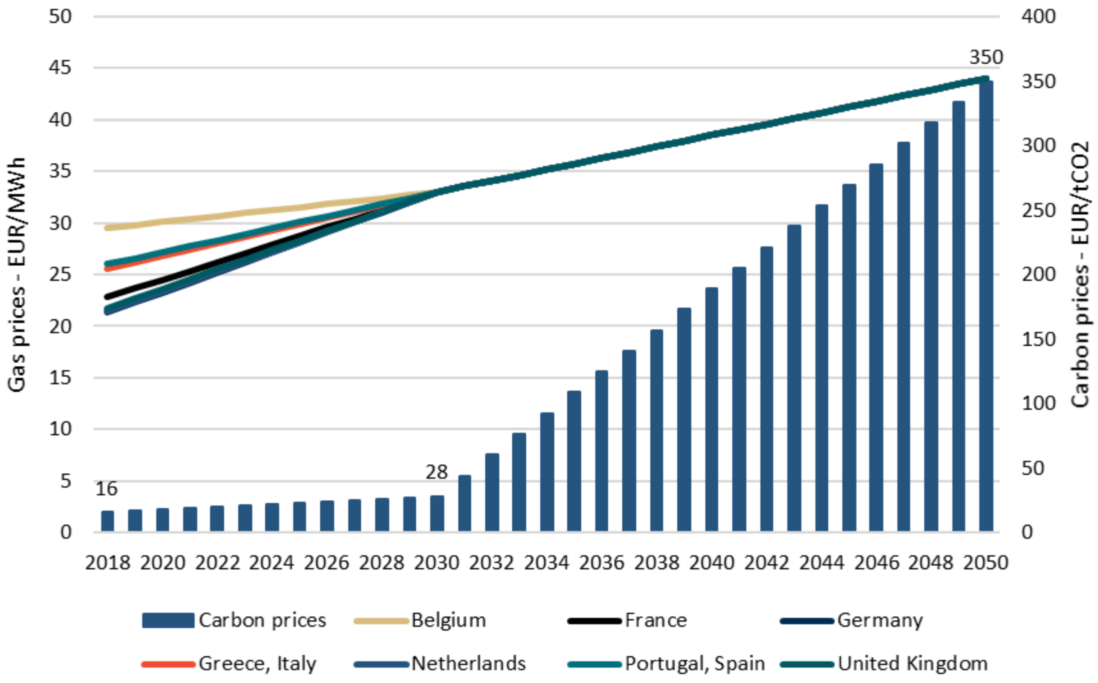
Projections on fuel and carbon costs (Europe only)

As gas-fired power plants have a lifespan of 30 years, projects commissioned in the period analysed will be operated beyond 2018. For this reason, an assumption regarding fuel costs and carbon costs beyond 2018 was necessary. Based on actual data and projections until 2030 and 2050 from Baseline scenario (METIS), fuel and carbon costs were assumed to evolve as the graph shown below[138].

Estimates indicate that European gas prices will reach 33 €/MWh in 2030 (from 22-30 €/MWh in 2018) and will continue to increase 1.6%/year to 44 €/MWh in 2050. A steeper surge will be witnessed in carbon prices from 16 €/tCO_2 to 28 €/tCO_2 in 2030 and 350 €/tCO_2 in 2050 (almost + 60%/year between 2030 and 2050).

[138] Gas and Carbon prices were estimated using based on a linear interpolation of figures reported in baseline scenario (METIS).

Figure 5-35 Gas prices and Carbon prices projections 2018-2050.

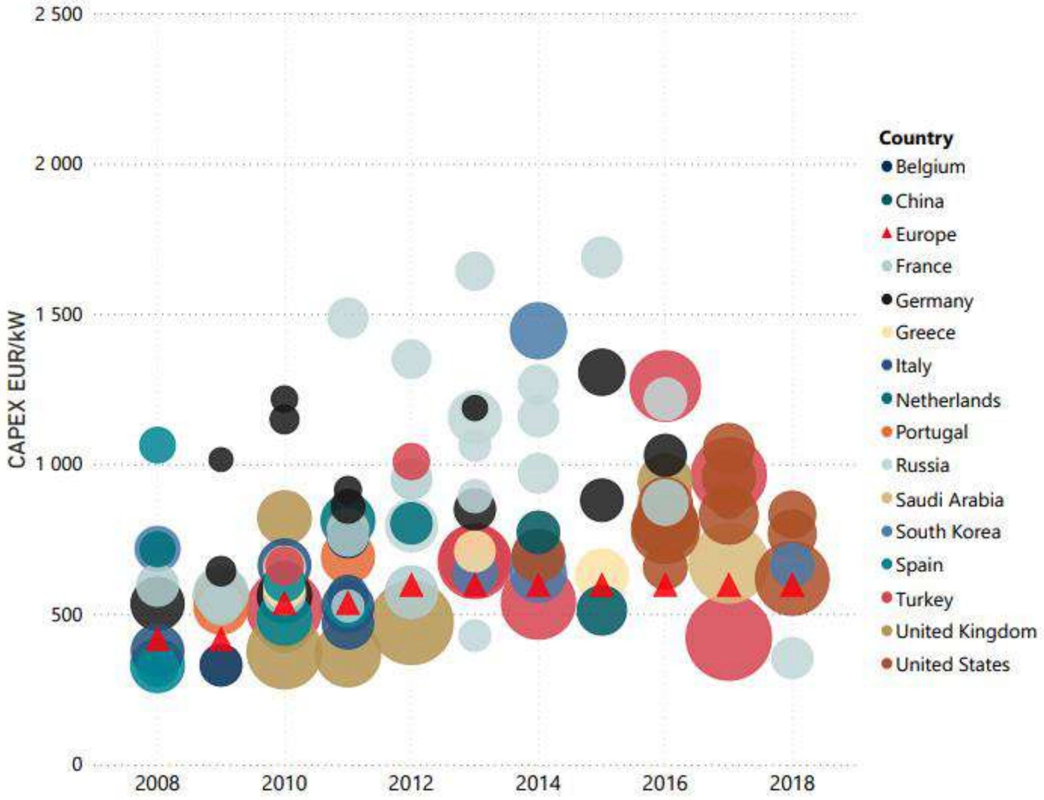


Investment Costs

As mentioned previously, this study only considers costs for CCGT power generation plants. Because gas projects between 2008 and 2018 were scarcer than RES, we decided to represent investment costs at a project level instead of a national level as what was done for RES technologies. Below are the investment costs of projects commissioned in selected countries over the period. For IRR calculations, some estimations were made using IEA's WEO publications and national sources when project specific CAPEX levels were not available.

A preliminary analysis shows no direct relation between the project's installed capacity and its CAPEX. It is possible to observe, however, that larger power plants (1 000-1 600 MW, and > 1 600 MW) stand in the lower spectrum of the graph with costs below 1 000 €/kW.

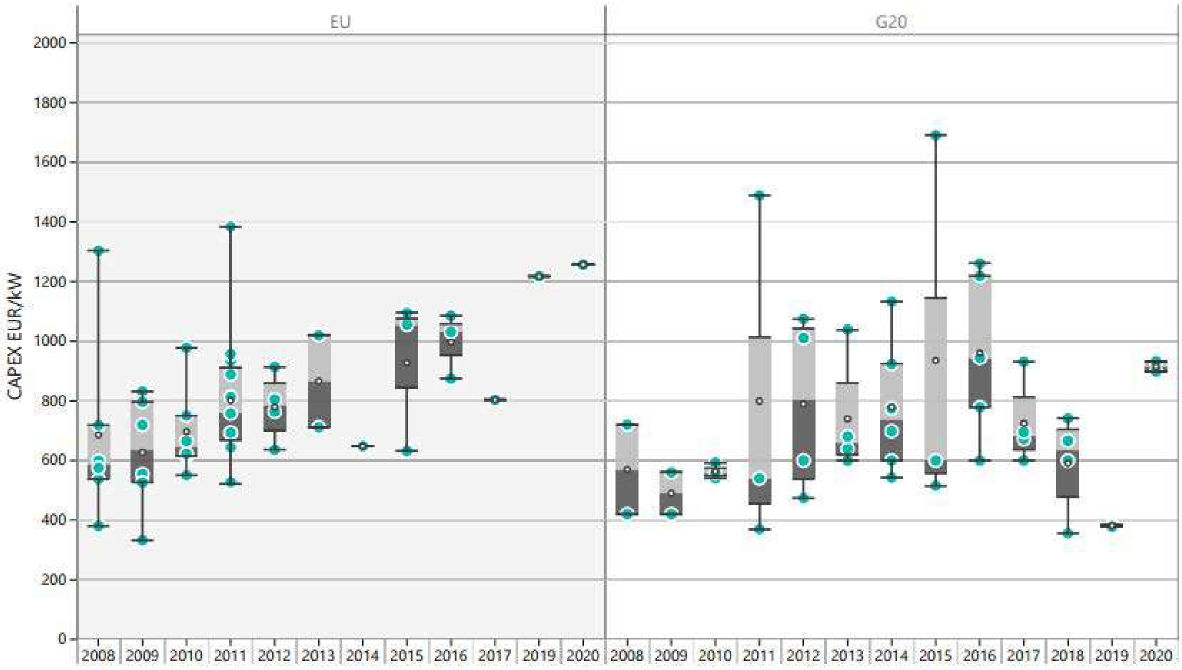
Figure 5-36 **Investment costs of CCGT power plants in selected countries (Enerdata's PPT) - I.**



Notes: Power plants range between <100 MW; 100-500 MW; 500-1 000 MW; 1 000-1 600 MW; and > 1 600 MW

Rearranged data suggests an increase in overall investment costs. This shift is much more accentuated in the EU countries as the development of smaller facilities is preferred.

Figure 5-37 **Investment costs of CCGT power plants in selected countries (Enerdata's PPT) - II.**

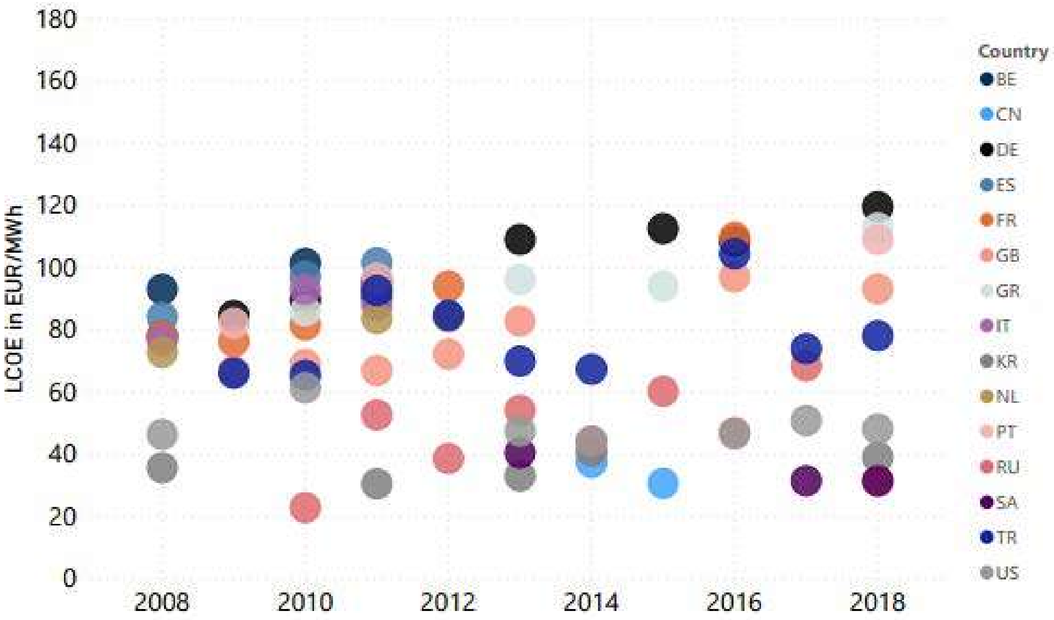


Notes: Box and whisker graphs showcase the minimum and maximum (whiskers) values of CAPEX for the group of countries in a given year. The grey boxes represent second and third quartiles and blue dots represent the datapoints that built the box. Grey dots represent the average between datapoints.

LCOEs

Using the LCOE calculation method, the differences highlighted in the Investment costs section become much more evident. Besides, assumptions regarding fuel, carbon costs and load factors until 2050/2060 also have a significant impact on results. For this reason, European countries show LCOE's in the higher spectrum of the graph above 70 €/MWh. Turkey is the exception regarding LCOE trends outside Europe, with costs rather high due to a significant decrease in load factors from 2008 (66%) to 2018 (40%).. The costs however are pushed upwards by the increase in carbon and fuel costs.

Figure 5-38 LCOE of CCGT power plants in selected countries

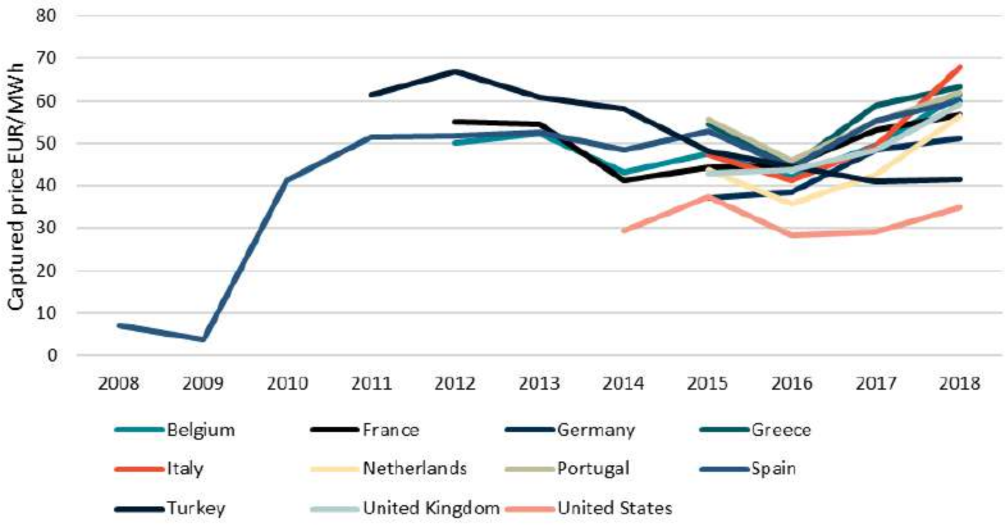


Revenues

Revenues for gas-fired power generation come from energy sales and the provision of system services (or ancillary services). The average mark-up on electricity market revenue varies from 5-15% (see section "Revenues from system services" for more details). For the profitability analysis, we assume that conventional power producers generate additional 7% mark-up on average wholesale prices (based on the ACER report).

Source: Study on energy prices, costs and their impact on industry and households

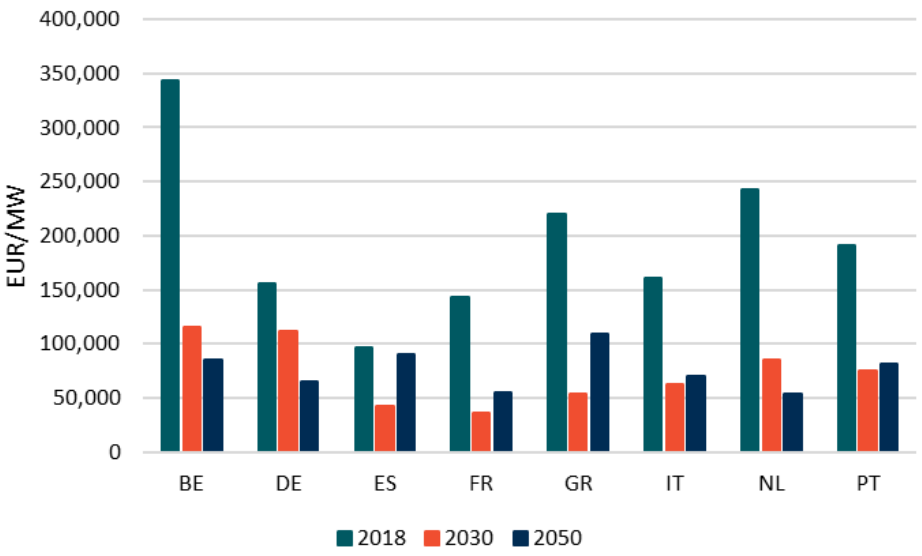
Figure 5-39 Realised price for gas-fired power per country.



Realised prices collected on the historical period and shown in the graph above increase for most EU countries at the end of the period due to increasing average market price.

Thanks to 2030 and 2050 the Baseline scenario (METIS) data, it is possible to extract projected realised prices and load factors to get the variations in revenues. As shown in the graph below, projected revenues are significantly lower in projections due higher CO_2 costs and lower load factors, below 1 000 hours/year.

Figure 5-40 Revenue for gas-fired power by installed MW



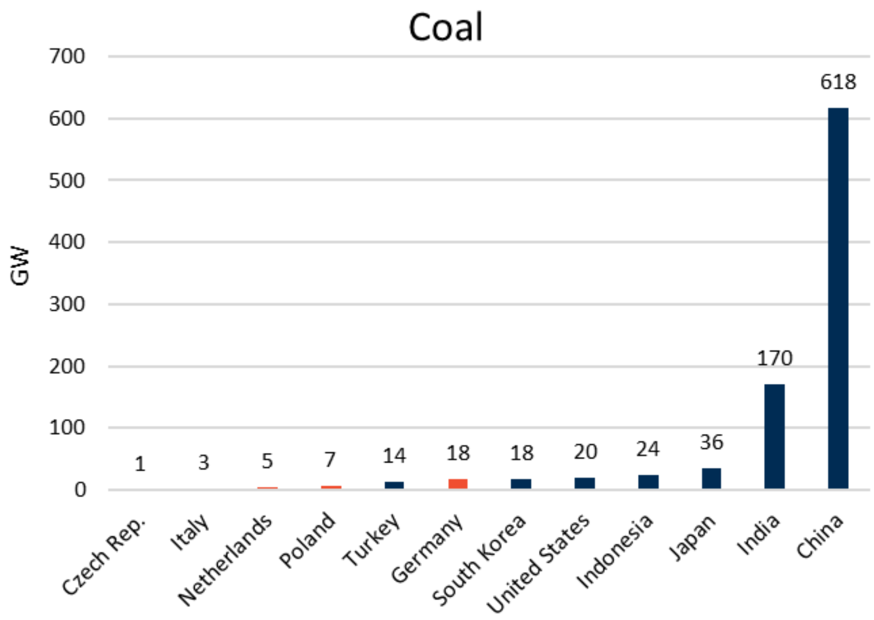
Profitability

With projections being based on decarbonised scenario, the Baseline scenario (METIS), thermal technologies are penalised, and costs are strongly boosted upwards. High carbon and fuel costs grant gas-fired power very high costs. Combined with load factor tending to utilization rates below 1 000 hours/year (France, Germany, the UK and Spain) this results in relatively low and negative IRR rates in most cases.

Coal

With 1 163 GW in 2019, China has the largest fleet of coal-fired power stations, followed by the US (249 GW) and India (228 GW). China commissioned almost 618 GW between 2008 and 2018, while India added 170 GW and the US 19.6 GW. The development of coal capacity in the European countries is considerably smaller and coal represents 15.2% of the EU power mix in 2018 (from 22.7% in 2008). Germany has added the most into its coal fleet with over 17 GW, followed by Poland (6.5 GW) and Italy (2.6 GW).

Figure 5-41 Countries with the highest coal added capacities 2008-2018 (EU countries in orange).



Coal consumption has been dropping in the EU due to climate policies, the development of renewables and gas-fired power plants, and an increase in the price per tonne of CO2. So far, eight EU Member States have decided to phase out coal by 2030. Germany, which produces 1/3 of its electricity from coal (and contributed to 36% of the EU's power production from coal in 2018), approved a bill to exit coal by 2038 and close 40% of its coal capacity by 2030[139]. The UK has established its coal phase out for 2024[140].

In the US, coal consumption reached its lowest level in 40 years, due to capacity retirements (15 GW in 2018), stricter emission standards and the availability of cheaper gas. Meanwhile, China seems to go on a different direction. The government cleared 6.6 GW of new coal-fired capacity for construction in March 2020 (more than the 6.3 GW registered during the entire year of 2019). Recent regulations already approved more relaxation on new coal-fired construction permitting and the government is looking to prioritize economic growth (i.e. boost coal development if needed).

Specific assumptions

Installed added capacity of thermal power plants were estimated using data from Enerdata's Power Plant Tracker (PPT) and the Global Energy and CO_2 database. For a specific year, if added capacity

[139] BMWi press release January 2020: https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2020/20200129-kabinett-beschliesst-kohleausstiegsgesetz.html
[140] UK Government press release February 2020: https://www.gov.uk/government/news/end-of-coal-power-to-be-brought-forward-in-drive-towards-net-zero

from PPT is greater than the difference between total installed capacity from one year to another, than PPT data is used. If the opposite is true, the difference between total installed capacity from one year to another calculated using Global Energy and CO_2's data was taken as the added installed capacity. This exercise was necessary for mature technologies plant where decommissioning must be considered. Conversely for young RES technologies, the development in recent years is substantial enough to render decommissioning insignificant.

Load factor in projection for a given year of commissioning is estimated as the observed average load factor between 2008-2018 and derived from Eurostat (EU) and Enerdata's Global Energy and CO_2 (outside EU) databases. Projected realised prices and load factors come from the Baseline scenario (METIS).

For this technology profitability analysis will be presented in detail for the following countries[141]:

- Czech Republic;
- Germany;
- Italy;
- Poland;
- Netherlands;
- Turkey;
- The United States.

It accounts for countries where realised prices are available (requiring both hourly power market price and coal power generation) and with significant coal capacities installed on the observed period.

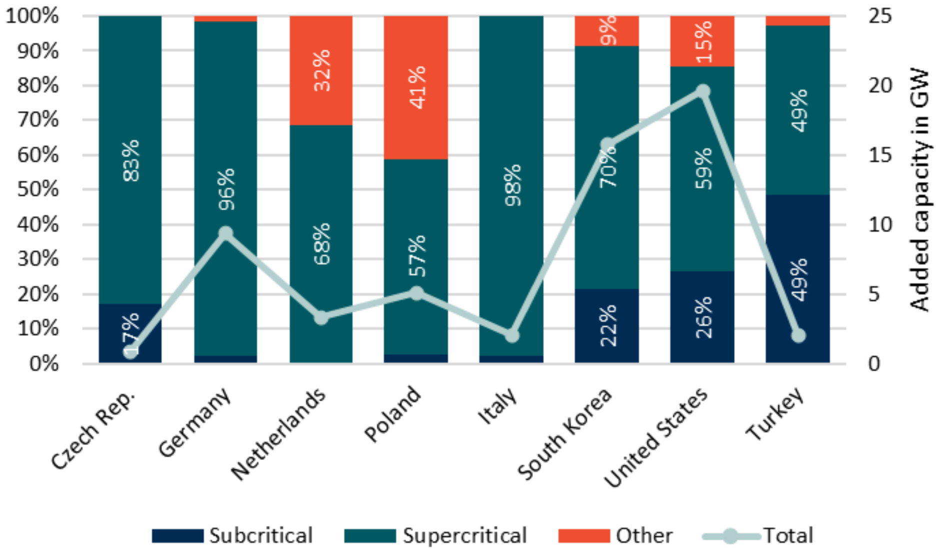
Added installed capacity structure

There are two different classification dimensions of coal-fired power plants, in terms of fuel (lignite and coal (bituminous, hard coal, etc.)) and in terms of technology (subcritical and supercritical[142]). The following capacity addition analysis encompasses data from Enerdata's PPT database.

Except for Bulgaria, European coal-fired power plants commissioned during the 2008-2018 period are assumed to use supercriticial technology, which compared to subcritical technology provides efficiency rates of up to 45% and has been developed in larger scale in recent years for this very reason[143]. For countries outside Europe, we consider South Korea and the US to have coal additions 100% supercritical to facilitate calculations and as this technology encompasses the majority of commissioning in the period. For Turkey, technology is divided into equal parts, but costs data is only available for supercritical technology and thus subsequent calculations were produced for this technology.

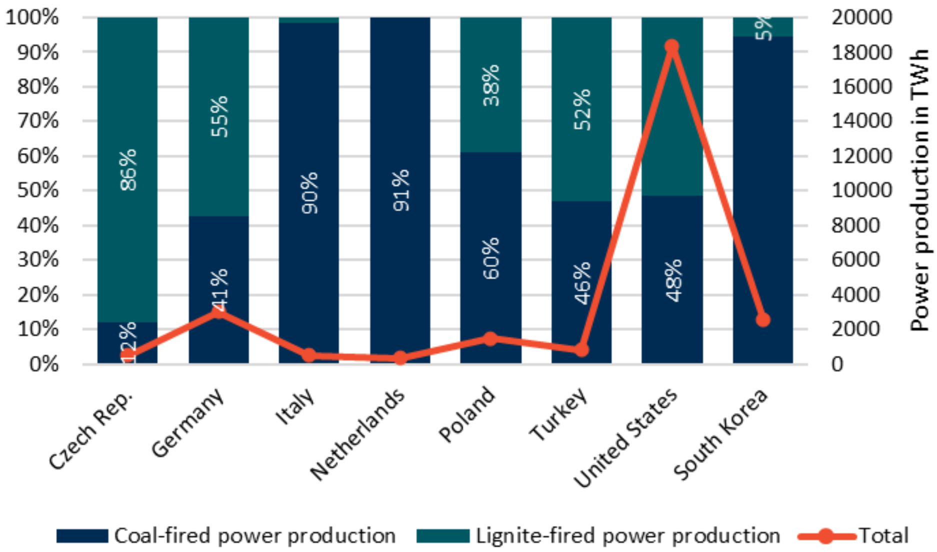
[141] Additional costs analysis will be provided for India, Indonesia, Japan, and China
[142] IGCC is also a technology for coal-fired power generation but it was not explored in this study as there are very few projects developed.
[143] For reference purposes subcritical power plants manage to reach efficiency rates of 39% (IEA WEO publication data)

Figure 5-42 Technological structure of coal commissioning between 2008-2018: Selected Countries.



Based on power generation data we consider most countries to run exclusively on bituminous coal except for the Czech Republic, which will be considered to run exclusively on lignite. Germany and Turkey have roughly equal shares of lignite and coal-fired power. The difference between each project is presented in the calculation. On all the projects from Enerdata's Power Plant Tracker commissioned between 2008-2018 each country presented 2 lignite-fired power plants. In the US despite lignite power generation having a significant weight, all recent power plants run on coal.

Figure 5-43 Fuel structure of coal power production between 2008-2018: power production.



O&M and other variables

In Europe fixed O&M costs and Efficiency rates are considered based on ASSET (2018) and data from IEA's WEO publications from 2009 until 2017. The linear variation of variables between 2009 and 2017 from the WEO publications were applied to 2020 data ASSET (2018) to generate estimates of variables between 2009 and 2017 based on the PRIMES model. For 2008 and 2018, the closest available rates were used as proxy.

For other countries, O&M costs are provided by IEA's WEO publications.
Variable O&M for European countries and other countries were based on estimates from ASSET (2018).

Costs

Fuel and Carbon Costs

Thermal power generation technologies are very sensitive to fuel costs while renewables and nuclear are more impacted by the initial investment costs of the power plants. Regarding fuel costs of coal-fired power generation we have considered the prices in €/ton of coal used for power generation from Enerdata's Global Energy and CO_2 database. The data was converted to €/MWh using a conversion factor of 8.141 ton of coal/MWh (3.306 ton of lignite/MWh). Most European countries were provided with country specific costs, but some needed to be estimated. The actual costs of coal by power generated depends on the power plants efficiency rate. For Czech Republic, an EU average calculated from data available in the database was used. Country specific coal prices were not available for China, India, and South Korea. For these countries we used the international coal price provided by Markets insider[144]. Furthermore, for lignite prices we consider the relative price between bituminous coal and lignite from US EIA's Annual Coal Report[145]. Assuming this, lignite prices are usually a third of the price of bituminous coal (between 2008 and 2018).

Another important cost factor for this technology are carbon prices although this dimension of cost was only applied to European countries in this study. Actual carbon prices were obtained from the EU Emissions Trading Scheme (ETS) from 2008 to 2018. Carbon prices for power generation assets were calculated using an "emission factor" by technology. For coal-fired power plants, the registered emission level from coal-fired power generation was divided by the power output of the coal-fired power plant fleet. The so-called "emission factor" is the amount of emissions generated per MWh of power output. For coal-fired power plants, this emission factor is around 1 tCO_2/MWh[146].

Thus, on the graph below, we can observe that European carbon costs for coal-fired power generation have dropped significantly between 2008 and 2013 (-15%/year) and remained relatively stable until 2017 to then reach 15 €/MWh in 2018. Coal prices in most analysed countries (except Indonesia) dropped from 2008 until 2016. They have been increasing since 2016 in all countries except the US and Turkey. Since 2016, European prices went from reaching 77 €/MWh in 2018 (+10%/year since 2016). Non-EU countries (except Japan) and Poland registered prices in the lower spectrum of the graph (below 60 €/MWh) with Turkey showing the lowest rates.

[144] https://markets.businessinsider.com/commodities/coal-price
[145] https://www.eia.gov/coal/annual/
[146] Data for calculation was provided by Enerdata's GED database

Figure 5-44 Coal prices (for all countries) 2008-2018.

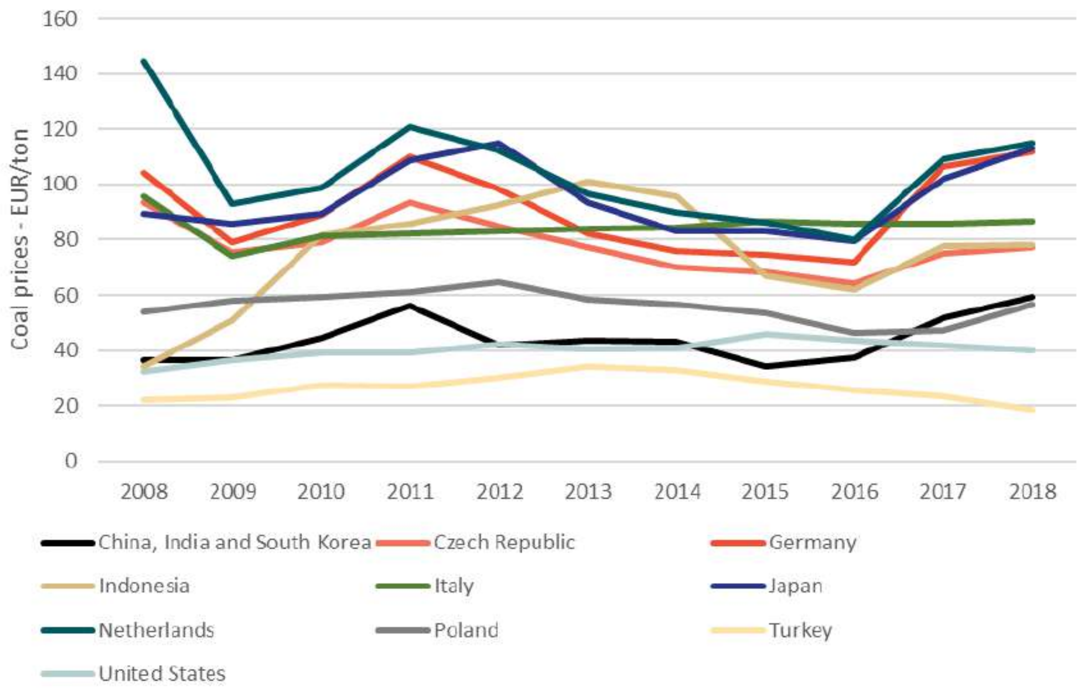
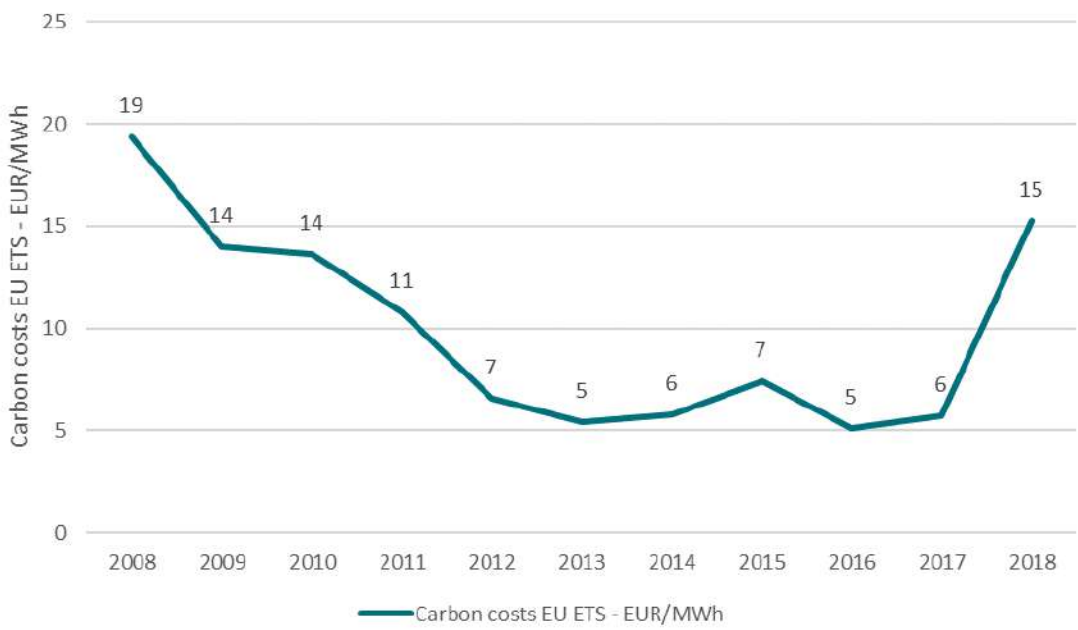


Figure 5-45 Carbon Costs (EU ETS for coal power generation) 2008-2018.

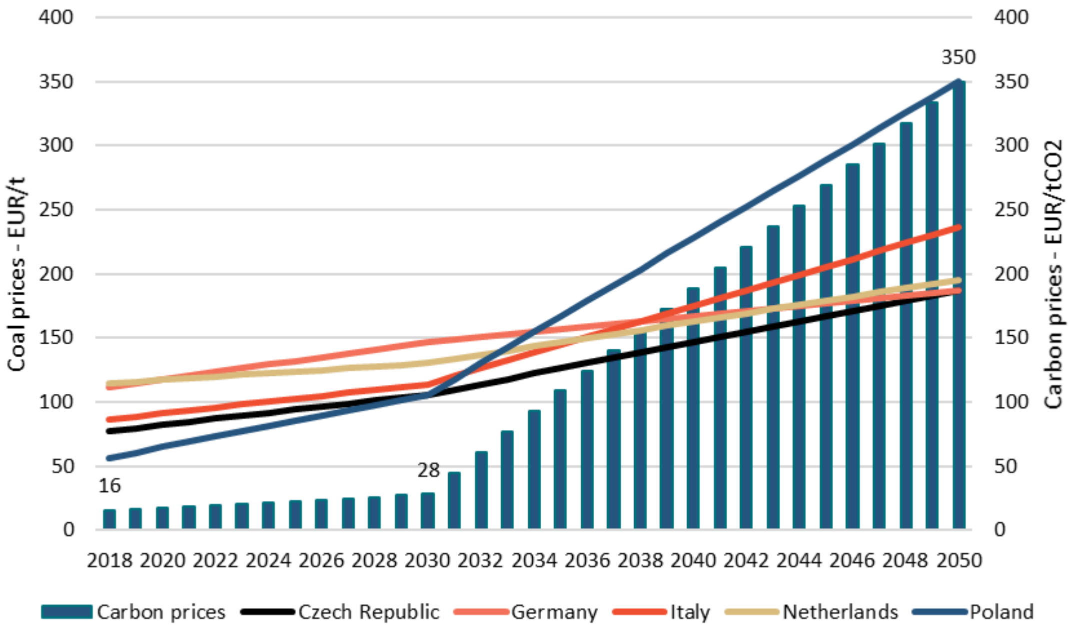


Projections on fuel and carbon costs (Europe only)

As coal-fired power plants have a lifespan of 40 years, projects commissioned in the period analysed will operated beyond 2018. For this reason, an assumption regarding fuel costs and carbon costs beyond 2018 was necessary. Based on actual data and projection until 2030 and 2050 from Baseline scenario (METIS), fuel and carbon costs were assumed to evolve as the graph show below.

Estimates based on Baseline scenario (METIS) and Enerdata's GED database indicate that European coal prices (except in Poland) will reach 100-150 €/t in 2030 and will continue to increase to around 200 €/t in 2050. In Poland, the change is the most significant with prices coming from the lowest in 2018 (7 €/MWh) to the highest in 2050 (43 €/MWh). A steeper surge will be witnessed in carbon prices from 16 €/tCO_2 to 28 €/tCO_2 in 2030 and 350 €/tCO_2 in 2059 (almost + 60%/year between 2030 and 2050).

Figure 5-46 Coal prices and Carbon prices projections 2018-2050 in selected European countries.

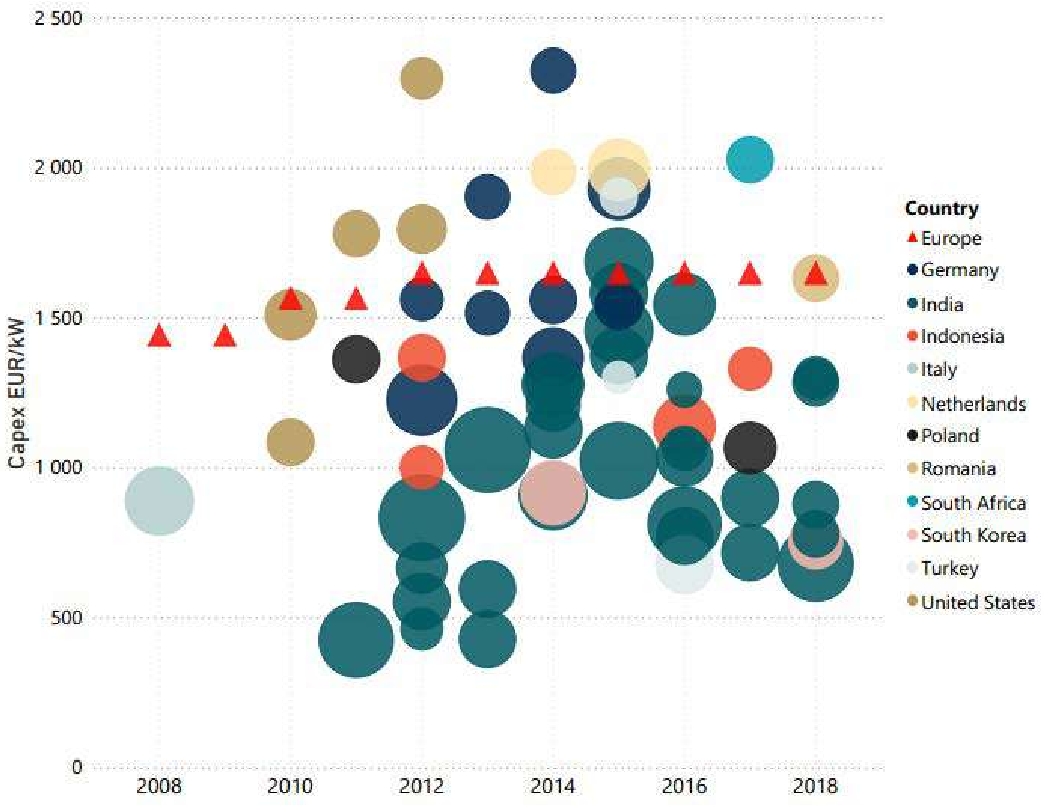


Investment Costs

Because coal-fired power generation projects in Europe between 2008 and 2018 were scarce, we decided to represent investment costs by project instead of a national average per country as what was done for RES. Below are the investment costs of projects commissioned in selected countries in the period. For IRR calculations, some estimations were made using IEA's WEO publications and national sources when project specific CAPEX levels were not available.

A preliminary analysis shows no direct relation between the project's installed capacity and its CAPEX. It is possible to observe, however, that larger power plants (1 320-2 000 MW, and > 2 000 MW) stand in the lower spectrum of the graph with costs ranging from 500 €/kW to 1 500 €/kW.

Figure 5-47 Investment costs of supercritical coal-fired power plants in selected countries **(Enerdata's PPT)** - I.



Notes: Projects (Except for "Europe") range from <600 MW, 600-1 300 MW, 1 320-2 000 MW, > 2 000 MW

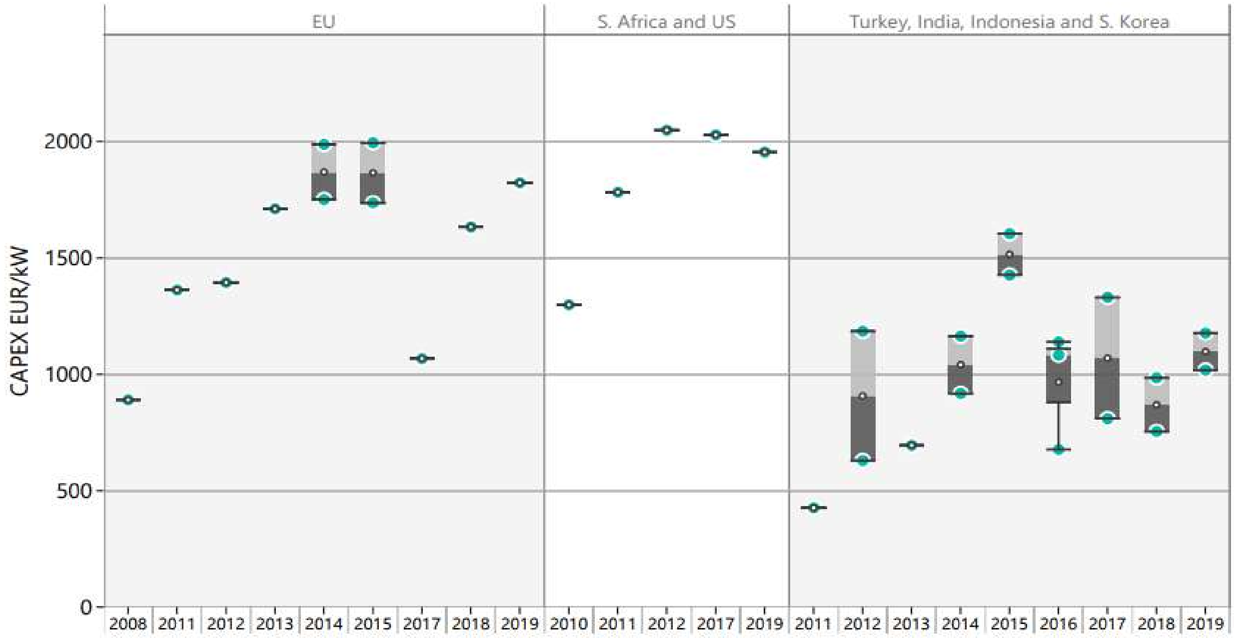
When dividing costs by region it becomes clearer that developed regions/countries such as the EU and the US present higher investment costs for the technology. South Africa's first 800 MW Kusile power unit commissioned in 2017 also presents higher CAPEX levels due to multiple cost overruns, as well as issues during the engineering process and allegedly, corruption. Power plants in Turkey, India and Indonesia have lower CAPEX levels as expected as in those countries the so-called "country specific[147]" costs are due to be lower than in more developed countries.

In South Korea, the 755 MW Bukpyeong power plant (commissioned in 2018) and the 918 MW Yeongheung plant (2014) present costs more in line with those registered in Turkey, India and Indonesia. Multiple factors may explain this observation. First, if we analyse the minimum wages in South Korea, those are considerably lower than the EU average. According to data from trading economics[148] the minimum wage in South Korean in 2018 was 7 530 KRW/hour (5.35 €/hour). Meanwhile Eurostat (2017) data shows that minimum wages in stood at 8.84 €/hour in Germany, in Ireland is 9.25 €/hour, and in France 9.76 €/hour[149], i.e. much higher than the value seen in South Korea. A second factor that could explain low coal-fired CAPEX in South Korea is the difference in subsidies applied to the technology. South Korea has 31% of its power mix composed of coal and, despite attempts to diversify, the energy source remains key. While European countries seem to move away from coal, support schemes and subsidies for this energy are likely decreasing for a while now. In South Korea, this is not the case yet.

[147] Here we consider costs related to design, installation, potential grid connection and all costs that have some human labour involved.
[148] https://tradingeconomics.com/south-korea/minimum-wages
[149] For reference purposes the minimum wage in the US is US$7.25/hour (€6.14/hour).

The graph below shows CAPEX levels divided into main groups of countries. Despite differences in range, a clear upward trend is witnessed in all datasets.

Figure 5-48 Investment costs of supercritical coal-fired power plants in selected countries (Enerdata's PPT) - II.



Notes: Box and whisker graphs showcase the minimum and maximum (whiskers) values of CAPEX for the group of countries in a given year. The grey boxes represent second and third quartiles and blue dots represent the datapoints that built the box. Grey dots represent the average between datapoints.

LCOEs

Using the LCOE calculation method, the differences highlighted in the Investment costs section become much more evident. Beyond that, assumptions regarding fuel, carbon costs and load factors until 2050/2060 also have a great impact on results. For this reason, European countries show coal-fired LCOE's in the higher spectrum of the graph above 80 €/MWh mostly due to high carbon costs. The same is observed for lignite-fired power plants which are more expensive to operate in Europe (above 70 €/MWh). For Coal-fired power plant, Germany and Poland present clear increases in costs, this is explained by the projections in load factors. In both countries this variable decreases considerably until 2050/2060, i.e. these plants are estimated to run less than 50 hours/year by 2050/2060.

Figure 5-49 LCOE of Supercritical coal-fired power plants in selected countries

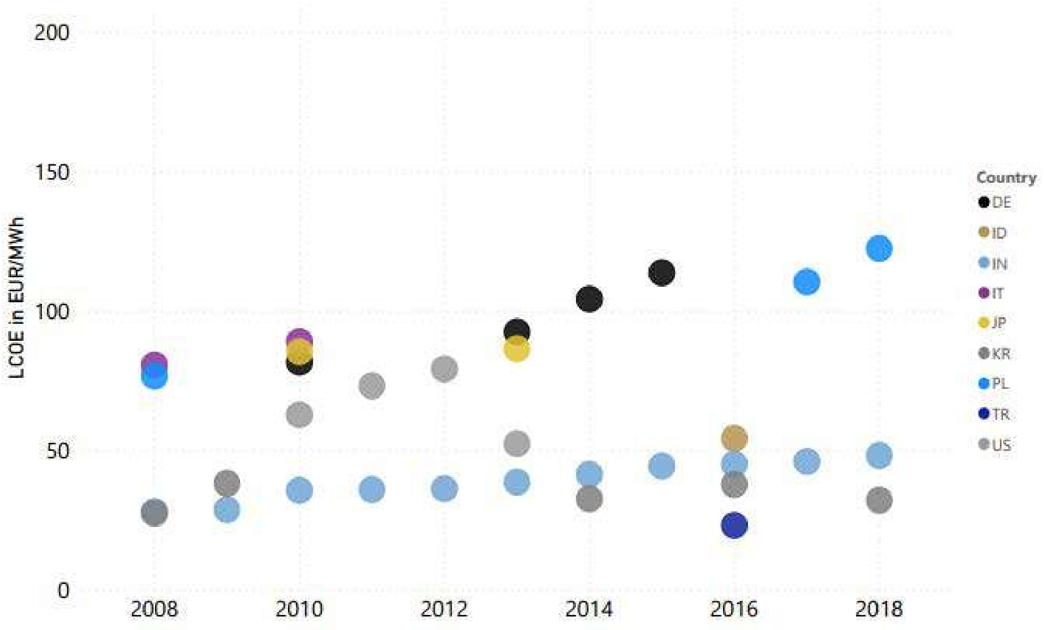
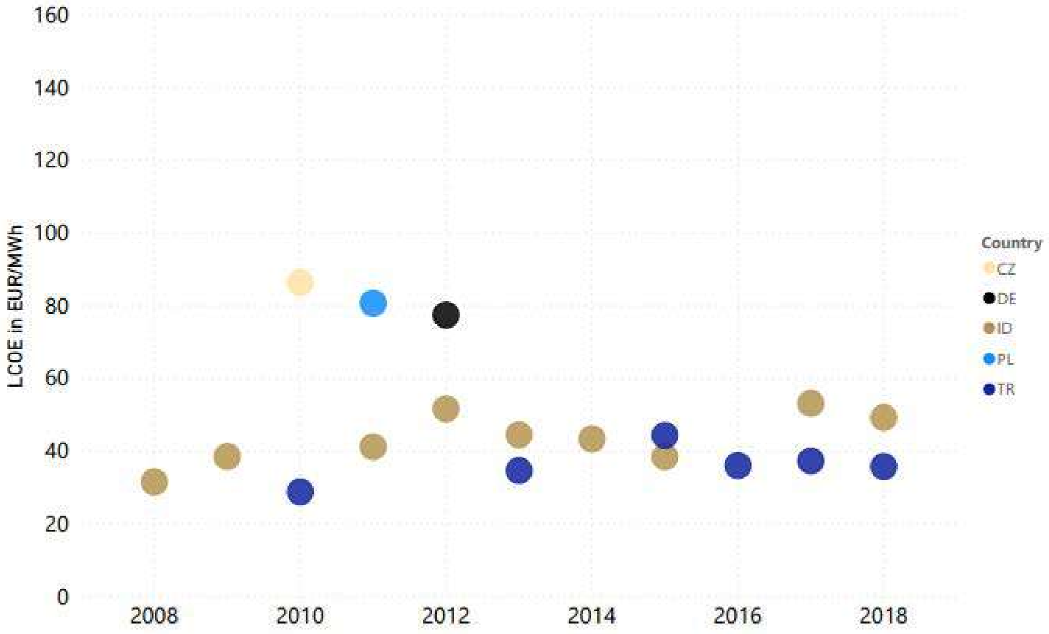


Figure 5-50 LCOE of Supercritical lignite-fired power plants in selected countries



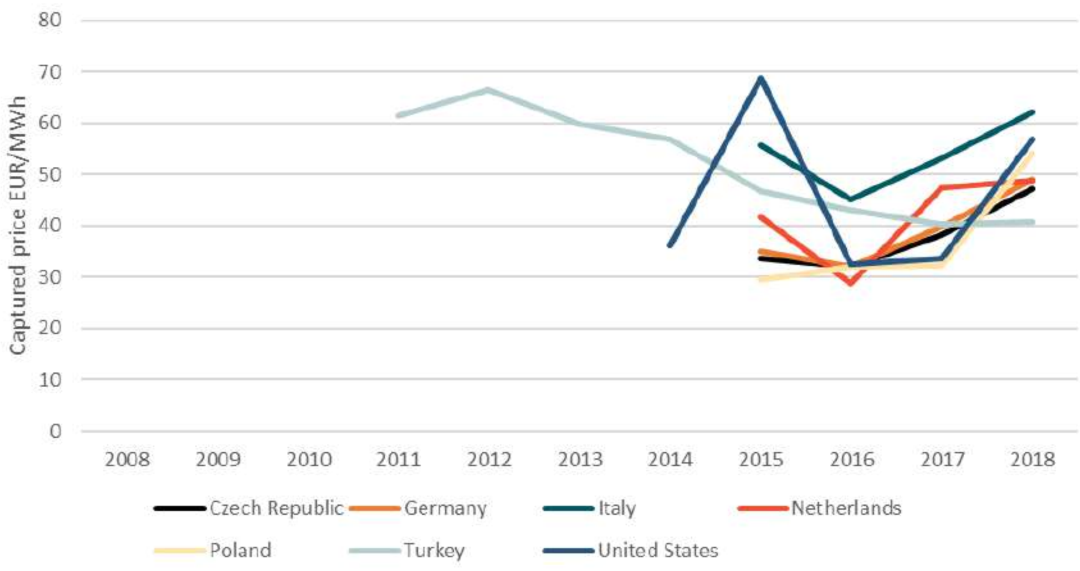
Revenues

Revenues for coal-fired power generation come from energy sales and the provision of system services (or ancillary services). The average mark-up on electricity market revenue varies from 5-15% (see section "Revenues from system services" for more details). For the profitability analysis, we assume that conventional power producers generate additional 7% mark-up on average wholesale prices (based on the ACER report).

Source: Study on energy prices, costs and their impact on industry and households

Revenue for coal-fired power plants seem to have increased in recent years in the European countries most likely due to the intervention of such power plants only in times of higher demand. In Turkey, the opposite trend is true as the country continues to develop coal power plants for baseload generation.

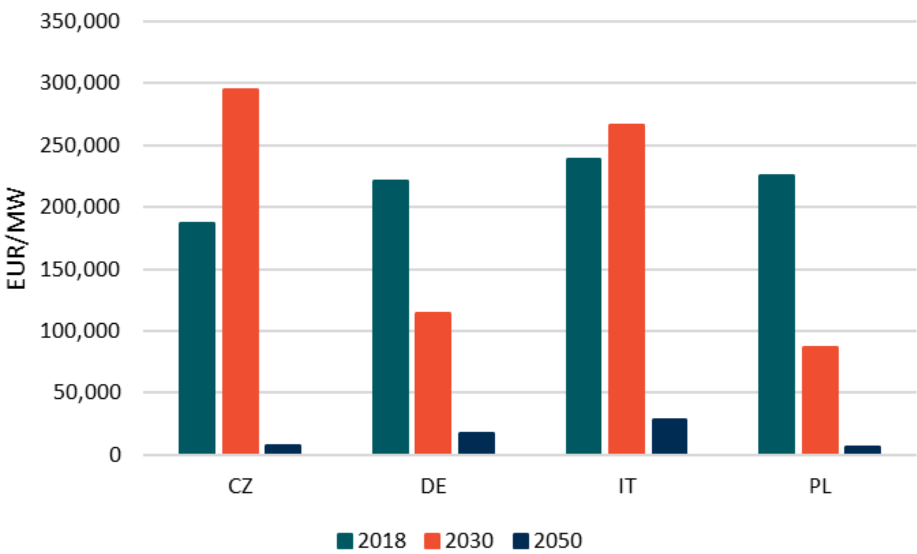
Figure 5-51 Realised price for coal-fired power per country



Realised prices collected on the historical period and shown in the graph above increase for most EU countries at the end of the period due to increasing average market price.

Thanks to 2030 and 2050 the Baseline scenario (METIS) data it is possible to extract projected realised prices and load factors to get the variations in revenues. As shown in the graph below, projected revenues per installed MW are dropping in 2050 with load factors below 25 hours/year in Poland and Czech republic for instance.

Figure 5-52 Revenue for coal-fired power by installed MW



Profitability

With projections being based on highly decarbonised scenarios thermal technologies are penalised and costs are strongly boosted upwards. High carbon costs and fuel costs grant coal-fired power plants very low IRR rates. In European countries the projections in load factor tend to utilization rates below 50 hours/year in 2050. This effect is partially offset with realised price increasing as coal power plants tend to run in few peak hours .

However, conditions indicate that not all the power plants recently commissioned would be economically viable in the next decades. It could be likely that only a few plants would be kept ensuring supply when RES cannot in countries that have not committed to a full coal phase-out yet..

IRRs can be estimated for a few plants in Italy, Germany, Czech Rep and Turkey as shown in the graphs below

Figure 5-53 IRR estimates for coal-fired power plants.

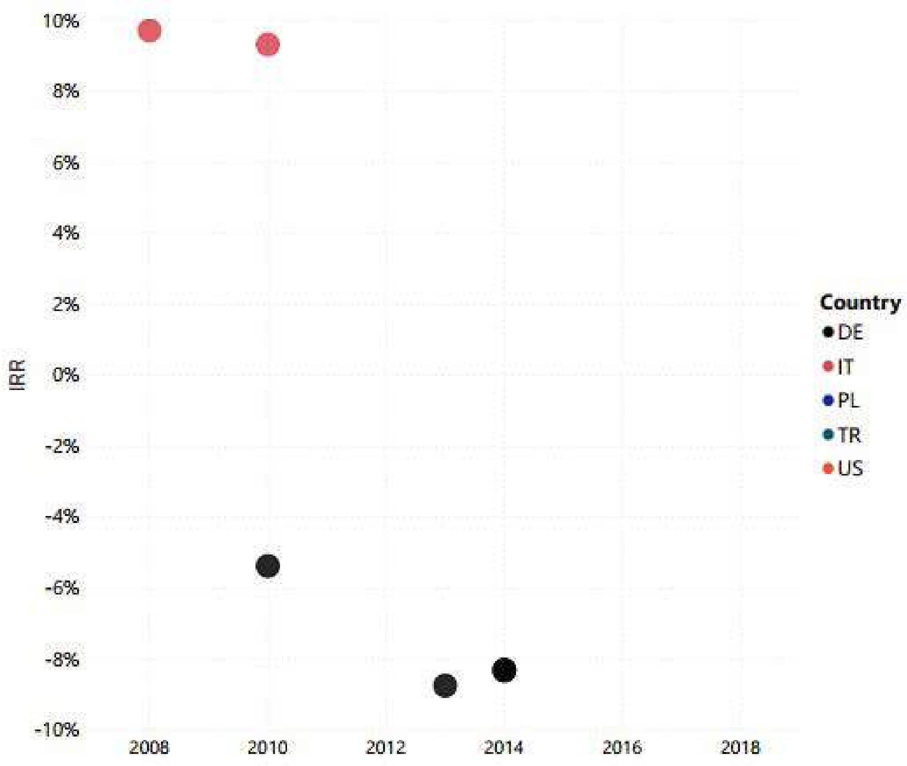
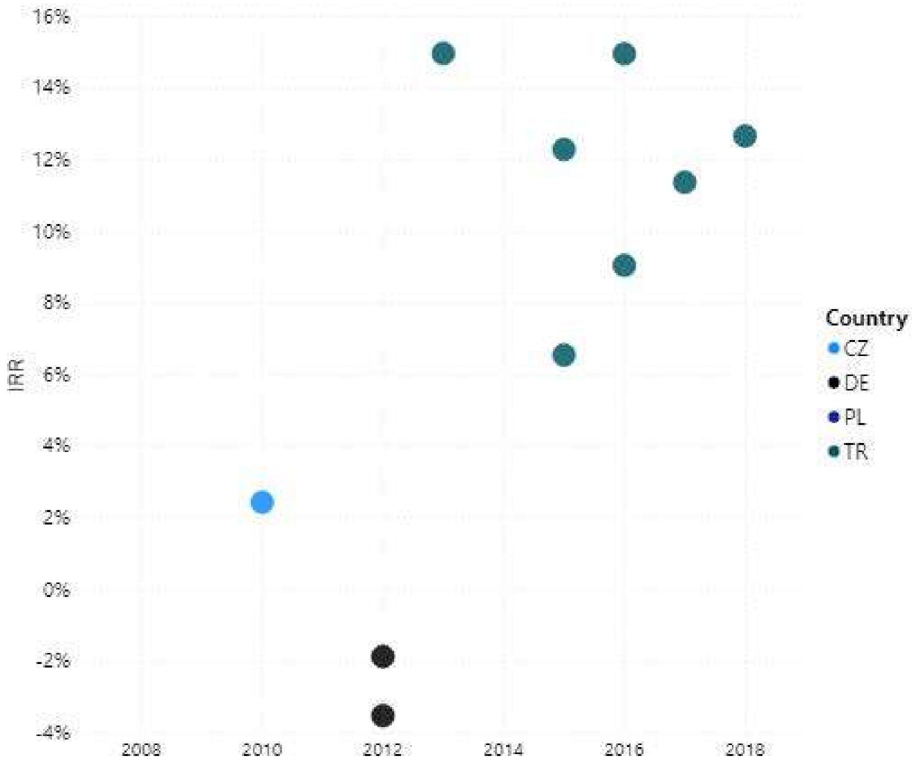


Figure 5-54 IRR estimates for lignite-fired power plants.

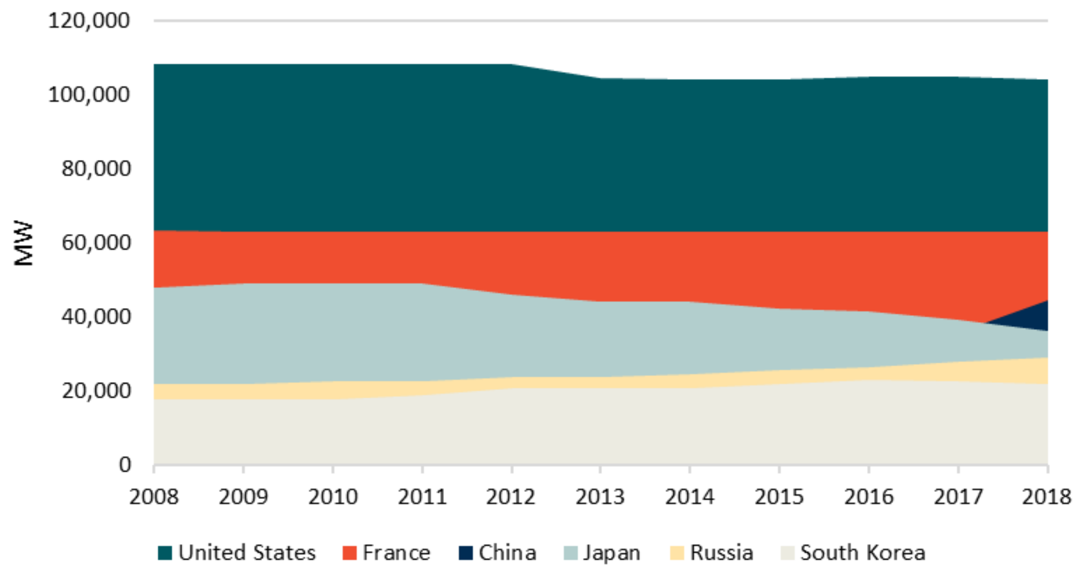


Nuclear

Nuclear power is a mature technology as first civil nuclear power plants (NPPs) were built shortly after World War II by the major economic powers: the Soviet Union in 1954, France and the UK in 1956 and in the USA in 1957 in the first instance. Technology developed at a rapid pace between 1960 and late 1970s, to reach around 150 installed nuclear power plants in 1980. But nuclear industry underwent a stagnation period until the new millennium, notably impacted by the aftermath of the Three Mile Island and Chernobyl nuclear accidents in 1979 and 1986 respectively during the 80s and 90s decades. In the new century, the increase in worldwide electricity demand, notably driven by fastly developing countries combined with the availability of new generation nuclear power reactors (e.g. EPR) reactivated the industry.

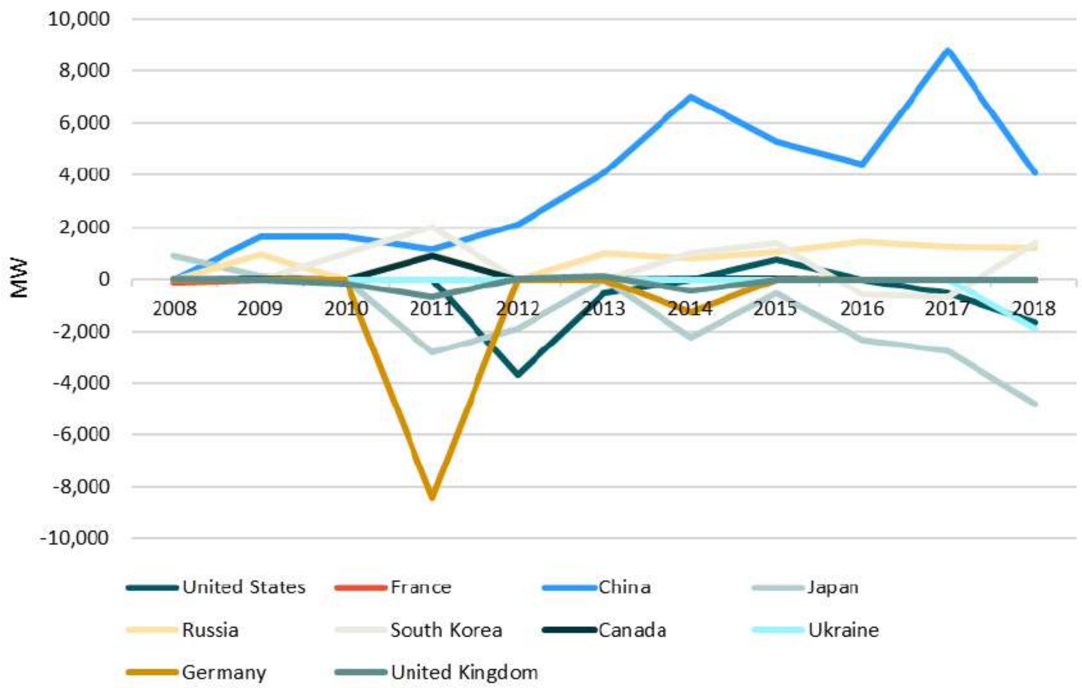
As shown below, the USA still dominates the nuclear branch with over 104 GW installed capacities end of 2018, followed by France (63 GW), China (49 GW), Japan (32 GW), Russia (30 GW) and South Korea (23 GW). As of 2019, only 31 countries worldwide produce nuclear power thanks to over 400 GW installed capacities.

Figure 5-55 Countries with the highest nuclear installed capacities 2008-2018



Over the past 2008-2018 period, China stood up from its nuclear peers with the cumulated commissioning of 40 GW nuclear power plants on its own, while immediate post-Fukushima decisions led Japan and Germany to decommission several reactors. Out of the 17 reactors, Germany immediately shut down 8 reactors in 2011 in line with its reintroduced nuclear energy phase-out policy. Other countries have not followed the German denuclearization path. As of 2019, about 55 GW of new NPPs are under construction, of which 11 GW in China. In the USA, 2 x 1.1 GW Pressurized Water Reactor (PWR) units are being built. In Europe, Hinkley Point (UK), Flamanville (France), Khmelnitski (Ukraine) and Olkiluoto (Finland) NPPs are under development.

Figure 5-56 Countries with the highest nuclear added/withdrawn capacities 2008-2018



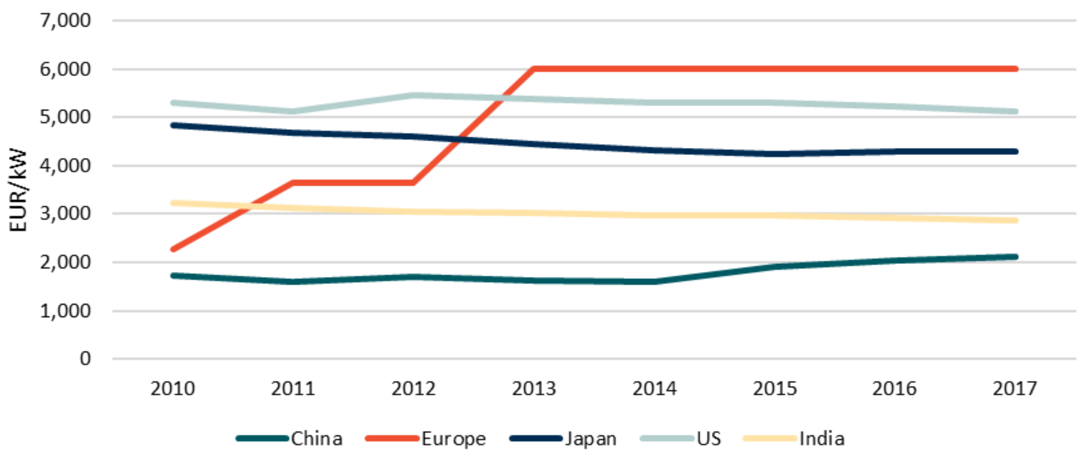
Costs

Investment Costs & LCOEs

Nuclear power over the lifetime of the project can be measured with the Levelized Cost of Electricity (LCOE). As nuclear sector is a very capital-intensive industry, CAPEX levels are key determinants of the technology LCOE. Nuclear CAPEX or investments costs often include the overnight costs (i.e. construction + engineering costs) and the financing costs (i.e. interest accrued during construction). Total nuclear power plant project costs thus comprise investment costs, O&M costs, plus the nuclear fuel cycle costs (including the recycling of used fuel) and the decommissioning & dismantling (D&D) costs occurred at the end of the plant life time. As the LCOE is based on discounted costs and NPP lifetime is long (e.g. over 60 years), discounted D&D costs contribute little to the NPP's LCOE in comparison with CAPEX and O&M costs.

As shown in the graph below, historical CAPEX for the nuclear sector remain high and stable over the 2008-2018 period with distinct levels between countries and regions. According to EC's PRIMES model data, Europe reports the highest CAPEX levels at around 6000 €/kW, notably marked by post-Fukushima safety equipment costs from 2012. The USA and Japan report intermediate CAPEX levels while Indian and Chinese nuclear CAPEX stand at the lowest levels, around 3000 €/kW and 2000 €/kW respectively.

Figure 5-57 Nuclear power plant CAPEX

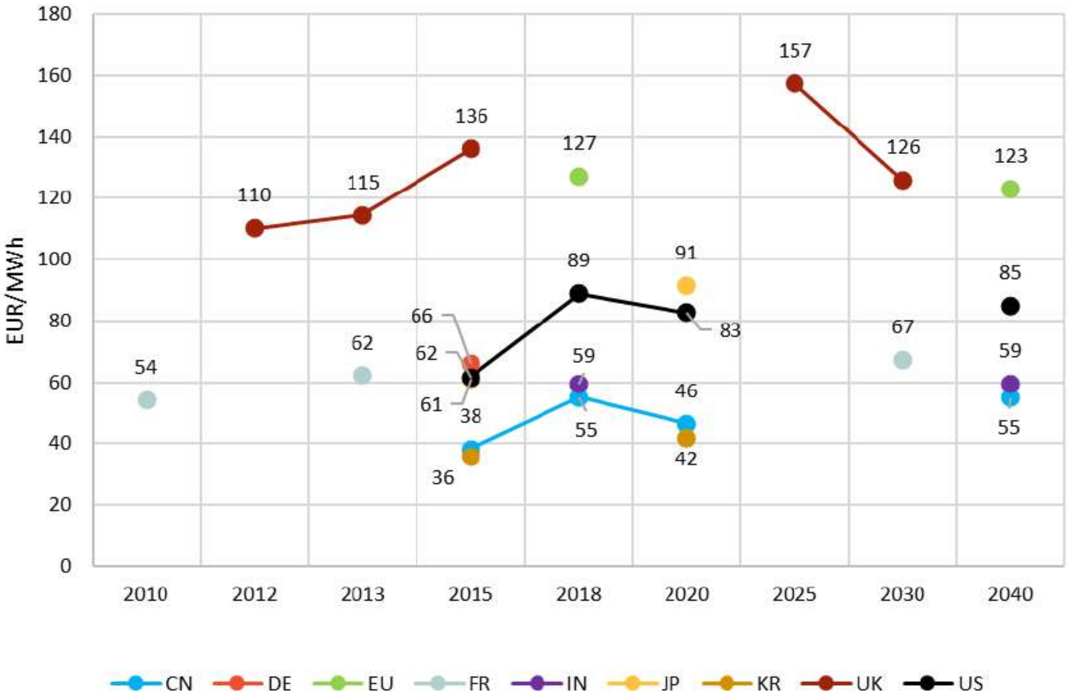


Source: EC's 2018 ASSET study for Europe, IEA WEO's publications for non-Europe

When studying historical and projected LCOEs collected from international (e.g. IEA, NEA-OECD) and national (e.g. French Court of Auditors, etc.) sources, we observe an overall increase in nuclear costs over the 2010-2018 period, notably caused by post-Fukushima safety upgrading measures. Projected 2020 and long-term LCOEs does not anticipate a cost decrease neither as new generation IV reactors may require significant CAPEX.

Europe, the USA and Japan report the highest LCOES while South Korea, China and India register LCOEs below €60/MWh.

Figure 5-58 LCOEs of Nuclear Power Plants in selected countries



Source: IEA WEO's publications, IEA/NEA-OECD Projected Electricity Cost Generation 2010 & 2015, National sources

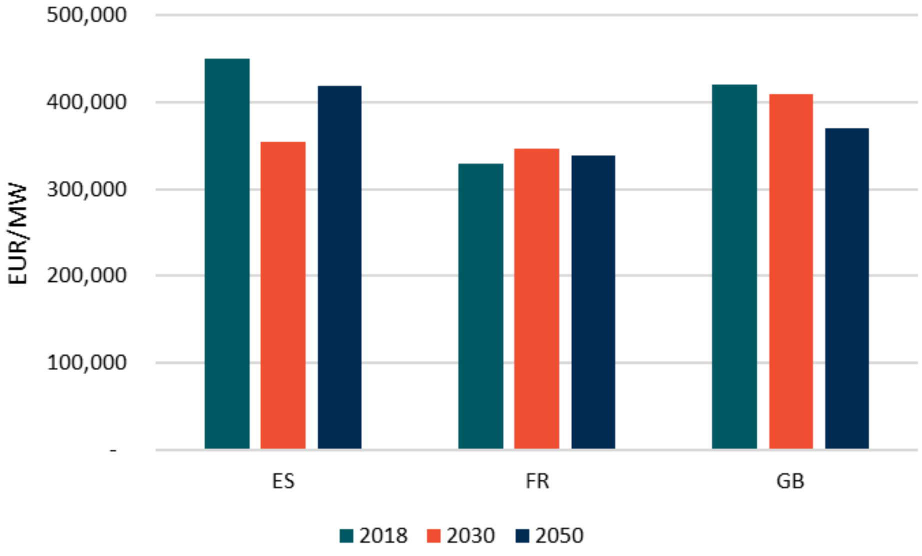
Revenues

Revenues for nuclear power generation come from energy sales and the provision of system services (or ancillary services). The average mark-up on electricity market revenue varies from 5-15% (see section "Revenues from system services" for more details)

Thanks to 2030 and 2050 realised prices from the Baseline scenario (METIS) for Spain, France and the United Kingdom, we can observe first that the nuclear power market value (i.e. ratio of the realised price over the average market price) slightly vary upwards from 100% in 2018 to 105-110% in 2030 and 2050. Overall the realised price remains relatively close to the market price and revenues are expected to vary with market price and load factor.

As shown in the graph below, projected revenues per installed MW would remain stable in France in 2030 and 2050. In the UK, we may project an equivalent level between 2018 and 2030 before a slight decrease in revenues for 2050 (around -10%) caused by a similar decrease in 2050 average market price. In Spain, revenues would decline in 2030 before increasing in 2050, but standing below the 2018's initial level. These variations may be driven by the combined variations of the projected average market price and load factor that follow an identical trend.

Figure 5-59 Projected revenues (EUR/MW) in selected countries according to the Baseline Scenario (METIS)



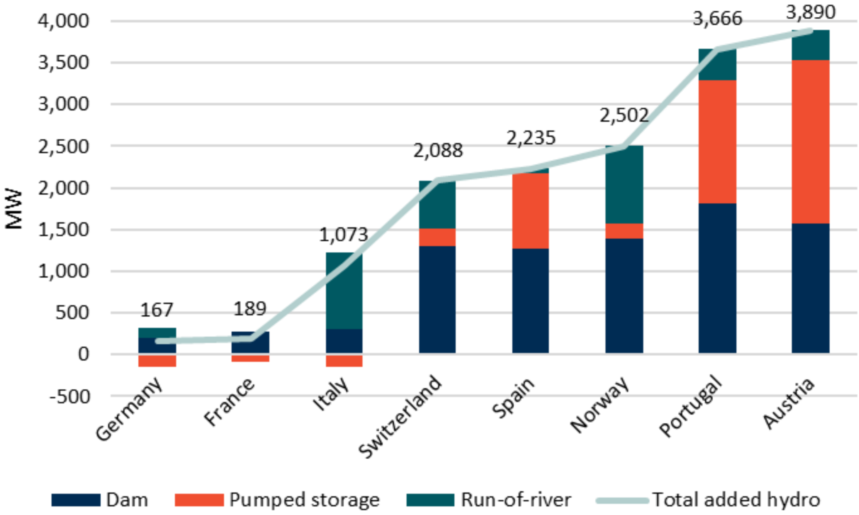
Profitability

As too few nuclear power plants were commissioned over the 2008-2018 period (e.g. none in Europe), data availability for both market revenues and cost over the same time period is a major obstacle preventing from computing the IRR.

Hydro

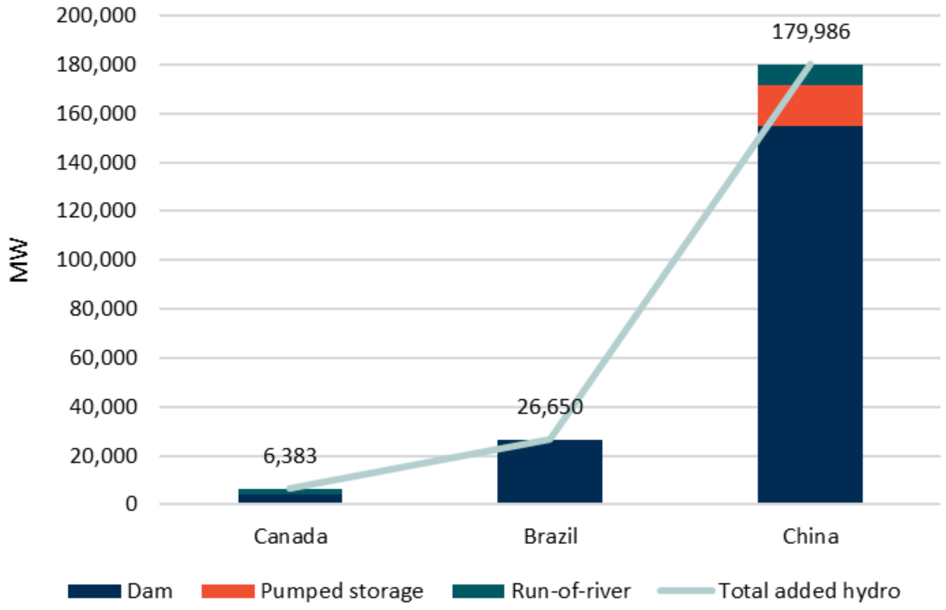
Hydropower is among the most mature technologies and, in Europe most of the installed capacity, was developed prior to 2008. Significant developments, however were registered in Austria which added 3.9 GW of hydropower capacity between 2008-2018 (1.9 GW of which was pumped storage), while Portugal added 3.7 GW (1.5 GW of pumped storage) and Norway added 2.5 GW (934 MW of pumped storage). If we disregard the development of pumped storage, most countries (except Italy, Norway, and Switzerland) have developed dams rather than run of river facilities.

Figure 5-60 EU countries with the highest hydropower added capacities 2008-2018 (by technology).



Outside the EU the main countries which developed hydropower capacities were China (180 GW), Brazil (26.6 GW) and Canada (6.4 GW). In all countries, the development of dams is greater, with China and Canada registering some addition of pumped storage (16.5 GW and 150 MW respectively) and run of river (8.7 GW and 2 GW respectively).

Figure 5-61 Other countries with the highest hydropower added capacities 2008-2018 (by technology).



Specific assumptions

Installed added capacity of hydropower plants were estimated using data from Enerdata's Global Energy and CO_2 database.

Load factor in projection for a given year of commissioning is estimated as the observed average load factor between 2008-2018 and derived from Eurostat (EU) and Enerdata's Global Energy and CO_2 (outside EU) databases. Projected realised prices and load factors come from the Baseline scenario (METIS).

For this technology IRR evaluations will be presented in detail for the following countries[150]:

- Portugal;
- Germany;
- Austria;
- Switzerland;
- Spain;
- Italy;
- France;
- Norway;
- Brazil.

It accounts for countries where realised prices are available (requiring both hourly power market price and hydro-dam power generation) and with hydro-dam capacities installed on the observed period.

[150] Costs analysis are also provided for China.

Technology coverage

Based on data availability and an analysis of the capacity added structure this study will only cover costs and profitability of dams.

O&M and other variables

In Europe fixed O&M costs and variable O&M rates are considered based on ASSET (2018) and data from IEA's WEO publications from 2009 until 2017. The linear variation of variables between 2009 and 2017 from the WEO publication were applied to 2020 data from ASSET (2018) to generate estimates of variables between 2009 and 2017 based on the PRIMES model. For 2008 and 2018 the closest available rates were used as proxy.

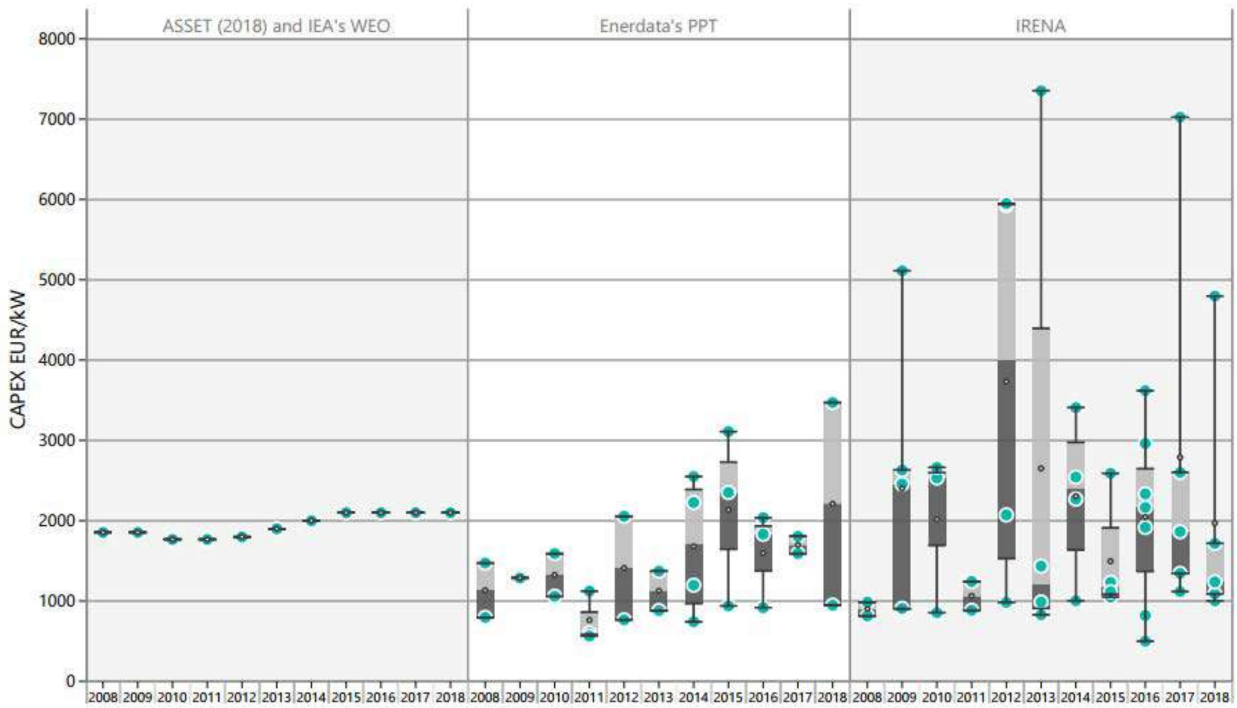
For other countries, fixed O&M costs are provided by IEA's WEO publications while variable O&M costs are considered from ASSET (2018).

Costs

Investment costs

Despite the development of hydropower, reliable data by technology is rather difficult to find. Considering data from IRENA for instance, no technological differentiation is made, and CAPEX levels seem rather high (between 1 000 €/kW and 7 500 €/kW) when compared to data from Enerdata's PPT and IEA's WEO estimates and ASSET (2018). For this reason, data from Enerdata's PPT was preferred for IRR calculations.

Figure 5-62 Comparison of CAPEX from different sources.



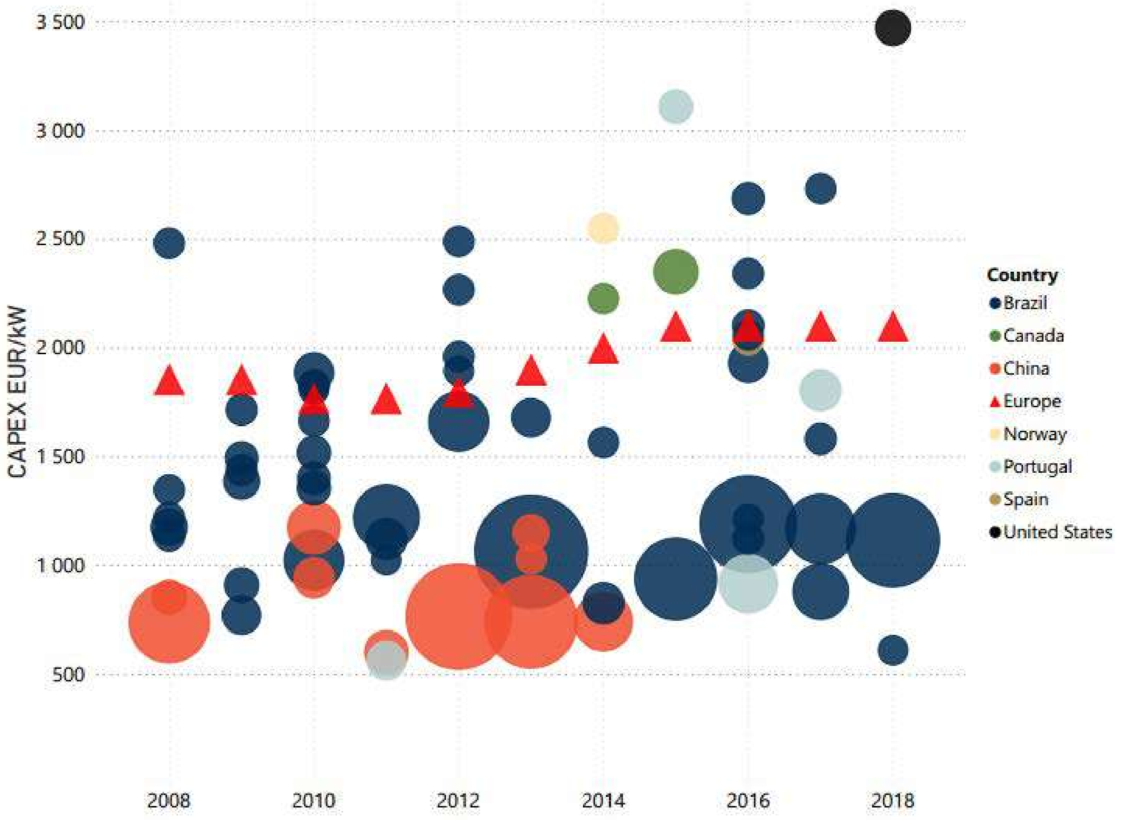
Notes: Enerdata's PPT and ASSET (2018) relate to dams only.

By analysing Enerdata's PPT data a clear inverse relation between project size and CAPEX appears. Furthermore, larger projects (1 000-2 000 MW, and >2 000 MW) were mostly developed in emerging markets (Brazil and China) with CAPEX levels ranging between 500 €/kW and slightly below 1 500 €/kW. Europe commissioned almost exclusively smaller projects (<300 MW) and those had CAPEX levels above

1 500 €/kW in most cases. ASSET (2018) estimates of investment costs for the technology in Europe reflect this trend for developing smaller power plants, hence the higher cost levels throughout the period (around 2 000 €/kW).

A slight increase in overall costs can be observed most likely due to the continuous development of smaller facilities as well as the need to exploit harder terrains as the easiest hydropower exploration sites have already been developed.

Figure 5-63 **Investment costs of dams in selected countries (Enerdata's PPT)**



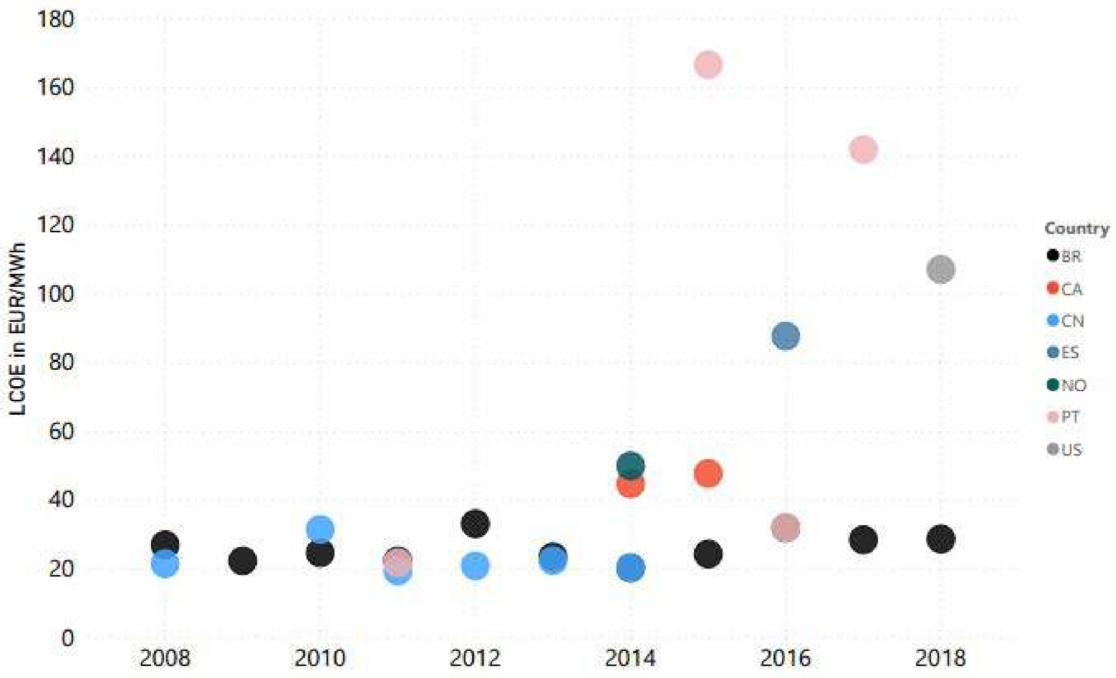
Notes: Projects (Except for "Europe") range from <100 MW, 100-300 MW, 700-1 000 MW, 1 000-2 000 MW, and >2 000 MW

LCOE costs

Using the LCOE calculation method, the differences highlighted in the Investment costs section become much more evident. For this reason, countries which provided CAPEX information for smaller projects for the most part show hydropower (dam) LCOE's in the higher spectrum of the graph above 80 €/MWh. In the case of Brazil and China average costs are driven down by CAPEX's from large scale projects (for more details regarding project size and CAPEX levels see Investment costs section).

Source: Study on energy prices, costs and their impact on industry and households

Figure 5-64 LCOE of Hydropower (Dam) power plants in selected countries

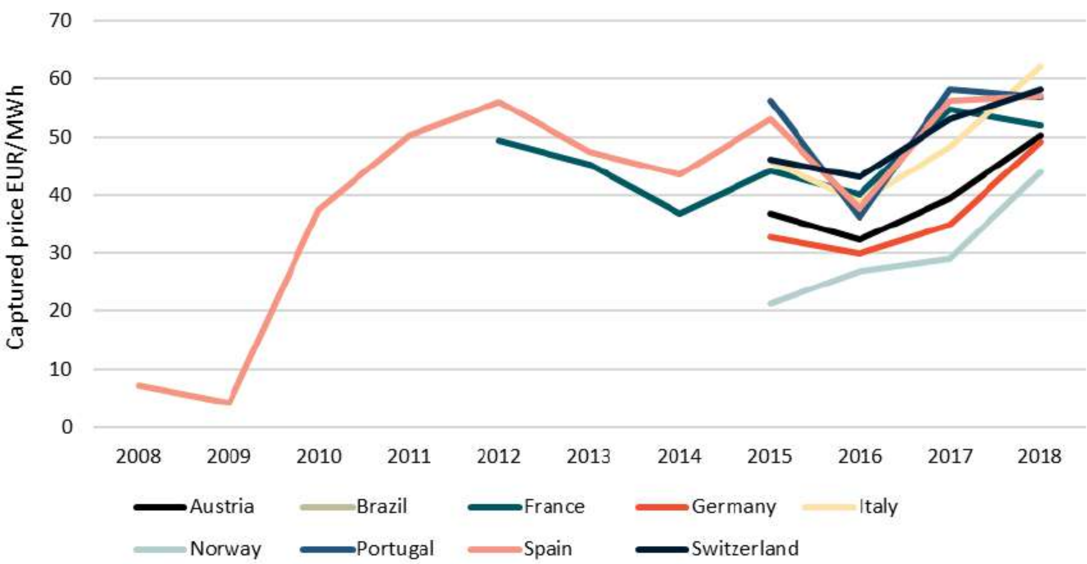


Revenues

Revenues for hydropower power generation come from energy sales and the provision of system services (or ancillary services). The average mark-up on electricity market revenue varies from 5-15% (see section "Revenues from system services" for more details).

In 2018 revenues ranged between 43-62 €/MWh with Brazil registering the lowest rates at 43 €/MWh. In main EU power markets, hydro (dam) benefits from a realised price around 5-15% higher than the average market price.

Figure 5-65 Realised price for dams per country.



Source: Study on energy prices, costs and their impact on industry and households

Profitability

Insufficient data for hydropower plants regarding market revenues and cost over the analysed period does not allow computing IRR figures.

5.3.9 Sensitivity results

The objective of this section is to assess the sensitivity of the annual profitability calculated in the Profitability per technology section to a selection of variables (that constitutes the main drivers of the profitability calculation). The sensitivity analysis focuses on the short term impact of Covid19 outbreak and on the longer term with key drivers. The following sensitivities have been calculated for the EU:

- COVID 19 impact on profitability;
- Impact of key drivers of profitability and potential futures of EU power system:
  - Variants of the Baseline scenarios from METIS:
    - Less flexibility around EV smart charging;
    - Less heat pump penetration in industry;
    - Less hydrogen demand from local production and more imports.
  - Lower CAPEX for renewables to be more in line with recent observed trends;
  - Lower realised price to reflect the 2020 drop in power market price and potential impact of long lasting low prices.

Those sensitivies allow us to test significant changes in both expected revenues and costs of power technologies. It is also possible to assess the impact of potential changes in the structure of power demand and the impact of various level of flexibility required by the EU power system. In a context of massive electrification and penetration of new technologies or energy vector (storage, hydrogen) those sensitivities are helpful to explore and assess long term uncertainties in the EU power system.

COVID 19 impact on profitability:

Beyond the sanitary crisis, Covid19 has a deep impact on economic activity due to prophylactic measures, from strict lockdown to travel restrictions, closure or partial activity of businesses and teleworking. The consequences on the energy systems are massive and this especially the case for the power sector.

Covid19 has both an impact on electricity demand and supply. Lockdown in some EU countries has reduced demand significantly, up to 20% in France for the first two weeks of lockdown. On the supply side, as mentioned by Eurelectric[151], social distancing measures are impacting the planned maintenance of power plants which are mostly scheduled in summer months. This delayed maintenance of power plants in winter months could have detrimental effects on System Adequacy, especially in countries with already tight margins and if demand returns to normal levels by winter 20-21. As stated by Eurelectric, the Covid19 crisis has accelerated the lowering trend of power prices appeared at the beginning of the year. As a consequence of the low demand and high share of RES generation, an acceleration of the downward trend of short-term maturity prices (Q2 2020) and an increasing number of negative price hours can be observed.

Regarding the impact on renewables, the recent AURES II's policy brief[152] summarizes the consequences of the crisis on renewable projects:

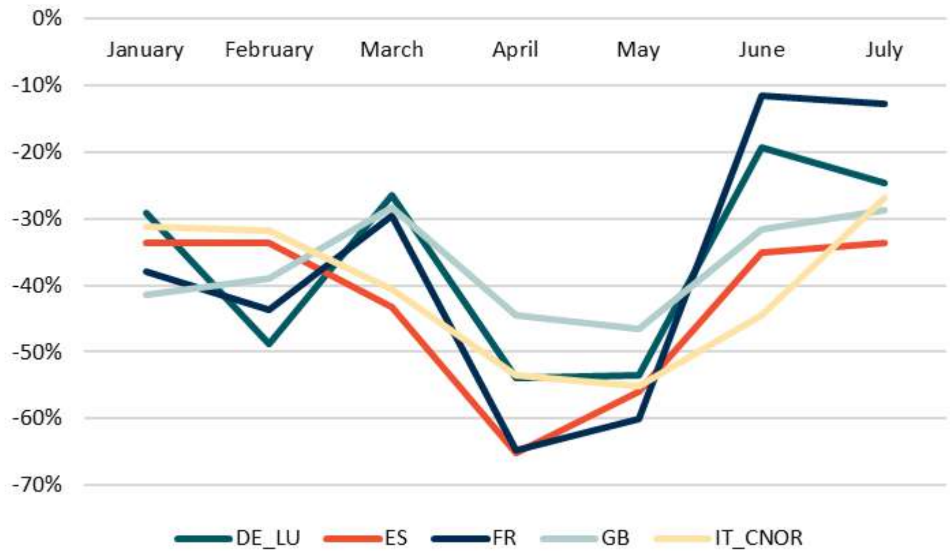
[151] IMPACT OF COVID-19 ON THE ELECTRICITY VALUE CHAIN - Insights from the European power sector
[152] AURES II - Policy Brief, May 2020 Impact of COVID-19 on Renewable Energy Auctions

- RES procurement: Decreased energy demand, resulting in potentially lower short-term demand for RES and potentially more EU Member States meeting their 2020 RES targets without additional policy action;
- RES project delays and auction delays: Disruptions in global supply chains and national permitting procedures might endanger project realization and increase penalties. Several EU Member States have prolonged realization deadlines while others have postponed or cancelled auctions;
- RES finance: Higher RES financing risks through increased country and policy risk;
- Wholesale market risk exposure: Falling wholesale market prices pose significant challenges for projects without market premiums with sufficient floor prices (e.g. merchant plants and plants with low fixed premium).

Given the great uncertainty of COVID19 impact on power sector in the medium and long term, we have rather focused on the short term. More precisely, we have tested a downward variation of realised price for 2020 and 2021 compared to the output of long term projections that does not take into account short term conjunctural effect (of which COVID19). Based on actual observations from the first seven months of 2020 from ENTSO-E we can make the assumption that for the largest EU power markets the variation follows this rough trajectory:

- January-February: around -40% (compared to the same period in 2019), mainly due to low commodity prices and high RES output;
- March-May: -50% with lockdown impact;
- June-July: -30%, mix of COVID19 impact but also commodity prices and RES.

Figure 5-66 Day ahead price variation 2020 vs. 2019 from ENTSO-E



Source: ENTSO-E

We assume that the August-December follows the same trend as post lockdown months (June and July) and in 2021 there is a progressive convergence to the standard baseline price scenario (METIS). Overall, it means a -40% variation on realised price in 2020 and -20% in 2021.

With those COVID impacted prices the IRRs based on market revenues decrease by around 0.2 pp for solar and wind technologies commissioned between 2008 and 2018. In conclusion, if the sanitary crisis only impacts 2020-2021 prices the impact on IRR remains limited. The real uncertainty is the long-term impacts on power system that could lead to more significant impacts on profitability.

Sensitivities on key drivers of profitability:

The objective of the sensitivity analysis is to explore different potential futures for the EU power system but also the impact of key technological parameters on wind and solar profitability.

Major uncertainties impacting costs and market revenues are directly captured by CAPEX levels and realised prices. Both elements present significant variations on the observed historical period (2008-2018) but also in projection. Those two components explain most of the differences in profitability observed for the selected countries.

Another area of uncertainty is the evolution of the power systems in the EU: structure of demand, penetration of new technologies (storage, digitalization), hydrogen developments, structure of power supply and required flexibility. Those potential futures of the EU power systems impact profitability through realised prices and power generation levels. It is essential to use robust modelling scenarios to assess those different trajectories which explains why we use METIS variants from the baseline (which also improves comparability). Several variants are available and we have selected the ones that cover a broad range of impacts on power system:

- Change in overall flexibility with EVnoFlex: less flexibility around EV smart charging compared to baseline which is interesting;
- Change in power demand and electrification level with NoIndusHP: less heat pump penetration in industry compared to baseline;
- Change in hydrogen EU production with LowH2Demand: less hydrogen demand from local production and more imports.

As mentioned previously, the sensitivity analysis uses 3 variants of the Baseline scenarios from METIS but also 2 additional sensitivities on realised price and CAPEX level. The main components of the sensitivity scenarios are described in the table below:

Table 5-15 Sensitivity scenarios description

Sensitivity	Definition	Average market price 2050 variation vs. Baseline	EnR penetration	Flexibility	CAPEX
EVnoFlex	Less flexibility around EV smart charging compared to baseline	Limited, -1% to -6% in largest market	limited impact	Lower daily flexibility from EV is offset by higher electrolysis, exchanges and batteries	No change
NoIndusHP	Less heat pump penetration in industry compared to baseline	Limited, around -2% in largest markets	Higher penetration (around +5%) due to higher electricity demand	Increased conventional flexibility needs	No change

Source: Study on energy prices, costs and their impact on industry and households

Sensitivity	Definition	Average market price 2050 variation vs. Baseline	EnR penetration	Flexibility	CAPEX
LowH2 Demand	Less hydrogen demand from local production and more imports	Limited, -1% to -6% in largest market	Lower (-30%) due to lower hydrogen demand electrication rates	Needs for higher conventional flexibility due to lower hydrogen electrification	No change
LowCAPEX	Lower CAPEX for renewables to be more in line with recent observed trends	No change	No change	na	-20% to reflect potential decrease in coming years
LowPrices	Lower realised price to reflect the 2020 drop in power market price and potential impact of long lasting low prices	-20%, to reflect recent low prices	No change	na	No change

Evolution of EU power system: EVnoFlex-NoIndusHP-LowH2Demand sensitivity analysis

With those three sensitivities it is possible to test key parameters of the future EU power system: flexibility, electricity demand & electrification and hydrogen production.

The three variants from Baseline scenario (METIS) used to perfom the tests result in significant changes in RES penetration or flexibility needs and as described in the table above. However, the impact on market prices is relatively limited with a maximum variation of -6%. This is mainly due to low differentiation between variants and Baseline on key variables:

- Global electricity demand does not change much between scenarios with same assumptions about energy efficiency and high hydrogen demand;
- Same technological assumptions.

Variants extracted from METIS come from the same Baseline and it would be possible to explore a broader range of possible futures with the development of different scenarios rather than sensitivities from a baseline scenario. However, the limited variations in market and realised prices observed in those variants is an interesting result that shows that changes in EV flexibility, heat pump penetration or local hydrogen production might have significant impact on flexibility and EnR penetration without strong impact on prices.

With those variants the main impacts on profitability of solar and wind plants commissioned between 2008 and 2018 come from the revenue part as the cost part remains unchanged. More precisely, the variation in revenue per MW installed in those variants only come from different realised prices as there is no significant changes on load factor. As the realised price has only minor variation in 2050 the overall impact on profitability is very limited at around +0.1 +0.2pp in the IRR for each variant.

Long lasting low market price: LowPrices sensitivity analysis

Just before Covid19 outbreak, electricity prices stood at relatively low level in the EU, with a relatively low electricity demand due lower economic grow and relatively midl weather but also low gas and oil international prices. With the sanitary and economic crisis, electricity wholesale prices have dropped significantly. The rebound expected once the crisis will be over should increase electricity prices.

However some bearish fundamental drivers combined with long term economic consequences of the sanitary crisis could lead to lower electricity prices in the long term compared to what was expected before the crisis.

In this sensitivity the realised price is decreased by 20% to reflect current low market prices (around -40% in 2020 compared to previous years) and potential long-lasting low market prices.

IRR calculations show that such lower realised prices result in a decrease of the IRR by around 2pp - 2.5pp for solar, onshore and offshore wind technologies in main EU markets. Regarding solar PV plants commissioned in 2018, the IRR would turn negative in Spain, France and Italy whereas it is positive in the baseline. Wind offshore plants commissioned in 2018 in Germany would have an IRR turning negative as well. Wind onshore's IRR of major European wind electricity producers would remain positive except for Spain in this sensitivity scenario.

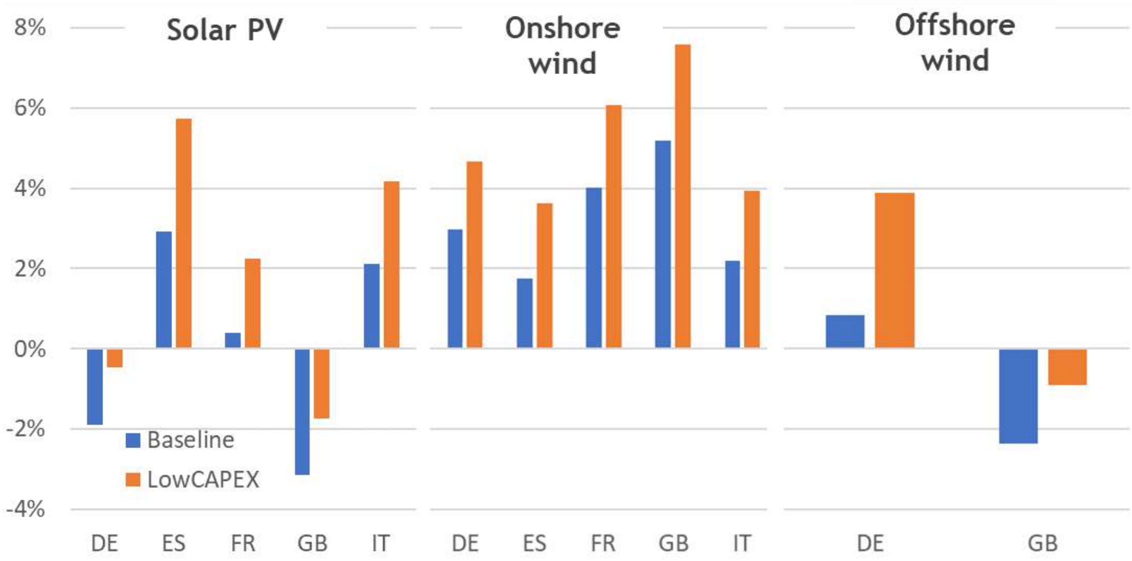
Recent decrease in production costs: LowCAPEX sensitivity analysis

Although this study covers mainly the 2008-2018 time period, it takes into account the recent low production costs observed for Solar PV and Wind technology. Some recent renewable power auctions have been won by relatively low bid. In the "Comparison of LCOE with recent auction results for offshore wind" section we present such low bids and explain why it could be compatible with our investment costs data.
To capture this decreasing trend we have tested the impact of lower CAPEX which could capture directly recent decreasing trends in investment costs or indirectly improvements in technological parameters (capacity factor) or O&M costs.The latest IRENA's Renewable Power Generation Costs in 2019[153] study shows that electricity costs from utility-scale solar PV fell 13% year-on-year in 2019 and by 9% for both onshore and offshore wind. With our -20% CAPEX sensitivity scenario it is possible to test the profitability of solar and wind power plants commissioned around 2020 if the observed trend in 2019 is pursued in 2020.

With a -20% CAPEX cost the first observation is that LCOE is decreased by around 17%. Regarding IRR, the lower costs result in a significant increase of the IRR by around 2pp for solar (+1.5pp - 3pp depending on countries), onshore and offshore wind technologies.

[153] https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019

Figure 5-67 IRR from market revenues for solar PV, onshore and offshore wind



The figure above shows that solar PV IRR remains negative in Germany and the UK. It becomes significantly above zero in countries with higher solar irradiation (Spain, Italy, France) and might be close to be profitable. Offshore wind IRR is significantly above zero in Germany with those lower costs. And onshore wind IRR reaches 4% and more in all countries which might be close to be profitable, depending on the weighted average cost of capital of the investors.

5.3.10 Factsheets

The data and analyses were also used to develop factsheets per country which highlight the main developments in terms of realised prices, profitability and the need for subsidies. Four metrics have been selected for the factsheets:

1. Penetration in power mix (%): an overview of the penetration of the different power generation technologies in the power mix. This provides relevant context for appreciating the developments shown in the other graphs. It shows how significant the penetration of the intermittent renewables is and consequently whether or not it is reasonable to expect a price effect. Additionally, it shows what the overall power mix looks like, which is particularly relevant for understanding the flexibility of the electricity generation sources. A country with a large share of hydroelectricity in its power mix may for instance experience little price erosion for intermittent renewables because the hydro capacities can be used flexibly to balance the supply. A system with large shares of nuclear on the other hand could experience relatively severe price erosion due to the inability to easily switch capacities on and off;
2. Realised price (%): the average sales prices of a specific technology (wind onshore, wind offshore or solar PV) divided by the average wholesale price. This metric is also called the captured price or the value factor and measures how significant the price erosion for the technology is (if any);
3. Effective subsidy level at year of commissioning (EUR/MWh): the effective sales price including subsidies minus the realised price of the technology (wind onshore, wind offshore or solar PV) in the first year of commissioning. Provides an indication of the subsidy need of the technology and thereby provides insight into the net effect of decreasing technology costs and potentially decreasing sales prices. The key insight of this metric is to show if the overall trend towards zero subsidy renewables continues in spite of the price erosion. The metric only

considers the first year of operation to provide a measurement that is more sensititive to the market conditions of that specific year, rather than working with estimated average sales prices for the remaining lifetime of the installation;

4. Estimated profitability without support (IRR - %): the internal rate of return of the technology (wind onshore, wind offshore or solar PV) per year of commissioning. Provides insight in the profitability of the technology over its full lifetime. Values should be compared against IRR thresholds (hurdle rates) used by investors for understanding if the technology would be considered a profitable investment without subsidies. In other words: an IRR higher than 0% does not mean that the technology does not require subsidies anymore.

The country factsheets are available in a separate Excel file. For the countries with sufficient data to properly evaluate trends in realised prices and profitability, a copy has been added to Annex H.

Annex A - Task 1 Data sources and detailed analytical tables

This annex contains the results of the energy costs decomposition analysis of the various fuels and prices as presented in Task 1

Price change decomposition tables

Wholesale electricity prices

Table A-1 Comparison of changes in wholesale electricity prices differential compared to the EU average price, constant 2018 euro per MWh

Country	Start price [EUR2018]	End price [EUR2018]	Change EUR	Change %	Start Gap [EUR]	End Gap [EUR]	Difference [EUR]	Relative for EU
EU27	72.16	36.54	-35.61	-49.4%				
Argentina	80.78	69.06	-11.73	-14.5%	8.63	32.51	23.89	Positive
Australia	42.42	46.17	3.76	8.9%	-29.74	9.63	39.37	Positive
Brazil	227.44	51.20	-176.24	-77.5%	155.29	14.66	-140.63	Negative
Canada	31.58	14.04	-17.54	-55.5%	-40.57	-22.50	18.07	Positive
China	111.04	80.88	-30.16	-27.2%	38.89	44.34	5.45	Positive
India	154.40	34.81	-119.59	-77.5%	82.24	-1.73	-83.97	Negative
Indonesia	65.76	65.96	0.20	0.3%	-6.40	29.42	35.81	Positive
Japan	107.66	63.06	-44.60	-41.4%	35.51	26.51	-8.99	Negative
Mexico	91.94	71.75	-20.19	-22.0%	19.79	35.21	15.43	Positive
Russia	19.82	15.99	-3.83	-19.3%	-52.34	-20.56	31.78	Positive
Saudi Arabia								
South Africa	57.97	70.50	12.54	21.6%	-14.19	33.96	48.15	Positive
South Korea	97.12	64.58	-32.54	-33.5%	24.97	28.04	3.07	Positive
Turkey	48.53	43.90	-4.63	-9.5%	-23.62	7.36	30.98	Positive
USA	75.61	29.74	-45.87	-60.7%	3.45	-6.81	-10.26	Negative

Source: own calculations.
Note: a positive impact for the EU is recorded if the price gap has improved over time, e.g. that if a country had lower prices initially the gap is now smaller or prices are higher than the EU average, or if a country had higher prices, that the gap has increased. A negative impact is recorded if a country had lower prices than the EU, and that the gap has now increased, or if the country had higher prices than the EU but this gap has narrowed or the country now has lower prices.

Table A-2 Factors in observed wholesale electricity price changes per country, nominal prices, EUR per MWh

Country	Start date	End date	Nominal Start price EUR	Change due to inflation [EUR]	Change due to price change in national currency [EUR]	Exchange rate effect [EUR]	Total change [EUR]	Nominal End price EUR	Change due to inflation [%]	Change due to real price change in national currency [%]	Exchange rate effect [%]	Total change [%]
EU27	2008-1	2019-12	64.94	8.00	-35.77	0.00	-27.76	37.18	12.3%	-55.1%	0.0%	-42.8%
Argentina	2008-4	2013-12	51.67	54.90	-6.85	-44.93	3.12	54.79	106.3%	-13.3%	-87.0%	6.0%
Australia	2008-3	2019-12	32.81	7.24	4.29	1.67	13.20	46.02	22.1%	13.1%	5.1%	40.2%
Brazil	2008-1	2019-12	191.97	139.25	-244.16	-37.31	-142.22	49.74	72.5%	-127.2%	-19.4%	-74.1%
Canada	2008-1	2019-12	28.60	4.29	-18.15	0.22	-13.64	14.96	15.0%	-63.5%	0.8%	-47.7%
China	2008-1	2019-12	61.93	19.15	-20.09	22.37	21.43	83.36	30.9%	-32.4%	36.1%	34.6%
India	2008-6	2019-12	107.79	65.99	-129.82	-6.97	-70.80	36.98	61.2%	-120.4%	-6.5%	-65.7%
Indonesia	2008-12	2019-12	40.72	25.87	8.74	-1.41	33.20	73.91	63.5%	21.5%	-3.5%	81.5%
Japan	2008-1	2019-12	89.82	-1.35	-36.68	15.99	-22.04	67.77	-1.5%	-40.8%	17.8%	-24.5%
Mexico	2010-1	2019-1	84.07	31.47	-28.10	-14.44	-11.07	73.00	37.4%	-33.4%	-17.2%	-13.2%
Russia	2008-1	2019-12	13.56	13.49	9.19	-17.58	5.10	18.66	99.5%	67.8%	-129.6%	37.6%
Saudi Arabia	No data											
South Africa	2015-4	2019-12	60.21	8.58	26.31	-18.32	16.57	76.78	14.3%	43.7%	-30.4%	27.5%
South Korea	2008-1	2019-12	76.31	13.79	-29.43	3.78	-11.86	64.45	18.1%	-38.6%	5.0%	-15.5%
Turkey	2011-12	2019-12	60.80	40.77	16.70	-73.47	-16.00	44.80	67.1%	27.5%	-120.8%	-26.3%
USA	2008-1	2019-12	51.75	9.58	-36.88	7.93	-19.37	32.39	18.5%	-71.3%	15.3%	-37.4%

Source: own calculations.

Explanation: this table shows the different components of the observed nominal price change, decomposed into inflation, price change and exchange rate effects. By summing the components between the Nominal start price EUR and Total change [EUR] the total change can be calculated, this corresponds to the difference between the Nominal Start price EUR and the Nominal End price EUR. For example, in the USA, prices started at EUR 51.75 in 2008 (USD 76.17), over the period prices increased by EUR 9.58 due to inflation (of 18.5%), whilst over the same period prices in national currency decreased by EUR 36.88 (-71.3%). Finally, due to an appreciation in the value of the USD compared to the EUR, the EUR denominated price increased by a further EUR 7.93, leading to a total change of EUR -19.37 between Jan-2008 and Dec-2019, a change of -37.4%. This is constructed from 51.75 (nominal start price) + 9.58 (inflation) - 36.88 (national price effect) + 7.93 (exchange rate effect) = 32.39 (nominal end price)

Note: This table presents nominal prices, differences can be observed with the previous table which used constant prices, the start prices differ due to application of the currency deflator for the constant price calculation. Whilst the end prices differ as we deflate to a particular year (2018) using an annual average exchange rate, as opposed to the monthly average exchange rate used for the nominal price calculation. This can result in small differences, for example in the USA in 2019-12(Dec) the nominal price of USD 35.99 / MWh is recorded, using the nominal approach the exchange rate for 2019-12 of 1.1113 USD=1 EUR was applied, resulting in the price of EUR 32.39 / MWh, whilst for the constant price approach the average annual exchange rate for 2019 as a whole, of 1.1196 USD=1 EUR was applied, in addition to a deflator for 2019, resulting in a price of EUR 29.74, both are correct in the context of their approach, but the difference in monthly and annual average exchange rates leads to these differences in EUR terms. This difference is typically less than +/- 5% of the price.

Household electricity prices

Table A-3 Changes in retail household electricity prices compared to EU prices, constant 2018 EUR/MWh

Country	Start price [EUR2018]	End price [EUR2018]	Change EUR	Change %	Start Gap [EUR]	End Gap [EUR]	Difference [EUR]	Relative for EU
EU27	172.93	207.99	35.06	20.3%				
Argentina	12.00	35.40	23.40	195.0%	-160.93	-172.59	-11.66	Negative
Australia	276.04	191.74	-84.30	-30.5%	103.10	-16.25	-119.35	Negative
Brazil	216.80	199.02	-17.79	-8.2%	43.87	-8.97	-52.84	Negative
Canada	89.64	92.94	3.31	3.7%	-83.30	-115.04	-31.75	Negative
China	87.49	64.71	-22.78	-26.0%	-85.44	-143.28	-57.84	Negative
India	53.38	57.36	3.97	7.4%	-119.55	-150.63	-31.08	Negative
Indonesia	62.16	65.61	3.45	5.6%	-110.77	-142.37	-31.60	Negative
Japan	214.73	202.24	-12.49	-5.8%	41.80	-5.74	-47.54	Negative
Mexico	95.35	53.25	-42.10	-44.2%	-77.59	-154.74	-77.16	Negative
Russia	57.71	45.11	-12.60	-21.8%	-115.22	-162.88	-47.66	Negative
Saudi Arabia	13.22	22.57	9.35	70.7%	-159.71	-185.42	-25.71	Negative
South Africa	58.12	85.55	27.43	47.2%	-114.81	-122.43	-7.63	Negative
South Korea	72.28	87.92	15.65	21.6%	-100.66	-120.06	-19.41	Negative
Turkey	110.86	109.84	-1.02	-0.9%	-62.07	-98.15	-36.08	Negative
USA	100.65	107.74	7.09	7.0%	-72.28	-100.24	-27.97	Negative

Source: own calculations.

Note: a positive impact for the EU is recorded if the price gap has improved over time, e.g. that if a country had lower prices initially the gap is now smaller or prices are higher than the EU average, or if a country had higher prices that the gap has increased. A negative impact is recorded if a country had lower prices than the EU, and that the gap has now increased, or if the country had higher prices than the EU but this gap has narrowed or the country now has lower prices.

Table A-4 Factors in observed household retail electricity price changes per country, nominal prices, per MWh

Country	Start date	End date	Nominal Start price EUR	Change due to inflation [EUR]	Change due to price change in national currency [EUR]	Exchange rate effect [EUR]	Total change [EUR]	Nominal End price EUR	Change due to inflation [%]	Change due to real price change in national currency [%]	Exchange rate effect [%]	Total change [%]
EU27	2008-1	2019-12	155.65	19.18	36.77	0.00	55.95	211.60	12.3%	23.6%	0.0%	35.9%
Argentina	2008-1	2019-1	8.21	26.41	306.80	-303.90	29.31	37.53	321.6%	3736.2%	-3700.8%	356.9%
Australia	2012-1	2019-1	228.54	15.60	17.62	-58.50	-25.28	203.27	6.8%	7.7%	-25.6%	-11.1%
Brazil	2008-12	2018-12	162.40	112.89	7.75	-76.49	44.15	206.55	69.5%	4.8%	-47.1%	27.2%
Canada	2008-1	2019-1	61.35	9.20	30.19	-2.21	37.18	98.54	15.0%	49.2%	-3.6%	60.6%
China	2008-1	2019-12	48.80	15.09	-15.09	17.89	17.89	66.69	30.9%	-30.9%	36.7%	36.7%
India	2008-1	2015-1	42.92	19.76	9.18	-14.35	14.59	57.51	46.0%	21.4%	-33.4%	34.0%
Indonesia	2008-12	2018-12	38.49	22.98	10.70	-5.40	28.28	66.76	59.7%	27.8%	-14.0%	73.5%
Japan	2008-1	2018-1	146.98	-2.09	22.05	28.92	48.88	195.86	-1.4%	15.0%	19.7%	33.3%
Mexico	2008-1	2018-1	65.26	28.81	-19.95	-22.56	-13.70	51.57	44.1%	-30.6%	-34.6%	-21.0%
Russia	2009-1	2019-12	44.52	42.56	-0.03	-34.40	8.13	52.65	95.6%	-0.1%	-77.3%	18.3%
Saudi Arabia	2008-1	2018-1	9.05	1.51	7.73	3.57	12.81	21.86	16.7%	85.4%	39.4%	141.5%
South Africa	2008-1	2019-1	49.67	31.22	53.75	-46.87	38.10	87.76	62.9%	108.2%	-94.4%	76.7%
South Korea	2008-1	2019-12	56.79	10.26	15.54	5.15	30.95	87.74	18.1%	27.4%	9.1%	54.5%
Turkey	2008-1	2019-12	99.78	101.25	218.43	-307.72	11.96	111.75	101.5%	218.9%	-308.4%	12.0%
USA	2008-1	2019-11	68.90	12.76	6.95	29.40	49.11	118.00	18.5%	10.1%	42.7%	71.3%

Source: own calculations.
Explanation: this table shows the different components of the observed nominal price change, decomposed into inflation, price change and exchange rate effects. By summing the components between the Nominal start price EUR and Total change [EUR] the total change can be calculated, this corresponds to the difference between the Nominal Start price EUR and the Nominal End price EUR. A worked example is provided in the notes to Table A-2.
Note: This table presents nominal prices, differences can be observed with the previous table which used constant prices, the start prices differ due to application of the currency deflator for the constant price calculation. Whilst the end prices differ as we deflate to a particular year (2017) using an annual average exchange rate, as opposed to the monthly average exchange rate used for the nominal price calculation. An example of this effect is presented in the notes to Table A-2. As noted there, the observed difference is typically less than +/- 5% of the price.

Industry electricity prices

Table A-5 Changes in retail industrial electricity prices compared to EU prices, constant 2018 EUR/MWh

Country	Start price [EUR2018]	End price [EUR2018]	Change EUR	Change %	Start Gap [EUR]	End Gap [EUR]	Difference [EUR]	Relative for EU
EU27	111.72	116.25	4.53	4.1%				
Argentina	15.86	37.96	22.11	139.4%	-95.87	-78.28	17.58	Positive
Australia	74.66	142.14	67.48	90.4%	-37.06	25.89	62.96	Positive
Brazil	149.09	153.38	4.29	2.9%	37.37	37.14	-0.23	Negative
Canada	70.39	74.74	4.35	6.2%	-41.33	-41.51	-0.17	Negative
China	112.73	88.35	-24.38	-21.6%	1.01	-27.90	-28.90	Negative
India	90.19	99.20	9.01	10.0%	-21.53	-17.05	4.48	Positive
Indonesia	65.76	67.29	1.53	2.3%	-45.96	-48.96	-3.00	Negative
Japan	138.27	135.98	-2.28	-1.7%	26.54	19.74	-6.81	Negative
Mexico	125.07	75.78	-49.29	-39.4%	13.35	-40.47	-53.82	Negative
Russia	**37.77**	**43.07**	5.29	14.0%	-73.95	-70.80	3.15	Positive
Saudi Arabia	31.76	40.63	8.86	27.9%	-79.96	-75.62	4.34	Positive
South Africa	23.36	50.35	26.98	115.5%	-88.36	-65.90	22.46	Positive
South Korea	61.94	78.35	16.41	26.5%	-49.78	-37.89	11.89	Positive
Turkey	71.43	84.19	12.77	17.9%	-40.29	-32.05	8.24	Positive
USA	62.83	55.28	-7.56	-12.0%	-48.89	-60.97	-12.08	Negative

Source: own calculations

Note: a positive impact for the EU is recorded if the price gap has improved over time, e.g. that if a country had lower prices initially the gap is now smaller or prices are higher than the EU average, or if a country had higher prices that the gap has increased. A negative impact is recorded if a country had lower prices than the EU, and that the gap has now increased, or if the country had higher prices than the EU but this gap has narrowed or the country now has lower prices.

Table A-6 Factors in observed industrial retail electricity price changes per country, nominal prices, EUR/MWh

Country	Start date	End date	Nominal Start price EUR	Change due to inflation [EUR]	Change due to price change in national currency [EUR]	Exchange rate effect [EUR]	Total change [EUR]	Nominal End price EUR	Change due to inflation [%]	Change due to real price change in national currency [%]	Exchange rate effect [%]	Total change [%]
EU27	2008-1	2019-12	100.55	12.39	2.90	0.00	15.29	115.84	12.3%	2.9%	0.0%	15.2%
Argentina	2008-1	2019-1	10.85	34.91	320.44	-325.95	29.40	40.25	321.7%	2952.5%	-3003.3%	270.9%
Australia	2008-1	2019-1	57.99	12.80	66.27	6.17	85.24	143.24	22.1%	114.3%	10.6%	147.0%
Brazil	2008-12	2017-12	111.68	74.25	-5.54	-30.92	37.79	149.47	66.5%	-5.0%	-27.7%	33.8%
Canada	2008-1	2019-1	48.18	7.23	25.61	-1.78	31.06	79.24	15.0%	53.2%	-3.7%	64.5%
China	2008-1	2019-2	62.87	19.44	-15.69	26.20	29.95	92.83	30.9%	-25.0%	41.7%	47.6%
India	2008-1	2015-1	72.52	33.38	18.38	-24.81	26.95	99.47	46.0%	25.3%	-34.2%	37.2%
Indonesia	2008-12	2017-12	40.72	22.75	7.81	-3.43	27.13	67.84	55.9%	19.2%	-8.4%	66.6%
Japan	2008-1	2018-1	94.64	-1.35	18.95	19.44	37.04	131.69	-1.4%	20.0%	20.5%	39.1%
Mexico	2008-1	2018-1	85.61	37.79	-17.91	-32.10	-12.22	73.38	44.1%	-20.9%	-37.5%	-14.3%
Russia	2008-1	2019-12	**33.57**	33.39	30.67	-47.37	**16.69**	**50.26**	99.5%	91.4%	-141.1%	**49.7%**
Saudi Arabia	2008-1	2018-1	21.74	3.62	7.56	6.42	17.60	39.34	16.6%	34.8%	29.5%	80.9%
South Africa	2008-1	2019-1	19.97	12.55	46.72	-27.58	31.69	51.64	62.9%	234.0%	-138.1%	158.7%
South Korea	2008-1	2019-1	42.40	7.66	26.65	6.36	40.67	83.07	18.1%	62.9%	15.0%	95.9%
Turkey	2008-1	2019-12	64.29	65.24	192.00	-235.87	21.37	85.66	101.5%	298.7%	-366.9%	33.2%
USA	2008-1	2019-2	43.01	7.96	-5.52	13.48	15.92	58.94	18.5%	-12.8%	31.3%	37.0%

Source: own calculations
Explanation: this table shows the different components of the observed nominal price change, decomposed into inflation, price change and exchange rate effects. By summing the components between the Nominal start price EUR and Total change [EUR] the total change can be calculated, this corresponds to the difference between the Nominal Start price EUR and the Nominal End price EUR. A worked example is provided in the notes to Table A-2.
Note: This table presents nominal prices, differences can be observed with the previous table which used constant prices, the start prices differ due to application of the currency deflator for the constant price calculation. Whilst the end prices differ as we deflate to a particular year (2017) using an annual average exchange rate, as opposed to the monthly average exchange rate used for the nominal price calculation. An example of this effect is presented in the notes to Table A-2. As noted there, the observed difference is typically less than +/- 5% of the price.

Wholesale gas prices

Table A-7 Changes in wholesale natural gas prices compared to EU prices, constant 2018 euros per MWh

Country	Start price [EUR2018]	End price [EUR2018]	Change EUR	Change %	Start Gap [EUR]	End Gap [EUR]	Difference [EUR]	Relative for EU
EU27	26.74	14.68	-12.06	-45.1%				
Argentina	48.06	14.24	-33.82	-70.4%	21.32	-0.44	-21.76	Negative
Australia	8.36	16.77	8.42	100.7%	-18.39	2.09	20.48	Positive
Brazil	28.34	28.59	0.25	0.9%	1.59	13.91	12.32	Positive
Canada	18.81	5.26	-13.55	-72.0%	-7.94	-9.42	-1.48	Negative
China	11.70	23.45	11.75	100.5%	-15.05	8.77	23.82	Positive
India	44.03	28.25	-15.78	-35.8%	17.29	13.57	-3.72	Negative
Indonesia	33.67	28.36	-5.31	-15.8%	6.92	13.68	6.76	Positive
Japan	56.37	18.04	-38.32	-68.0%	29.62	3.36	-26.26	Negative
Mexico	21.88	12.97	-8.91	-40.7%	-4.86	-1.71	3.15	Positive
Russia	4.11	3.91	-0.20	-4.8%	-22.64	-10.77	11.87	Positive
Saudi Arabia								
South Africa								
South Korea	25.34	31.36	6.03	23.8%	-1.41	16.68	18.09	Positive
Turkey	41.56	29.05	-12.51	-30.1%	14.82	14.37	-0.45	Negative
USA	27.06	6.26	-20.80	-76.9%	0.32	-8.42	-8.74	Negative

Source: own calculations.

Note: a positive impact for the EU is recorded if the price gap has improved over time, e.g. that if a country had lower prices initially the gap is now smaller or prices are higher than the EU average, or if a country had higher prices that the gap has increased. A negative impact is recorded if a country had lower prices than the EU, and that the gap has now increased, or if the country had higher prices than the EU but this gap has narrowed or the country now has lower prices.

Table A-8 Factors in observed wholesale natural gas price changes per country, nominal prices per MWh

Country	Start date	End date	Nominal Start price EUR	Change due to inflation [EUR]	Change due to price change in national currency [EUR]	Exchange rate effect [EUR]	Total change [EUR]	Nominal End price EUR	Change due to inflation [%]	Change due to real price change in national currency [%]	Exchang e rate effect [%]	Total change [%]
EU27	2008-1	2019-12	24.07	2.97	-12.10	0.00	-9.14	14.93	12.3%	-50.3%	0.0%	-38.0%
Argentina	2012-8	2019-12	41.41	46.89	90.62	-163.42	-25.91	15.51	113.2%	218.8%	-394.6%	-62.6%
Australia	2008-9	2019-12	6.18	1.36	7.85	1.32	10.53	16.71	22.0%	127.1%	21.4%	170.5%
Brazil	2014-12	2018-2	25.46	3.83	4.48	-6.41	1.90	27.36	15.0%	17.6%	-25.2%	7.5%
Canada	2010-1	2018-4	13.53	1.68	-9.90	-0.25	-8.47	5.06	12.4%	-73.2%	-1.8%	-62.6%
China	2008-1	2018-2	8.01	2.24	6.19	6.00	14.43	22.44	28.0%	77.3%	74.9%	180.2%
India	2008-11	2017-5	34.84	18.46	-19.51	-4.33	-5.38	29.47	53.0%	-56.0%	-12.4%	-15.4%
Indonesia	2008-1	2019-12	23.04	14.64	-2.93	-3.86	7.85	30.89	63.5%	-12.7%	-16.8%	34.1%
Japan	2014-3	2019-12	45.17	0.95	-29.28	2.81	-25.52	19.65	2.1%	-64.8%	6.2%	-56.5%
Mexico	2008-11	2019-12	17.31	8.50	-7.80	-3.89	-3.19	14.12	49.1%	-45.1%	-22.5%	-18.4%
Russia	2014-10	2019-10	4.54	1.02	0.59	-1.66	-0.05	4.49	22.5%	13.0%	-36.6%	-1.1%
Saudi Arabia	No data											
South Africa	No data											
South Korea	2010-1	2018-1	18.23	1.89	4.20	6.05	12.14	30.37	10.4%	23.0%	33.2%	66.6%
Turkey	2008-1	2015-4	28.45	14.09	7.53	-19.89	1.73	30.17	49.5%	26.5%	-69.9%	6.1%
USA	2008-1	2019-12	18.52	3.43	-16.81	1.67	-11.71	6.82	18.5%	-90.7%	9.0%	-63.2%

Source: own calculations.
Explanation: this table shows the different components of the observed nominal price change, decomposed into inflation, price change and exchange rate effects. By summing the components between the Nominal start price EUR and Total change [EUR] the total change can be calculated, this corresponds to the difference between the Nominal Start price EUR and the Nominal End price EUR. A worked example is provided in the notes to Table A-2.
Note: This table presents nominal prices, differences can be observed with the previous table which used constant prices, the start prices differ due to application of the currency deflator for the constant price calculation. Whilst the end prices differ as we deflate to a particular year (2017) using an annual average exchange rate, as opposed to the monthly average exchange rate used for the nominal price calculation. An example of this effect is presented in the notes to Table A-2. As noted there, the observed difference is typically less than +/- 5% of the price.

Household gas prices

Table A-9 Changes in household retail natural gas prices compared to EU prices, constant 2018 euro per MWh

Country	Start price [EUR2018]	End price [EUR2018]	Change EUR	Change %	Start Gap [EUR]	End Gap [EUR]	Difference [EUR]	Relative for EU
EU27	60.32	71.42	11.10	18.4%				
Argentina	0.44	26.12	25.68	5828.9%	-59.88	-45.30	14.58	Positive
Australia	48.14	72.41	24.27	50.4%	-12.17	0.99	13.17	Positive
Brazil	42.78	50.27	7.49	17.5%	-17.53	-21.14	-3.61	Negative
Canada	43.11	21.49	-21.62	-50.1%	-17.20	-49.93	-32.72	Negative
China	34.52	29.57	-4.96	-14.4%	-25.79	-41.85	-16.06	Negative
India	4.33	8.80	4.47	103.4%	-55.99	-62.61	-6.63	Negative
Indonesia								
Japan	133.41	99.39	-34.02	-25.5%	73.10	27.98	-45.12	Negative
Mexico	38.22	21.89	-16.34	-42.7%	-22.09	-49.53	-27.44	Negative
Russia	4.23	0.57	-3.65	-86.4%	-56.09	-70.84	-14.76	Negative
Saudi Arabia	11.63	11.15	-0.49	-4.2%	-48.68	-60.27	-11.59	Negative
South Africa								
South Korea	55.48	46.76	-8.72	-15.7%	-4.84	-24.66	-19.82	Negative
Turkey	35.48	27.43	-8.05	-22.7%	-24.84	-43.99	-19.16	Negative
USA	45.53	29.05	-16.48	-36.2%	-14.78	-42.36	-27.58	Negative

Source: own calculation.

Note: a positive impact for the EU is recorded if the price gap has improved over time, e.g. that if a country had lower prices initially the gap is now smaller or prices are higher than the EU average, or if a country had higher prices that the gap has increased. A negative impact is recorded if a country had lower prices than the EU, and that the gap has now increased, or if the country had higher prices than the EU but this gap has narrowed or the country now has lower prices.

Table A-10 Factors in observed household retail natural gas price changes per country, nominal prices, per MWh

Country	Start date	End date	Nominal Start price EUR	Change due to inflation [EUR]	Change due to price change in national currency [EUR]	Exchange rate effect [EUR]	Total change [EUR]	Nominal End price EUR	Change due to inflation [%]	Change due to real price change in national currency [%]	Exchange rate effect [%]	Total change [%]
EU27	2008-1	2019-12	54.29	6.69	11.68	0.00	18.37	72.66	12.3%	21.5%	0.0%	33.8%
Argentina	2008-9	2019-6	3.35	9.68	202.44	-195.61	16.51	19.86	288.9%	6041.3%	-5837.5%	492.7%
Australia	2008-1	2019-1	37.39	8.26	24.18	3.14	35.58	72.97	22.1%	64.7%	8.4%	95.1%
Brazil	2008-12	2018-12	33.85	21.12	18.08	-19.35	19.85	52.25	62.4%	53.4%	-57.2%	58.6%
Canada	2008-1	2019-1	29.51	4.43	-10.64	-0.51	-6.72	22.78	15.0%	-36.1%	-1.7%	-22.8%
China	2008-1	2019-12	19.26	5.95	-2.91	8.18	11.22	30.47	30.9%	-15.1%	42.5%	58.3%
India	2008-1	2018-1	4.98	2.85	4.47	-3.14	4.18	9.15	57.2%	89.7%	-63.0%	83.9%
Indonesia	No data											
Japan	2009-1	2018-1	102.29	-0.84	7.28	-12.48	-6.04	96.26	-0.8%	7.1%	-12.2%	-5.9%
Mexico	2008-1	2016-1	26.16	8.51	-6.83	-5.03	-3.35	22.81	32.5%	-26.1%	-19.2%	-12.8%
Russia	2008-1	2019-1	3.76	3.74	-6.19	-0.69	-3.14	0.61	99.5%	-164.7%	-18.4%	-83.6%
Saudi Arabia	2009-1	2015-4	8.92	1.73	-0.60	1.53	2.66	11.58	19.4%	-6.7%	17.2%	29.8%
South Africa	No data											
South Korea	2008-1	2019-1	37.97	6.86	0.59	4.15	11.60	49.57	18.1%	1.6%	10.9%	30.5%
Turkey	2008-1	2019-12	31.93	32.40	40.40	-76.83	-4.03	27.90	101.5%	126.5%	-240.6%	-12.6%
USA	2008-1	2019-1	31.17	5.77	-13.05	6.91	-0.37	30.80	18.5%	-41.9%	22.2%	-1.2%

Source: own calculations

Explanation: this table shows the different components of the observed nominal price change, decomposed into inflation, price change and exchange rate effects. By summing the components between the Nominal start price EUR and Total change [EUR] the total change can be calculated, this corresponds to the difference between the Nominal Start price EUR and the Nominal End price EUR. A worked example is provided in the notes to Table A-2.

Note: This table presents nominal prices, differences can be observed with the previous table which used constant prices, the start prices differ due to application of the currency deflator for the constant price calculation. Whilst the end prices differ as we deflate to a particular year (2017) using an annual average exchange rate, as opposed to the monthly average exchange rate used for the nominal price calculation. An example of this effect is presented in the notes to Table A-2. As noted there, the observed difference is typically less than +/- 5% of the price.

Industry gas prices

Table A-11 Changes in the industry retail natural gas price differential compared to EU prices, constant 2018 euros per MWh

Country	Start price [EUR2018]	End price [EUR2018]	Change EUR	Change %	Start Gap [EUR]	End Gap [EUR]	Difference [EUR]	Relative for EU
EU27	**33.14**	**24.07**	-9.07	-27.4%				
Argentina	**0.20**	**1.94**	1.75	891.1%	-32.94	-22.13	10.81	Positive
Australia	**15.18**	**21.35**	6.17	40.6%	-17.95	-2.72	15.23	Positive
Brazil	**23.06**	**13.60**	-9.46	-41.0%	-10.07	-10.47	-0.40	Negative
Canada	**30.07**	**8.24**	-21.83	-72.6%	-3.07	-15.83	-12.77	Negative
China	**39.52**	**34.27**	-5.25	-13.3%	6.39	10.20	3.81	Positive
India	**4.33**	**8.80**	4.47	103.4%	-28.81	-15.27	13.54	Positive
Indonesia								
Japan	**45.61**	**38.93**	-6.68	-14.7%	12.47	14.85	2.38	Positive
Mexico	**20.44**	**9.61**	-10.84	-53.0%	-12.69	-14.46	-1.77	Negative
Russia	**8.44**	**7.00**	-1.44	-17.1%	-24.69	-17.07	7.62	Positive
Saudi Arabia	**2.17**	**3.12**	0.95	43.9%	-30.96	-20.95	10.02	Positive
South Africa	**35.27**	**11.39**	-23.88	-67.7%	2.13	-12.68	-14.81	Negative
South Korea	**46.38**	**35.68**	-10.71	-23.1%	13.25	11.61	-1.64	Negative
Turkey	**27.07**	**24.43**	-2.64	-9.8%	-6.06	0.36	6.42	Positive
USA	**31.69**	**10.58**	-21.11	-66.6%	-1.44	-13.49	-12.04	Negative

Source: own calculations.

Note: a positive impact for the EU is recorded if the price gap has improved over time, e.g. that if a country had lower prices initially the gap is now smaller or prices are higher than the EU average, or if a country had higher prices that the gap has increased. A negative impact is recorded if a country had lower prices than the EU, and that the gap has now increased, or if the country had higher prices than the EU but this gap has narrowed or the country now has lower prices.

Table A-12 Factors in observed industrial retail natural gas price changes per country, nominal prices, per MWh

Country	Start date	End date	Nominal Start price EUR	Change due to inflation [EUR]	Change due to price change in national currency [EUR]	Exchange rate effect [EUR]	Total change [EUR]	Nominal End price EUR	Change due to inflation [%]	Change due to real price change in national currency [%]	Exchange rate effect [%]	Total change [%]
EU27	2008-1	2019-11	29.82	3.68	-9.01	0.00	-5.34	24.49	12.3%	-30.2%	0.0%	-17.9%
Argentina	2008-9	2019-6	1.49	4.30	10.23	-14.55	-0.02	1.48	288.4%	686.2%	-975.9%	-1.3%
Australia	2008-1	2019-1	11.79	2.60	6.19	0.93	9.72	21.51	22.0%	52.5%	7.9%	82.4%
Brazil	2008-12	2018-12	17.55	10.95	-8.54	-5.05	-2.64	13.64	62.4%	-48.7%	-28.8%	-15.0%
Canada	2008-1	2019-1	20.58	3.09	-14.74	-0.20	-11.85	8.73	15.0%	-71.6%	-1.0%	-57.6%
China	2008-1	2019-11	22.04	6.82	-3.02	9.66	13.46	35.50	30.9%	-13.7%	43.8%	61.1%
India	2008-1	2018-1	4.98	2.85	4.47	-3.14	4.18	9.15	57.2%	89.7%	-63.0%	83.9%
Indonesia	No data											
Japan	2009-1	2018-1	34.97	-0.29	7.90	-4.89	2.72	37.70	-0.8%	22.6%	-14.0%	7.8%
Mexico	2008-1	2019-1	18.78	9.23	-13.75	-3.80	-8.32	10.46	49.1%	-73.2%	-20.2%	-44.3%
Russia	2008-1	2015-4	5.78	4.07	1.61	-4.18	1.50	7.27	70.4%	27.9%	-72.3%	26.0%
Saudi Arabia	2008-1	2018-1	1.49	0.25	0.80	0.49	1.54	3.02	16.8%	53.8%	33.0%	103.7%
South Africa	2008-1	2017-12	30.14	16.58	-30.12	-5.62	-19.16	10.98	55.0%	-99.9%	-18.6%	-63.6%
South Korea	2008-1	2019-1	31.75	5.74	-2.83	3.17	6.08	37.82	18.1%	-8.9%	10.0%	19.2%
Turkey	2008-1	2019-11	24.37	24.73	41.90	-66.14	0.49	24.85	101.5%	171.9%	-271.4%	2.0%
USA	2008-1	2019-1	21.69	4.02	-17.01	2.52	-10.47	11.22	18.5%	-78.4%	11.6%	-48.3%

Source: own calculations

Explanation: this table shows the different components of the observed nominal price change, decomposed into inflation, price change and exchange rate effects. By summing the components between the Nominal start price EUR and Total change [EUR] the total change can be calculated, this corresponds to the difference between the Nominal Start price EUR and the Nominal End price EUR. A worked example is provided in the notes to Table A-2.

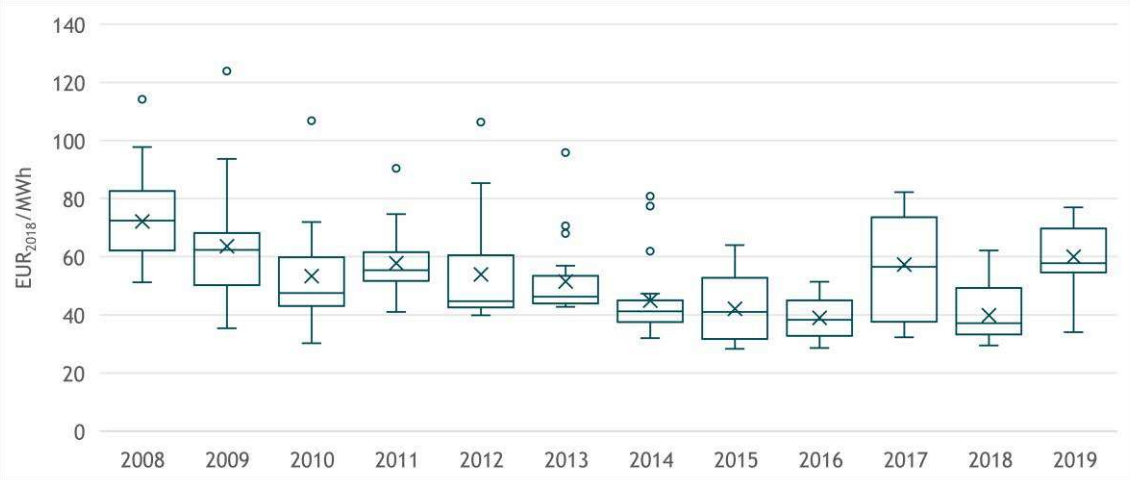
Note: This table presents nominal prices, differences can be observed with the previous table which used constant prices, the start prices differ due to application of the currency deflator for the constant price calculation. Whilst the end prices differ as we deflate to a particular year (2017) using an annual average exchange rate, as opposed to the monthly average exchange rate used for the nominal price calculation. An example of this effect is presented in the notes to Table A-2. As noted there, the observed difference is typically less than +/- 5% of the price.

Box plots and Member State price trend figures

Note on Box Plots: The box represents the 25th to 75th percentile of data in the set, the line represents the median (middle) value of the range, whilst the cross represents the mean. The T lines (whiskers) extending from the box representing the full range of values in that period, except in the case of values denoted by o which represent outliers in the data. The mean and median values diverge from the EU weighted averages presented in chapter 3 as the values here are unweighted, whilst in chapter 3 the EU average is calculated from country values weighted by consumption.

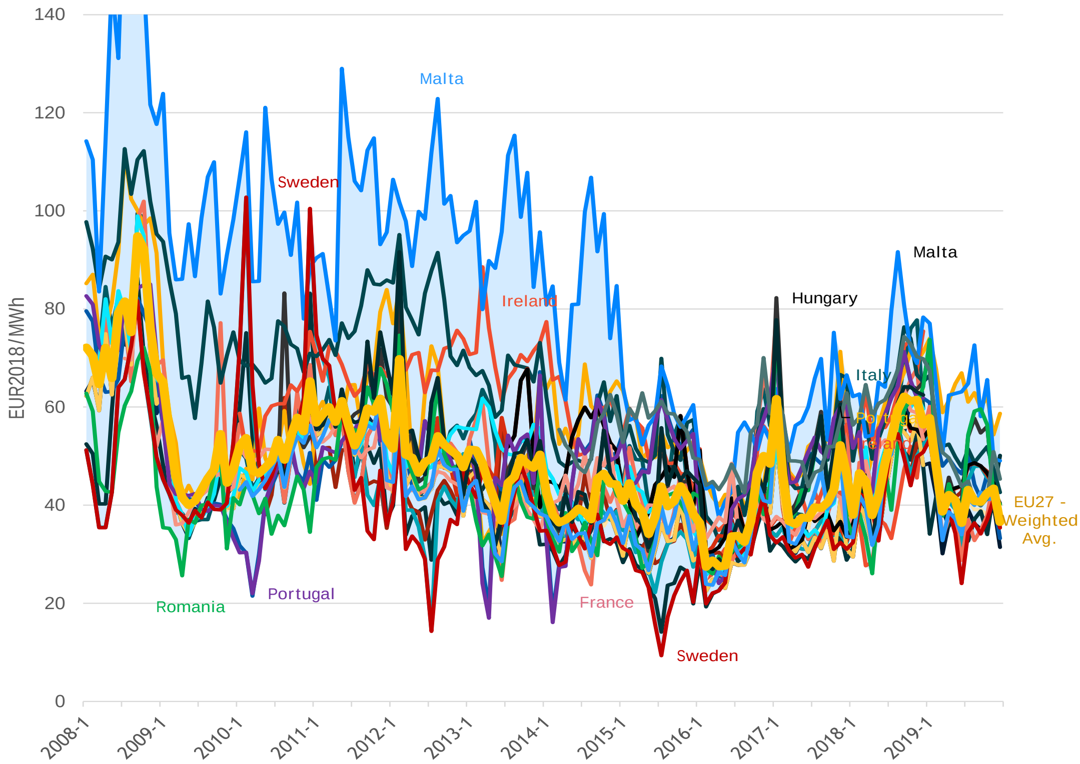
Electricity

Figure A-1 Box plot of EU27 wholesale electricity prices 2008-2019



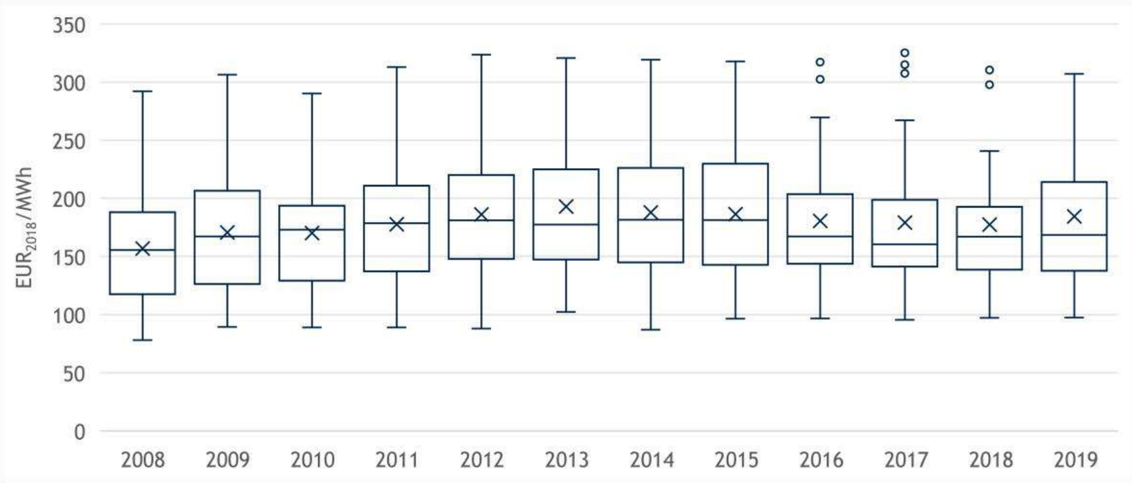
Source: Own calculations

Figure A-2 EU27 wholesale electricity prices 2008-2019, individual Member States lines visible, outliers named



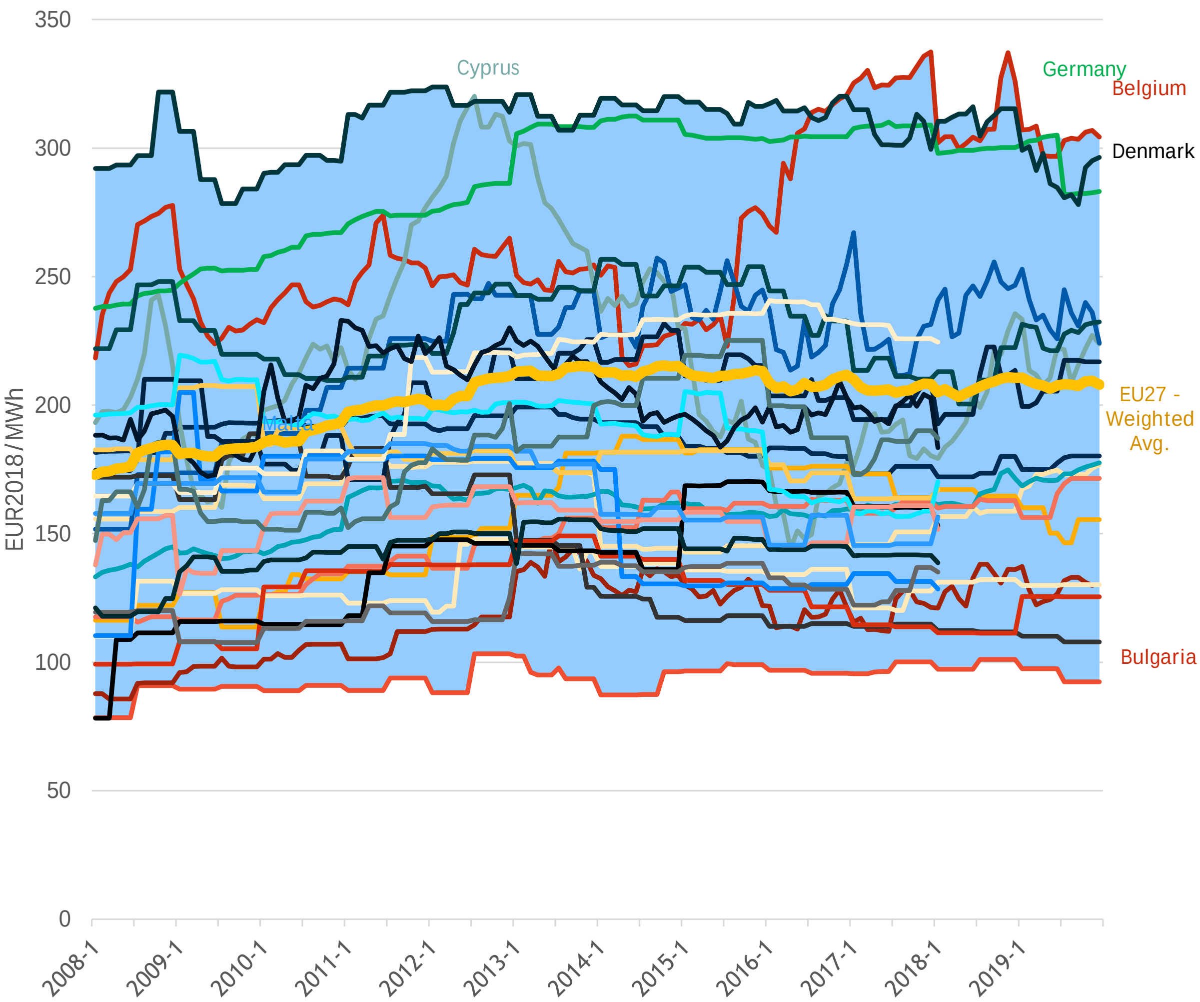
Source: Own calculations

Figure A-3 Box plot of EU27 retail household electricity prices 2008-2019



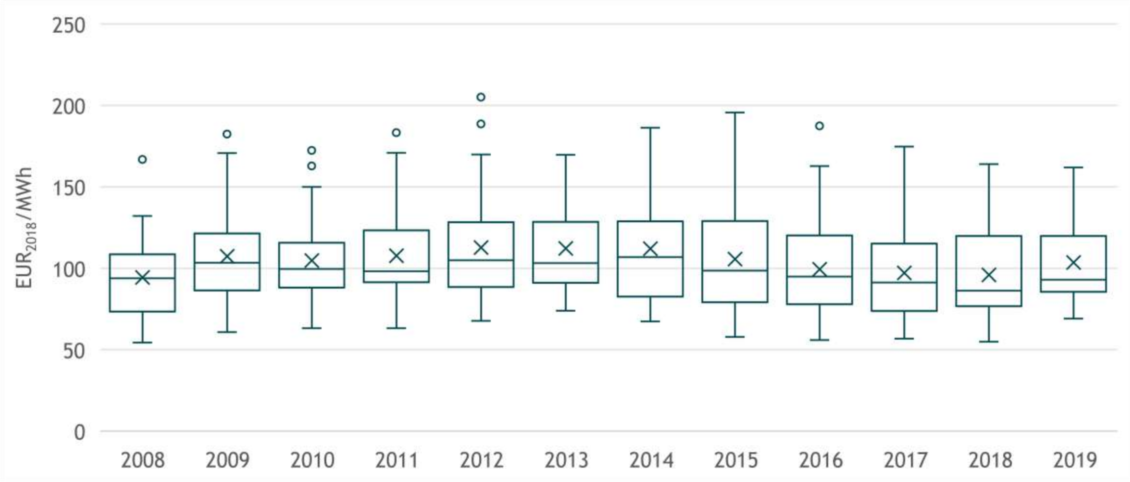
Source: Own calculations

Figure A-4 EU27 retail household electricity prices 2008-2019, individual Member States lines visible, outliers named



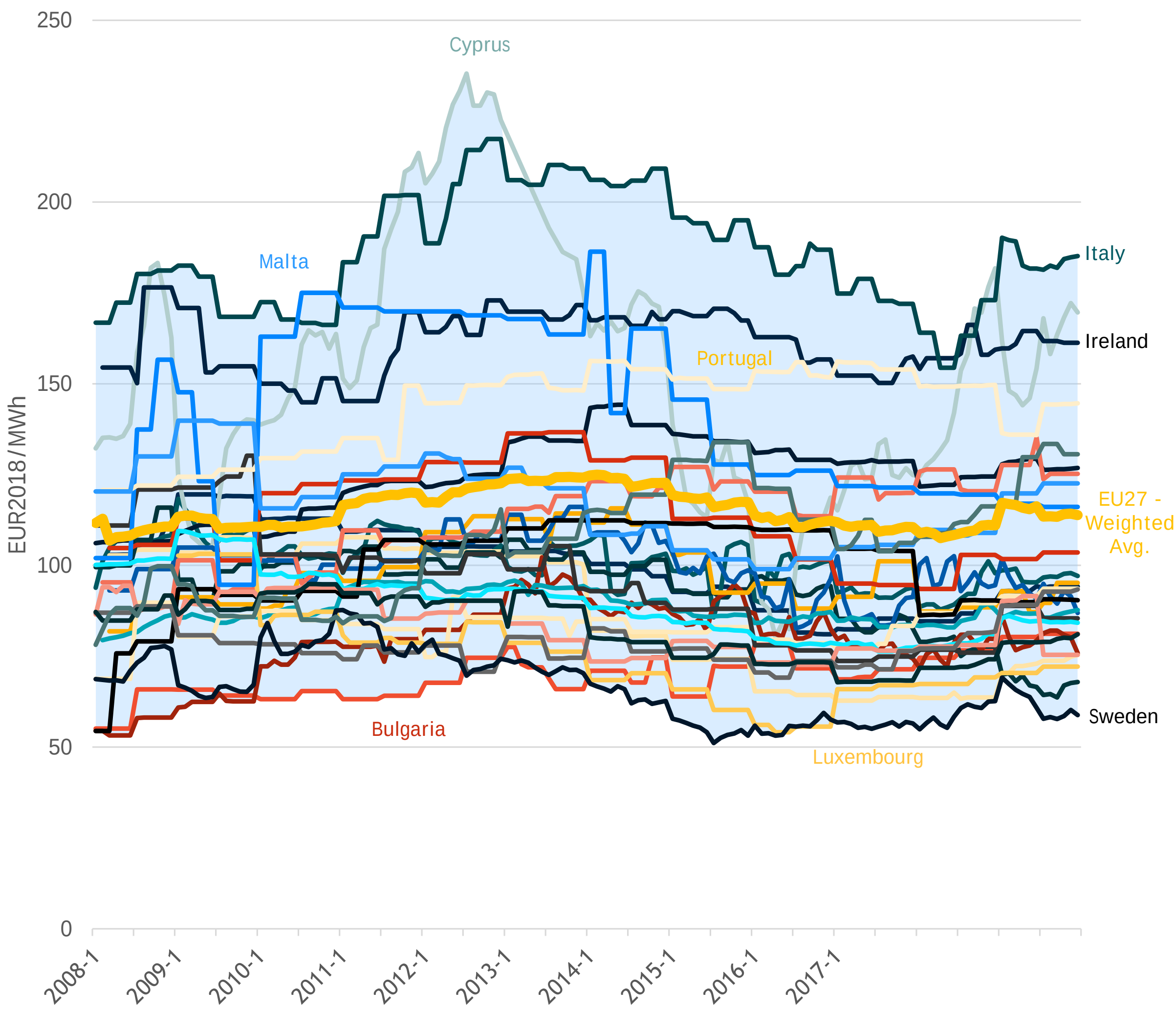
Source: Own calculations

Figure A-5 Box plot of EU27 retail industrial electricity prices 2008-2019



Source: Own calculations

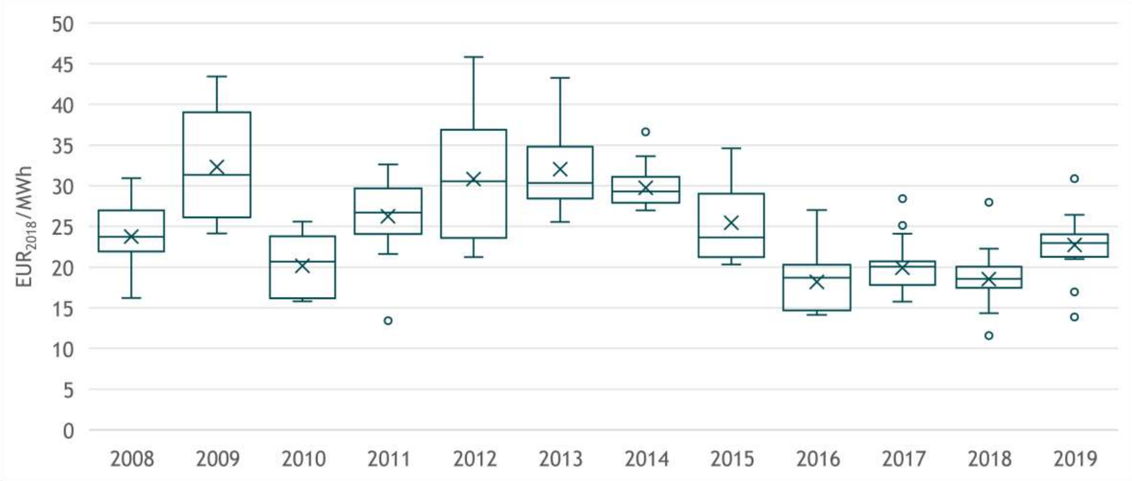
Figure A-6 EU27 retail industrial electricity prices 2008-2019, individual Member States lines visible, outliers named



Source: Own calculations

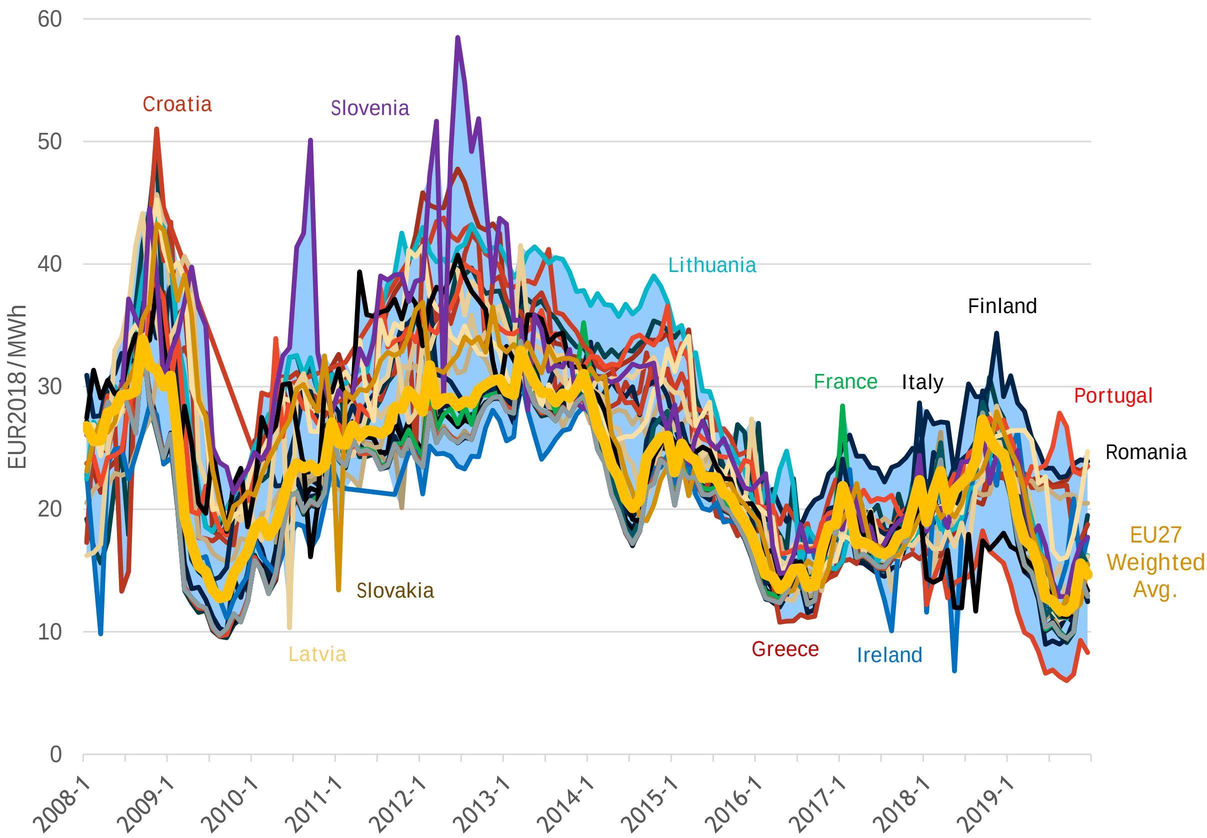
Natural Gas

Figure A-7 Box plot of EU27 wholesale natural gas prices 2008-2019



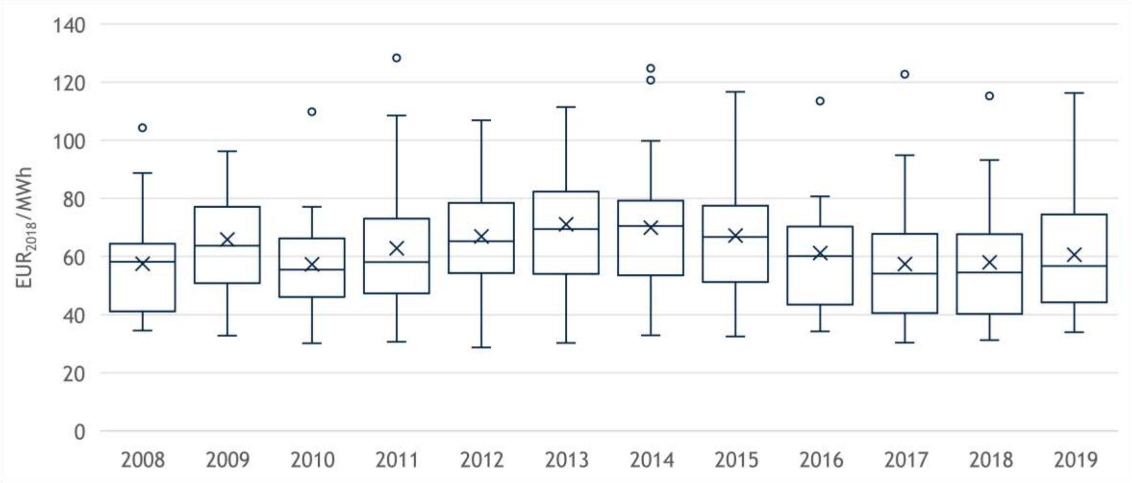
Source: Own calculations

Figure A-8 EU27 wholesale natural gas prices 2008-2019, individual Member States lines visible, outliers named



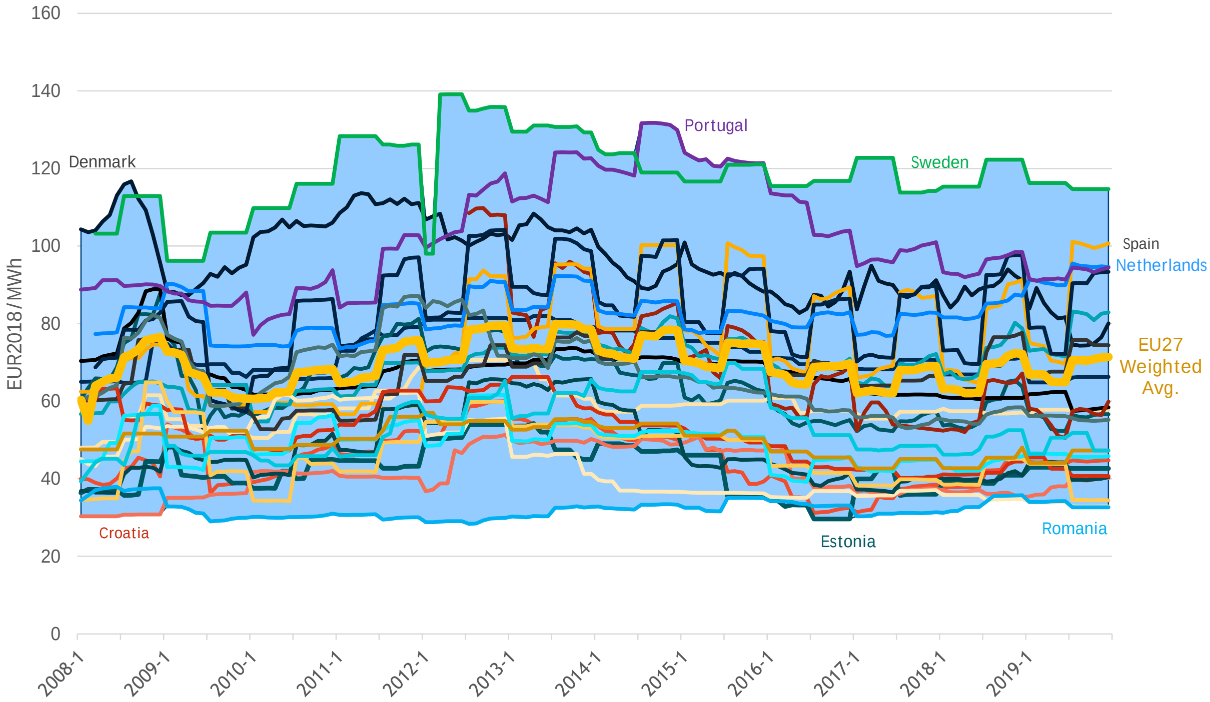
Source: Own calculations

Figure A-9 Box plot of EU27 retail household natural gas prices 2008-2019



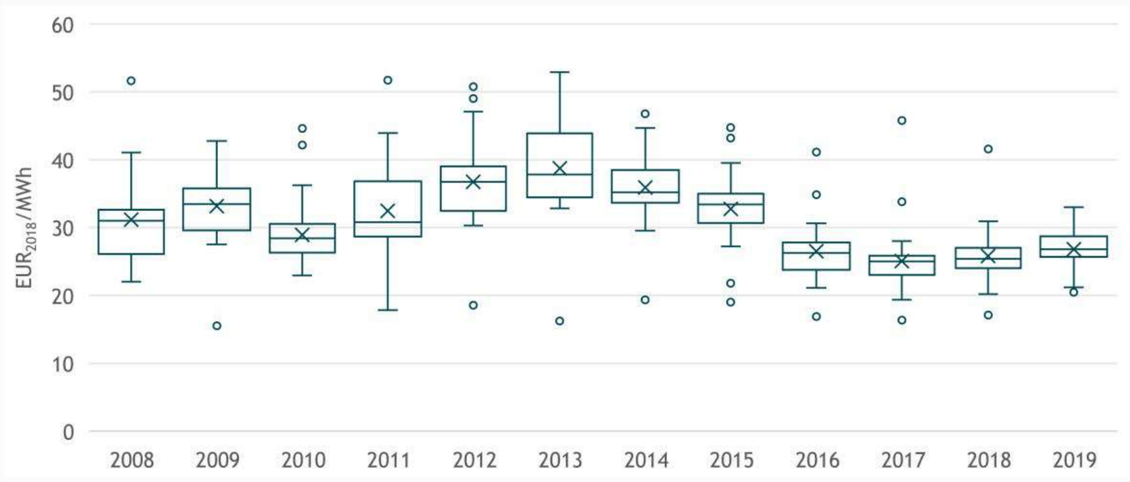
Source: Own calculations

Figure A-10 EU27 retail household natural gas prices 2008-2019, individual Member States lines visible, outliers named



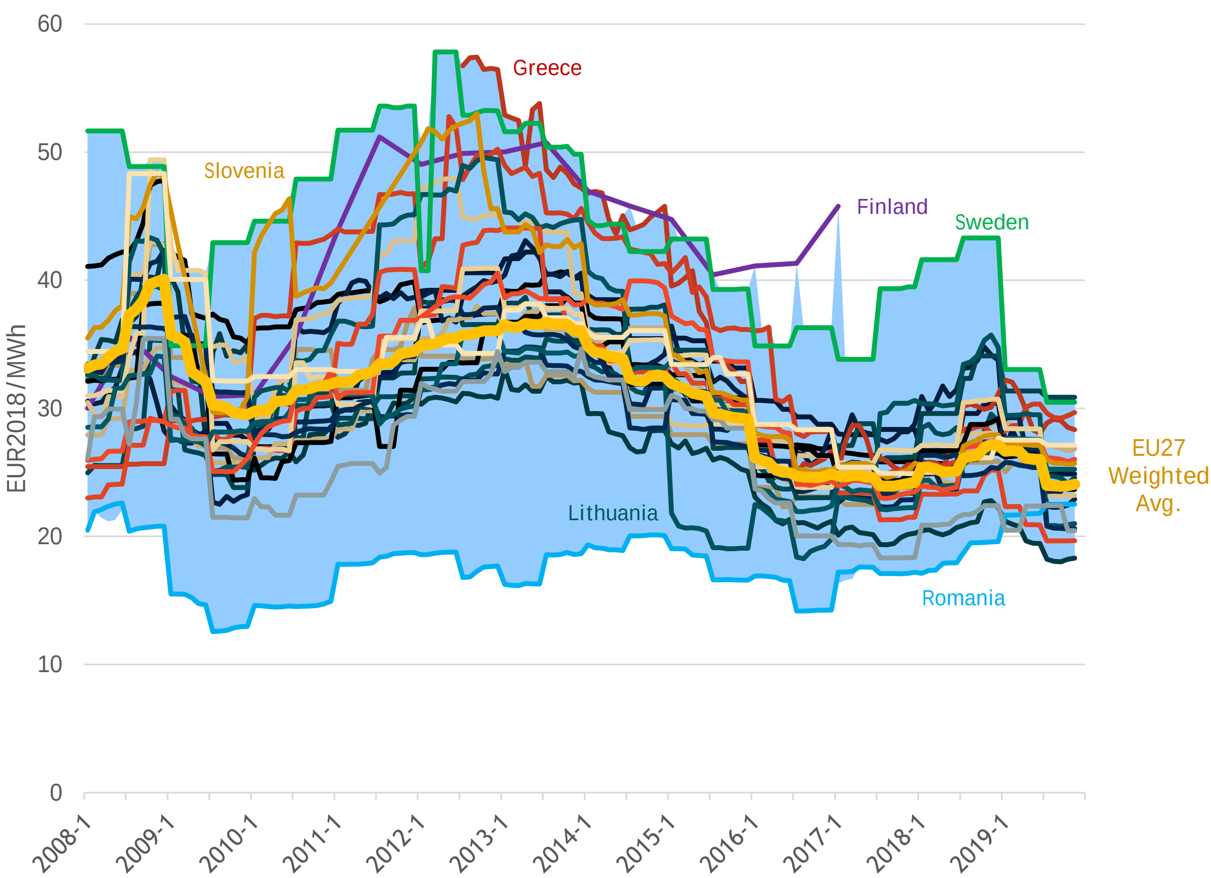
Source: Own calculations

Figure A-11 Box plot of EU27 retail industrial natural gas prices 2008-2019



Source: Own calculations

Figure A-12 EU27 retail industrial natural gas prices 2008-2019, individual Member States lines visible, outliers named



Source: Own calculations

Annex B - Task 1 Electricity prices for road transport, detailed findings

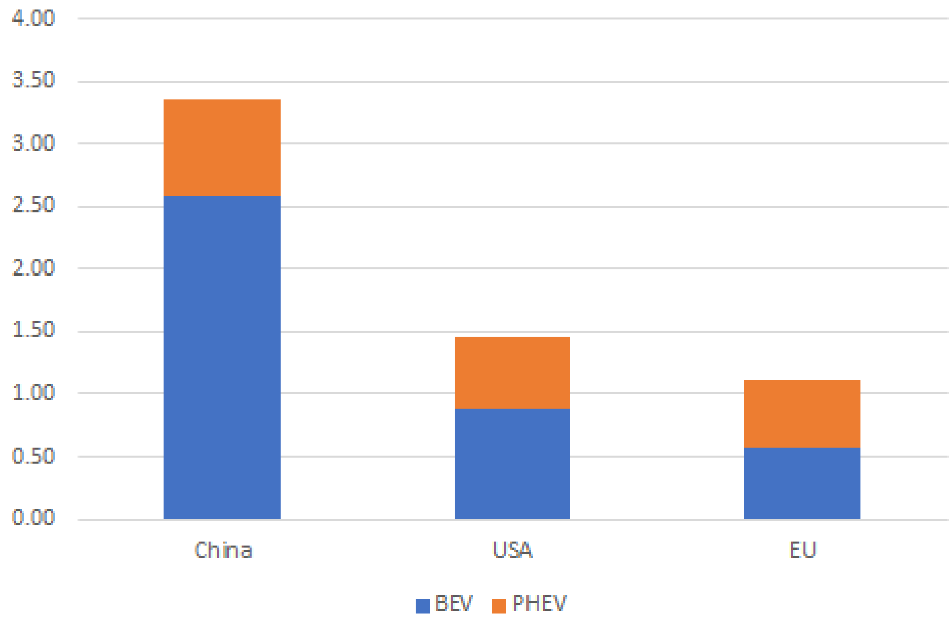
This section details the main findings used to understand EV markets and uses to provide a relevant scope to focus on for the data price collection.

EV dynamics

A first task consisted in analysing briefly the EV dynamics to determine in which countries there are the most EV. Information on vehicle stocks was supplemented by a focus on the number of charging stations across countries to get a vision on the distribution network, and when possible by type of charging mode.

By the end of 2019, the number of electric passenger cars reached 7.2 million units worldwide. Battery electric vehicles (BEV) account for 67% of this fleet. Around 47% of the world electric car fleet is located in China, while Europe accounts for around 25% of global stock and 20% for the USA.

Figure B-1 Size of electric car fleet in China, USA and EU end of 2019 (IEA, EV Outlook, 2020)

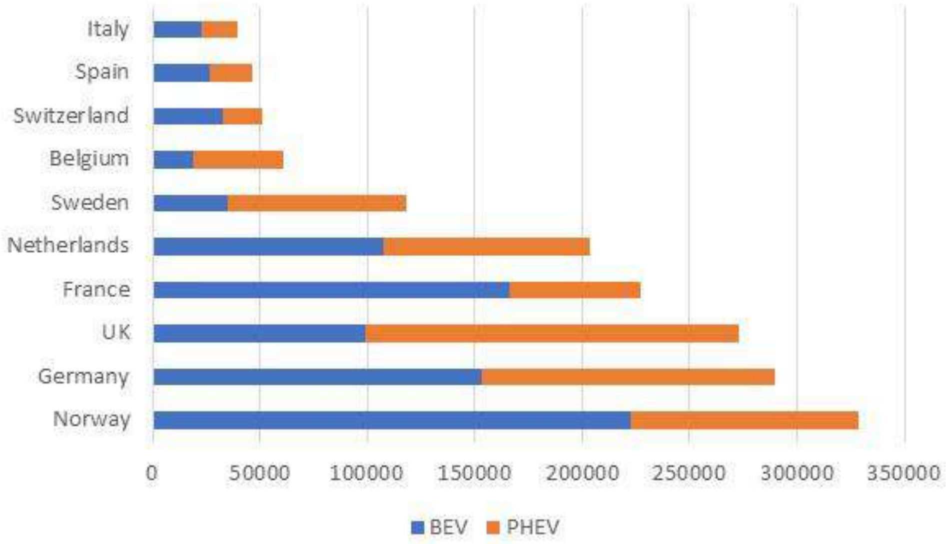


Note: BEV: Battery electric vehicles. PHEV: Plug-in hybrid electric vehicle[154]

Norway is by far the leading country in Europe with the highest number of electric passenger cars, followed by Germany and the UK (Figure B-2).

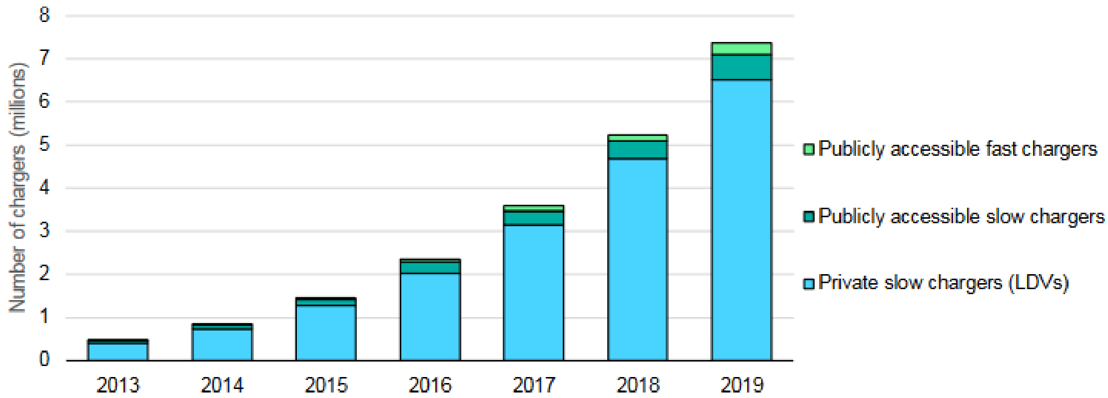
[154] BEV: Also known as all-electric vehicle, BEV's has all its power from its battery packs and thus has no internal combustion engine, fuel cell, or fuel tank. PHEV: A PHEV shares the characteristics of both a hybrid electric vehicle, having an electric motor and an internal combustion engine (ICE), and of an all-electric vehicle, having a plug to connect to the electrical grid for battery recharging.

Figure B-2 Top 10 leading passenger electric cars in EU27, Norway, the UK and Switzerland (EAFO)



The number of charging points worldwide is estimated at 7.3 million (end-2019). Most charging points are private installations, accounting for around 89% of the total infrastructure in 2019. Public normal (also called slow) chargers accounted for around 9% and fast chargers for 2% (Figure B-3) [155]. China remains the country with the largest installed publicly charging infrastructure, accounting for half of the total points. IEA estimates that around one third of the public charging points newly installed in 2018 were fast chargers. In China, almost half of newly installations were fast, whereas in Europe and the USA a large majority were normal chargers.

Figure B-3 Number of charging points installed worldwide, 2013-2019- (IEA, EV Outlook, 202019)

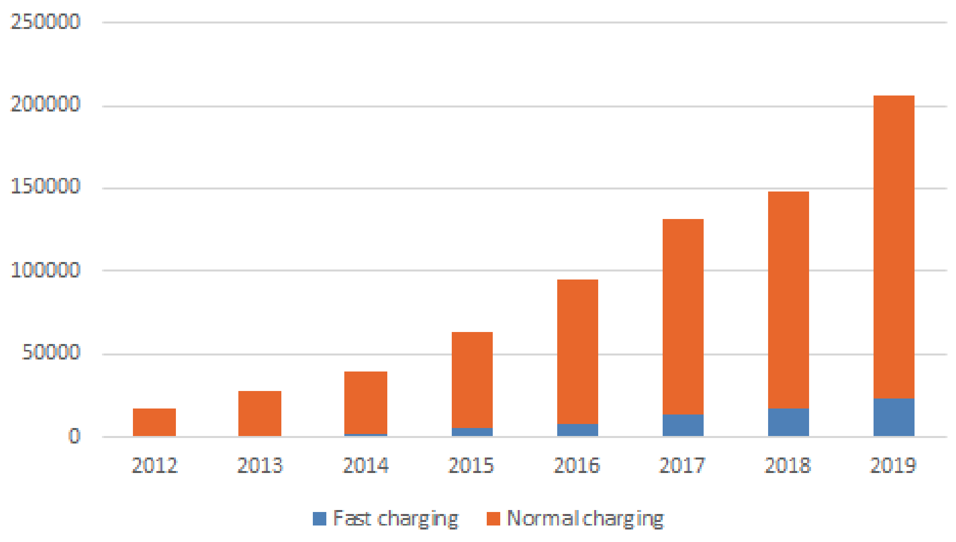


In the EU plus the UK and Norway , the number of normal (<= 22 KW) and fast public charging points (> 22 kW) reached around 206 000 points in 2019. Normal charging points represent 89% of total infrastructure (Figure B-4).

[155] IEA, Global EV Outlook 2019

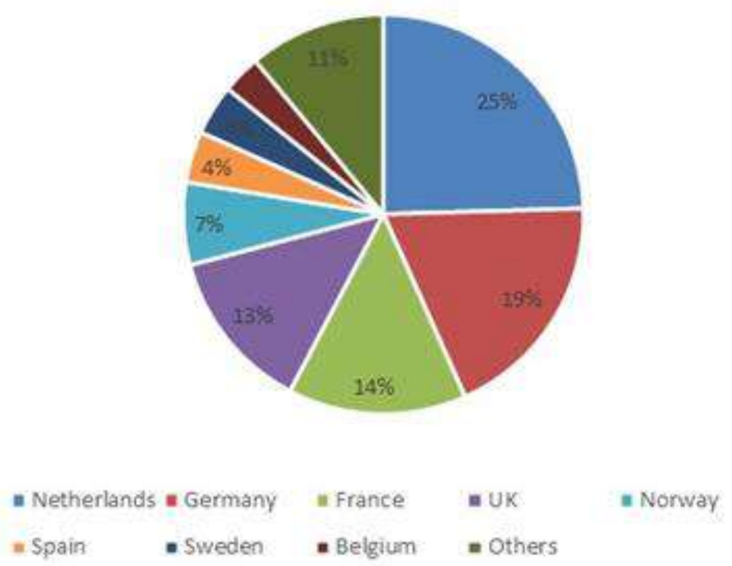
Source: Study on energy prices, costs and their impact on industry and households

Figure B-4 Number of charging points in Europe (EU plus the UK and Norway) (EAFO)



Around 1/3 of public charging points are located in the Netherlands (25% of total), followed by Germany (with 19%), France and UK (around 15% each) (Figure B-5).

Figure B-5 Distribution of public charging points by country in the EU plus UK and Norway (2019) (EAFO)



For the next part of the study we mainly focused on the most important electric vehicle markets, China, USA, Japan, the Netherlands, Norway, Germany, France and the UK.

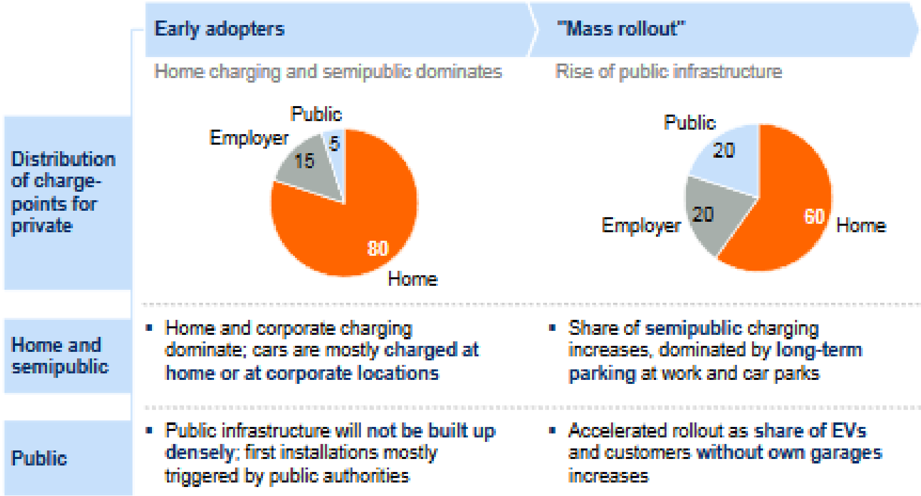
Charging habits and locations

There are three main channels for charging EVs:

- Charging at home, the most common way for EV owners. Most electric car drivers charge their vehicles over night when the general demand for electricity is lower than during the day;
- Charging at work (or other private places like some hostels): employers can install workplace charging points and typically offer free access throughout the day;
- Charging at public locations for free, under subscription or per charge.

Figure B-6 presents the distribution of charging points between home/employer/public depending on the situation of the EV market (early adopters, mass rollout). In any case, charging at home remains the main way of charging a car, although going somewhat down in mass market rollout.

Figure B-6 Implications for charging infrastructure (Amsterdam Roundtables Foundation and McKinsey, Evolution, Electric vehicles in Europe)



We have identified three main charging technologies:

- Level 1, classic power outlet, too slow so not very used, even at home;
- Level 2 (slow or normal charging), faster, main technology in all places (home, work and private places or public charging);
- Level 3 (fast or rapid charging), fastest, being developed more and more with the network.

Table B-1 Type of chargers (IEA, EV Outlook, 2019)

	Conventional plugs	Slow chargers	Fast chargers	
Level	Level 1	Level 2	Level 3	
Current	AC	AC	AC, Three-phase	DC
Power	≤ 3.7 kW	> 3.7 kW and ≤ 22 kW	> 22 kW and ≤ 43.5 kW	Currently < 400 kW

The table below gives an approximate charging time of an electric car in US. The charger categories vary a little in their definitions and more levels are considered as the fast chargers are quickly diversifying. This example, not directly linked to our topic on electricity prices, can be meanwhile useful to understand why electric vehicle owners are willing to pay more for fast charging.

Table B-2 shows that for a low power, the charging time is very important (more than 16 hours for 100 kilometres). In contrast, fast charging solutions allow to charge the car in less than an hour (DC current). Of course, these last ones are more convenient for the customer. The pricing scheme in use in a country may be very different and may have an impact on the solution chosen by EV owners.

However, infrastructures manufacturers are currently developing this solution to provide a better service. Even if fast charging points are not yet representing the major part of publicly accessible stations, as the charging time is a lot shorter and allows more turnover, we can assume they have already a much larger share in the energy sold. It becomes very important in areas of high population density or along highways. In Japan, the objective is to have fast charger every 9.3 miles (15 km) and the government accords subsidies to charging station operators.

Table B-2 Charger types and charging time.

Charger type	Current type	Average Power Delivered (kW)	Time taken to replenish daily usage (13.65 kW)	Time taken to charge 100 km (37 kWh)
Level 1	AC	1,4	9h 45min	16h 25min
Level 2 [standard]	AC	6,6	2h 4min	3h 29min
Level 2 [maximum]	AC	19,2	43 min	1 h11min
Level 3	DC	50	16 min	27 min
Level 4	DC	150	5 min	9 min
Level 5	DC	350	2 min	4 min

Notes: Table numbers assuming power usage of 37 KWh per 100 kilometres
Source: Harvard Kennedy School, 2018.[156]

The selection of the charging location by the EV user is quite complex and heterogenous as it depends on different factors such as the charging infrastructure (frequency of public/private charging points, fast charging points), the pricing applied by the operators, EV owners' habits (use of the car for short trips or longer distance), etc.

Charging at home is very convenient for EV owners. Most daily trips do not exceed a few tens of kilometres, and these travel needs are covered at a reduced price in 1 to 2 hours overnight. The charging can be done using a simple socket (power level of 2.3 kW) or using a box fitted to the wall ("wall box") (the latter option is the commonly used at residential locations). In countries or regions with low potential home charging availability, public charging infrastructure will be important as substitute.

Thus, public normal charging infrastructure remains important mainly in some metropolitan areas. For commuters, especially for those with no home charging option, a regular workplace charging is an important option. The role of fast charging stations delivering DC high power differs by country due to differences in long driving shares and highway coverage. So far, there is no simple conclusion as countries differ with regard to their charging infrastructure framework conditions.

EV owners are also limited by their car model. Not all batteries are able to receive higher power from the charging station and so cannot benefit of quicker ones. Of course, this constraint should disappear when the technology improvement will slow down. Several plug types are also available, and customers can only use the ones compatible with their car, even if adaptors exist. The main ones are:

- Chademo, mainly used by Japanese and east Asian car manufacturers;
- Combo CCS, mainly used by German car manufacturers;
- Tesla Supercharger.

[156] Charging the future: Challenges and Opportunities for electric vehicle adoption, Harvard Kennedy School, 2018

Free charging points also exist and provide an early incentive for consumers to purchase electric vehicles. This is the case for instance at supermarkets or car parks for the duration of your stay. In some cities, public charging points are also free for electric vehicle users. Vehicle manufacturers as Tesla or Nissan can also offer free fast-charging under conditions, such as buying their last models.

The Norwegian case can be very instructive as Norway is the front runner of EVs in Europe. The table below describes how often Norwegian EV owners charge their cars. Respondents are split into two groups based on what sort of housing they live in. As the table shows, EV owners who live in detached housing to a very large degree charge at home, while those living in apartment buildings to a larger degree also charge at public charging stations and use fast charging more frequently. We also note that most EV users do not fast charge on a weekly basis. Normal charging while the car is parked is in other words the dominating charging method. However, fast charging is crucial when needed, for instance on longer trips.

Table B-3 Norwegian EV charging habits (a survey from Norwegian EV owner 2017, www.elbil.no.)

	Detached housing	Apartment buildings
At home, daily or weekly	97 %	64 %
At home, monthly or never	3 %	36 %
At work, daily or weekly	36 %	38 %
At work, monthly or never	64 %	62 %
At public charging stations, daily or weekly	11 %	28 %
At public charging stations, monthly or never	89 %	72 %
At fast charging stations, daily or weekly	12 %	18 %
At fast charging stations, monthly or never	88 %	82 %

Rooftop solar and electric vehicles appear as a great combination in several countries, in particular where electricity prices from the grid is expensive or when public charging stations are not sufficient or not practical. In such cases, solar panels are a cost-effective way to charge electric vehicles - On average 8-12 solar panels are useful to charge an electric car - of course the energy production of a solar panel is dependent on its material, size, efficiency, solar irradiation. The time for charging an electric car also will also depend on the size of the battery.

In several countries we can see some correlation between electric vehicle ownership and rooftop solar panel installation. However, finding robust and coherent statistics on this is not easy. According to a survey published in 2017 by a US-based news website (CleanTechnica) specialised on clean technology especially sustainable energy and electric cars, around 28-40% of EV drivers have solar panels (2017 EV driver report [157]). An update of this survey published in April 2020[158] underlines that a large share of EV owners have also installed solar panels at home to charge their vehicles. According to their panel[159],

157 https://cleantechnica.com/2017/06/25/28-40-ev-drivers-solar-panels-cleantechnica-ev-report/
158 https://cleantechnica.com/2020/04/05/ev-ownership-rooftop-solar-in-germany-france-netherlands-norway-cleantechnica-report/
159 In the public version of the survey, the number of surveyed EV owners is unknown

around 60% of electric vehicle owners have solar panels installed on their roofs. This share is around 38% in Germany, USA and Canada, to only 13% in France and 10% in Norway.

For this second step in our methodology, it is possible to conclude that charging "at home" is the most representative charging behaviour, but we can also observe a switch to public charging. It is interesting to note that fast charging only represents a small part of charging today, but that this type of charging has high growth potential.

The main pricing systems

There are four main pricing schemes in the global charging market:

- At home, with possible off-peak pricing;
- Energy consumption pricing;
- Time consumption pricing;
- Subscription.

Part of the work in this section was to collect prices or customer tariffs from energy suppliers for home charging and some public charging. We can roughly convert a time pricing scheme to an energy pricing scheme (by technology) as the load curve is rather linear until 80%. A subscription scheme generally includes a time or energy related part and is much difficult to take into account. Some stations can also propose a price “per session” but these are not representative. Our results are presented in Euros (cents) per kWh.

The level of electricity prices and the tariff design can provide signals to influence efficient utilisation and development of the grid, as well as influencing demand shifting to off-peak times. Off peak tariffs (i.e. lower prices during night mainly) are proposed in some countries by some electricity providers and are already used by customers to reduce the bill of heating devices for example. Another solution currently adopted mostly in Nordic markets is to propose a dynamic price contract where customers are charged at a variable rate (this is particularly the case for households having a smart meter). This means that the electricity rate can vary by hour. In this case we can suppose that EV owners charge their cars by preference when electricity tariffs are lower, usually at night.

Based on this, we have selected some countries (mainly EU countries due to price availability and transparency) to try to identify whether main electricity providers propose reduced tariffs during nights, as off-peak tariffs could be considered amongst the proxies for the electricity prices used for charging EV’s at home. In addition to these off-peak prices, we have tried to identify whether these electricity providers propose specific tariffs for EV owners.

Annex C - Summary of collected data and supplementary statistical analysis for Task 2

Data sources and variables covered

Table C-1 Large-scale databases processed and integrated into the updated model

Database	Sectors covered	Countries covered	Variables covered
Eurostat SBS	C103; C106; C11; C132; C161; C171; C172; C192; C201; C206; C21; C222; C231; C232; C233; C234; C235; C237; C239; C241; C244; C245; C25; C26; C27; C28; C29; C30; C32; C33; B; B06; B07; B08; D35; E38; F; G; H49; H51; I; J	AT; BE; BG; CY; CZ; DE; DK; EE; EL; ES; FI; FR; HR; HU; IE; IT; LT; LU; LV; MT; NL; PL; PT; RO; SE; SI; SK; UK; EU27, UK; NO; CH; TR	Number of companies Turnover Production value Value added (at factor cost) Gross operating surplus Total purchases of goods and services Personnel costs Purchases of energy products
Eurostat Energy Balances	H49; H51	AT; BE; BG; CY; CZ; DE; DK; EE; EL; ES; FI; FR; HR; HU; IE; IT; LT; LU; LV; MT; NL; PL; PT; RO; SE; SI; SK; UK; EU27, UK, NO; CH; TR	Energy consumption - Coal Energy consumption - Oil Energy consumption - Gas Energy consumption - Other Energy consumption - Electricity Energy consumption - Total
IEA World Energy Balances	B; F; C241; C201; C244; C239; C28; C171; C161; C132; A	AR; AU; BR; CA; CN; IN; ID; JP; KR; MX; RU; SA; ZA; TR; US	Energy consumption - Coal Energy consumption - Oil Energy consumption - Gas Energy consumption - Other Energy consumption - Electricity Energy consumption - Total
Odyssee	C231; C235; C241; C244; A; B; F; G; I	AT; BE; BG; CY; CZ; DK; EE; EL; ES; FI; FR; HR; HU; IE; IT; LT; LU; LV; MT; PL; PT; RO; SE; SI; SK; NO; NL	Value added (at factor cost) Energy consumption - Coal Energy consumption - Oil Energy consumption - Gas Energy consumption - Other Energy consumption - Electricity Energy consumption - Total
OECD SISS	A; B; C103; C106; C11; C132; C161; C171; C172; C192; C201; C206; C21; C222; C231; C232; C233; C234; C235; C237; C239; C241; C244; C245; C25; C26; C27; C28; C29; C30; C32; C33; D35; E38; F; G; H49; H51; I; J; M; N; B06; B08; B07	AU; NZ; AT; BE; DK; FI; FR; DE; HU; IE; IT; LU; PL; PT; SK; ES; SE; UK; EE; SI; KR; JP; BG; RO; NO; CH; CZ; LV; LT; TR; NL; MX; US; IS; CY; HR; EL; MT; BR; CA; RU	Number of companies Production value Value added (at factor cost) Gross operating surplus Total purchases of goods and services Personnel costs Purchases of energy products
IHS	C11; C192; C201; C206; C21; C222; C231; C25; C26; C27; C28; C29; C30; C32; C33; A; B; B06; F; G; H49; H51; I; J; M; N	AR; AU; BR; CA; CN; IN; ID; JP; KR; MX; SA; ZA; US; RU; TR	Turnover Value added (at factor cost) Gross operating surplus Total purchases of goods and services
CEPI dataset	C171	AT; BE; CZ; DE; ES; FI; FR; IT; NL; PL; PT; SE; SK; UK; NO	Energy consumption - Coal Energy consumption - Oil Energy consumption - Gas Energy consumption - Other Energy consumption - Electricity Energy consumption - Total

Table C-2 National sources processed and integrated into the updated model

Database	Sectors covered	Countries covered	Variables covered
BEA	C106; C132; C161; C171; C192; C201; C206; C231; C232; C233; C234; C235; C237; C241; C244; C26; C27; C29; A; B; B06; F; G; H51	United States	Total purchases of goods and services Personnel costs Purchases of energy products
BEIS	C103; C106; C11; C132; C161; C171; C172; C192; C201; C206; C21; C222; C232; C233; C234; C237; C239; C244; C245; C25; C26; C27; C28; C29; C30; C32	United Kingdom	Energy consumption - Coal Energy consumption - Oil Energy consumption - Gas Energy consumption - Other Energy consumption - Electricity Energy consumption - Total
CBS Statline	C103; C106; C11; C192; C201; C21; C231; C233; C25; C26; C27; C28; C29; C30; C32; C33	Netherlands	
CSB Latvia	C21; C25; C26; C27; C28; C29; C30; C33	Latvia	
DESTATIS	C103; C106; C11; C132; C161; C171; C172; C192; C201; C206; C21; C222; C231; C232; C233; C234; C237; C239; C244; C245; C25; C26; C27; C28; C29; C30; C32; C33; B; B06; B07; B08	Germany	
EIA	C103; C106; C11; C132; C161; C171; C192; C201; C206; C21; C231; C235; C241; C244; C245; C25; C26; C27; C28	United States	
INEGI	C11; C231; C235; C241; C29	Mexico	
METI	C106; C11; C132; C161; C171; C192; C201; C206; C222; C231; C232; C233; C234; C235; C237; C241; C244; C26; C27; C29	Japan	Total purchases of goods and services Personnel costs Purchases of energy products Number of companies Production value
NBS	C11; C206; C21; C222; C25; C26; C27; C29; A; B; B06; B07; B08; D35; E38; F	China	Energy consumption - Coal Energy consumption - Oil Energy consumption - Gas Energy consumption - Other Energy consumption - Electricity Energy consumption - Total
STATCAN	C103; C11; C161; C171; C172; C192; C201; C206; C21; C222; C231; C235; C241; C244; C245; C25; C26; C27; C28; C29; C30; C32	Canada	
Statistics Finland	C11; C21; C25; C26; C27; C28; C29; C30; C32; C33	Finland	Energy consumption - Electricity Energy consumption - Total
Statistics Norway	C25; C28; C33	Norway	Energy consumption - Coal Energy consumption - Oil Energy consumption - Gas Energy consumption - Other Energy consumption - Electricity Energy consumption - Total

Energy costs and Total production costs in absolute figures

Below we present the full data tables with energy and non-energy costs (Million €)

Table C-3 Total EU 27 e**nergy Costs in M€, by sector**

Sector	2010	2011	2012	2013	2014	2015	2016	2017	Absolute change (M€) 2010-2017	Relative change 2010-2017
C103 - Fruit and vegetables	963.4	1031	1112.7	1106.1	1163.7	1028.5	1067.2	1002.3	38.9	4.0%
C106 - Grain products	803.4	922.6	928.8	892.8	968.8	893.7	767.2	715.5	-87.9	-10.9%
C132 - Textiles	410.9	299.4	281.8	250.6	237.1	215.5	220.4	239.2	-171.7	-41.8%
C161 - Sawmills	817.2	1073.3	933.8	929.2	940.5	877.5	862.2	815.7	-1.5	-0.2%
C171 - Pulp and paper	6429.1	6830.3	6167.7	6119.6	5428.2	5085.1	4403.1	4267.7	-2161.4	-33.6%
C172 - Articles of paper	1696.1	1629.6	1671.4	1728.1	1554.5	1485.8	1293.8	1373.5	-322.6	-19.0%
C192 - Refineries	126.5	133.6	145	140.5	126.7	108	75	78.6	-47.9	-37.9%
C201 - Basic chemicals	12102.3	14198.5	13104.9	13268.1	11662.7	10653	9064.8	10087.4	-2014.9	-16.6%
C206 - Man-made fibres	359.2	384.3	297.9	437.4	336.7	319.1	379.3	291.7	-67.5	-18.8%
C222 - Plastics products	3821.6	4093.5	3885.7	4154.1	3899.6	3803.9	3555.6	3641.6	-180	-4.7%
C231 - Glass	2321.8	2460.6	2709.9	2594.6	2360.3	2283.2	1933.1	1928	-393.8	-17.0%
C232 - Refractory products	234.3	243.2	266.6	254.3	227.7	223	228.4	190.7	-43.6	-18.6%
C233 - Clay building materials	1510.1	1488.2	1543.9	1477.9	1357.6	1374.9	1213.4	1204.9	-305.2	-20.2%
C234 - Porcelain and ceramics	300	328.3	320.2	317	314.7	281.5	274.4	255.5	-44.5	-14.8%
C235 - Cement, lime and plaster	2407.6	2530.6	2097.3	2001.1	1884.4	1799.9	1619.5	1741	-666.6	-27.7%
C237 - Stone	409.9	387.3	284.5	456.2	325	313.5	254.9	295.2	-114.7	-28.0%
C239 - Abrasive products	780.4	910.3	918.6	914.4	896.9	854.7	851.5	814.2	33.8	4.3%
C241 - Iron and steel	9550.2	8885.8	8591.6	7958.4	6709.9	6836.1	6112.7	6781.2	-2769	-29.0%
C244 - Non-ferrous metals	3150.4	3848.1	3613	3549	3262.1	3457.3	2578.3	3042.6	-107.8	-3.4%
C245 - Casting of metal	1565.9	1571.4	1575.9	1519.9	1459.7	1384.7	1279.2	1338.9	-227	-14.5%
C11 - Beverages	1470.5	1565.8	1604.3	1580.9	1516.2	1454.3	1381	1370.3	-100.2	-6.8%
C21 - Pharmaceutical products	996.5	1011.3	1063	1142.6	1071.5	1045.8	1006	913.2	-83.3	-8.4%
C25 - Fabricated metal products	6308.4	5729.8	5727.1	6056.3	5902.2	5499.7	5343.3	5516	-792.4	-12.6%
C26 - Computer and electronics	1133.3	1232.3	1165.3	1185.4	1120.3	1140.2	1069	1052.6	-80.7	-7.1%

Source: Study on energy prices, costs and their impact on industry and households

Sector	2010	2011	2012	2013	2014	2015	2016	2017	Absolute change (M€) 2010-2017	Relative change 2010-2017
C27 - Electrical equipment	1978.7	2040.3	1958	1953.2	2248.5	1749.4	1667.1	1678.7	-300	-15.2%
C28 - Machinery and equipment	3898.1	4218.4	4107.5	4336.4	4254.8	3989.8	3833.1	3962.2	64.1	1.6%
C29 - Motor vehicles	4408.2	4694.1	4910	4978.9	4828.6	5258.1	4441	4704	295.8	6.7%
C30 - Other transport equipment	679.3	662	697	695.9	632.1	722.3	564.7	570.6	-108.7	-16.0%
C32 - Other manufacturing	664.6	658.4	614.4	611.4	603.8	606.2	573.4	592	-72.6	-10.9%
C33 - Repair of machinery	787.1	834.7	832.3	882.3	885.5	734.5	694.2	761.5	-25.6	-3.3%

Table C-4 Total EU 27 Production **Costs in M€, by sector**

Sector	2010	2011	2012	2013	2014	2015	2016	2017	Absolute change (M€) 2010-2017	Relative change 2010-2017
C103 - Fruit and vegetables	33390.6	36028.2	36096.6	37932.8	39424.6	40996.9	41851.1	44471	11080.4	24.9%
C106 - Grain products	21437.8	26859.2	25449.6	26581.7	26910.1	27157.2	27580.3	27486.9	6049.1	22.0%
C132 - Textiles	11237.3	11769.4	10566.4	10737.3	10772.7	10714.2	10695.7	10968.8	-268.5	-2.4%
C161 - Sawmills	23238.9	26898.1	26157.2	26367	27448.2	28100.6	26777.1	26572.6	3333.7	12.5%
C171 - Pulp and paper	56446.9	60239.8	57775.2	62447.3	60094.1	60761.6	63926	63402.2	6955.3	11.0%
C172 - Articles of paper	56587	60900.7	59397.7	60499.4	61180	62663.4	61108	64781.2	8194.2	12.6%
C192 - Refineries	5871.4	6738.7	6578.3	6649.4	6302	4758.3	4123	5065.5	-805.9	-15.9%
C201 - Basic chemicals	177798.3	200121.4	206323.9	207841.6	201739.8	195236.9	179549	220082	42283.7	19.2%
C206 - Man-made fibres	5300.9	5638	5059.2	5168.7	5232.9	5131.1	5232.7	5531.6	230.7	4.2%
C222 - Plastics products	132238.9	143411.4	141748.1	144123.2	145218	151736.9	154804.9	163943.1	31704.2	19.3%
C231 - Glass	27630.7	29179.2	28012.5	27377.8	27446.8	28606	28335.4	29312	1681.3	5.7%
C232 - Refractory products	3591.4	3831.5	3789.5	3512.4	3629.6	3439.5	3363.5	3590.9	-0.5	0.0%
C233 - Clay building materials	12521.7	13487	12443.1	11957.2	12090.6	12366.7	12599.9	13334.2	812.5	6.1%
C234 - Porcelain and ceramics	5769.5	6113.8	5745.6	5586.6	5934.5	6218.9	6249.1	6346.8	577.3	9.1%
C235 - Cement, lime and plaster	11844.3	11928.5	10996.2	10364.1	10135.4	10204.9	10532.6	11463.3	-381	-3.3%
C237 - Stone	11876.5	10778.3	9865	9950.1	10347.7	9143.3	9691.1	9070.6	-2805.9	-30.9%
C239 - Abrasive products	15674.4	18978.3	17936.5	17519.2	17817.8	17085.9	17044.2	17632	1957.6	11.1%

Source: Study on energy prices, costs and their impact on industry and households

Sector	2010	2011	2012	2013	2014	2015	2016	2017	Absolute change (M€) 2010-2017	Relative change 2010-2017
C241 - Iron and steel	100665.1	118602.8	105255.2	96850.7	96313.3	90939.8	84644.1	103336.4	2671.3	2.6%
C244 - Non-ferrous metals	76865.8	95024.7	92610.6	86358.2	85973.4	90355	84481.3	96992.5	20126.7	20.8%
C245 - Casting of metal	25772.4	29751.1	28754	27819.3	27682.2	28384.6	26694.7	29160.8	3388.4	11.6%
C11 - Beverages	56801.8	58908.6	60102.7	60303.9	59400.5	60004.4	61780.8	62886.5	6084.7	9.7%
C21 - Pharmaceutical products	83615.5	86869.8	88072.8	92419	92832.9	98317	99264.8	94171.1	10555.6	11.2%
C25 - Fabricated metal products	279249.4	303457.3	293497.6	289441.6	293650.8	296059.3	302239.7	324983.7	45734.3	14.1%
C26 - Computer and electronics	173639.2	171769.1	161733.7	154596.8	152052.5	160227.7	157725.5	162132.8	-11506.4	-7.1%
C27 - Electrical equipment	192604.1	209045.3	202962	200307.4	206045.2	208820.1	210988.2	226034.5	33430.4	14.8%
C28 - Machinery and equipment	397291.2	454096.1	460598	459101.3	471109.7	481767.2	492308	531370.6	134079.4	25.2%
C29 - Motor vehicles	524369.5	603716.3	609704.6	624553.3	665120	737913.5	765761.9	811401.5	287032	35.4%
C30 - Other transport equipment	76665.2	77451.9	79529	80900.7	85643.8	93350.7	97835.4	105153.3	28488.1	27.1%
C32 - Other manufacturing	58715.8	61897.9	61222.5	60851.6	61976	65451.1	67022.9	74204.8	15489	20.9%
C33 - Repair of machinery	75851.5	77880.8	78894.9	78826.4	80882	82164.5	84447.3	89889.5	14038	15.6%

Table C-5 Overview of energy and total production cost changes across manufacturing and non-manufacturing sectors between 2010-2017 in the EU27.

Manufacturing sectors	Changes in total values across the EU27 2010-2017				Change in energy cost share 2010-2017 (simple average)	
	Absolute Δ Energy costs (M€)	**Relative Δ** Energy costs (%)	**Absolute Δ Total production costs (M€)**	**Relative Δ Total** production costs (%)	**Absolute Δ energy costs as a** share of total production costs (%)	**Relative Δ** energy costs as a share of total production costs (%)
C103 - Fruit and vegetables	38.9	4.0%	11080.4	24.9%	-0.6%	-21.9%
C106 - Grain products	-87.9	-10.9%	6049.1	22.0%	-1.1%	-30.5%
C132 - Textiles	-171.7	-41.8%	-268.5	-2.4%	-1.5%	-40.4%
C161 - Sawmills	-1.5	-0.2%	3333.7	12.5%	-0.4%	-12.7%
C171 - Pulp and paper	-2161.4	-33.6%	6955.3	11.0%	-4.7%	-40.9%
C172 - Articles of paper	-322.6	-19.0%	8194.2	12.6%	-0.9%	-29.3%
C192 - Refineries	-47.9	-37.9%	-805.9	-15.9%	-0.6%	-28.0%
C201 - Basic chemicals	-2014.9	-16.6%	42283.7	19.2%	-2.2%	-32.7%

Source: Study on energy prices, costs and their impact on industry and households

Manufacturing sectors	Changes in total values across the EU27 2010-2017				Change in energy cost share 2010-2017 (simple average)	
	Absolute Δ Energy costs (M€)	**Relative Δ** Energy costs (%)	**Absolute Δ Total production costs (M€)**	**Relative Δ Total** production costs (%)	**Absolute Δ energy costs as a** share of total production costs (%)	**Relative Δ** energy costs as a share of total production costs (%)
C206 - Man-made fibres	-67.5	-18.8%	230.7	4.2%	-1.5%	-22.2%
C222 - Plastics products	-180	-4.7%	31704.2	19.3%	-0.7%	-23.1%
C231 - Glass	-393.8	-17.0%	1681.3	5.7%	-1.8%	-21.7%
C232 - Refractory products	-43.6	-18.6%	-0.5	0.0%	-1.2%	-18.6%
C233 - Clay building materials	-305.2	-20.2%	812.5	6.1%	-3.0%	-25.1%
C234 - Porcelain and ceramics	-44.5	-14.8%	577.3	9.1%	-1.2%	-22.6%
C235 - Cement, lime and plaster	-666.6	-27.7%	-381	-3.3%	-5.1%	-25.3%
C237 - Stone	-114.7	-28.0%	-2805.9	-30.9%	-0.2%	-5.7%
C239 - Abrasive products	33.8	4.3%	1957.6	11.1%	-0.4%	-7.3%
C241 - Iron and steel	-2769	-29.0%	2671.3	2.6%	-2.9%	-30.8%
C244 - Non-ferrous metals	-107.8	-3.4%	20126.7	20.8%	-1.0%	-23.5%
C245 - Casting of metal	-227	-14.5%	3388.4	11.6%	-1.5%	-24.4%
C11 - Beverages	-100.2	-6.8%	6084.7	9.7%	-0.4%	-15.8%
C21 - Pharmaceutical products	-83.3	-8.4%	10555.6	11.2%	-0.2%	-18.6%
C25 - Fabricated metal products	-792.4	-12.6%	45734.3	14.1%	-0.6%	-24.9%
C26 - Computer and electronics	-80.7	-7.1%	-11506.4	-7.1%	0.0%	-0.5%
C27 - Electrical equipment	-300	-15.2%	33430.4	14.8%	-0.3%	-27.7%
C28 - Machinery and equipment	64.1	1.6%	134079.4	25.2%	-0.2%	-24.0%
C29 - Motor vehicles	295.8	6.7%	287032	35.4%	-0.3%	-31.0%

Manufacturing sectors	Changes in total values across the EU27 2010-2017				Change in energy cost share 2010-2017 (simple average)	
	Absolute Δ Energy costs (M€)	**Relative Δ** Energy costs (%)	**Absolute Δ Total production costs (M€)**	**Relative Δ Total** production costs (%)	**Absolute Δ energy costs as a** share of total production costs (%)	**Relative Δ** energy costs as a share of total production costs (%)
C30 - Other transport equipment	-108.7	-16.0%	28488.1	27.1%	-0.3%	-38.8%
C32 - Other manufacturing	-72.6	-10.9%	15489	20.9%	-0.3%	-29.5%
C33 - Repair of machinery	-25.6	-3.3%	14038	15.6%	-0.2%	-18.4%
Other sectors						
B - Mining and quarrying	-320.4	-9.8%	-55231.7	-48.8%	2.2%	76.2%
B06 - Oil and gas	38.1	31.0%	-49815.4	-72.7%	0.7%	380.6%
B07 - Mining of metal ores	6.3	8.4%	96.5	25.3%	-2.7%	-13.5%
B08 - Other mining	-137.4	-7.6%	-1896.4	-9.0%	0.1%	1.6%
D35 - Electricity, gas and steam	-3388.1	-4.1%	98789.9	19.4%	-3.2%	-19.7%
E38 - Waste management	-16.8	-5.5%	1859.0	11.9%	-0.3%	-15.5%
F - Construction	-1815.2	-13.9%	54740.1	5.0%	-0.2%	-18.0%
G - Wholesale and retail trade	24.2	2.6%	43054.0	19.6%	-0.1%	-14.2%
H49 - Land transport	4594.7	15.1%	30085.9	29.8%	-3.4%	-11.3%
H51 - Air transport	155.6	22.5%	386.4	9.3%	2.0%	12.1%
I - Accommodation and restaurants	-18.5	-3.1%	4844.4	37.7%	-1.4%	-29.6%
J - Information and communication	-26.7	-13.7%	3668.1	22.8%	-0.4%	-29.7%

Annex D - Task 2 Overview of selected Energy Intensive Industries

This annex contains the complete overview of one non-manufacturing sector (Data Centres) and five selected Energy Intensive Industries.For the five energy-intensive industries were analysed based on a bottom-up approach, with the cooperation of EU industry associations. Results of sectoral analysis are detailed subsequently. The initial results of the analysis were circulated to EU industry associations so they could corroborate results and conclusions.

The following sections are the results from Trinomics analysis, together with comments on the main findings of the study from the following industry associations: Glass Europe, Zinc Association, Euroalliages, Fertilizers Europe, Concawe and Fuels Europe.

Data Centres

Introduction

Data centres are a relatively new phenomenon, dating back to the late 1990s and the first Internet bubble. They consist in the concentration in one location of a very large number of server computers that provide on-line services over the Internet, with a high availability and reliability which are part of the contract offered to the customer. This concentration enables the sharing of a common infrastructure, such as electric power supply, cooling, high-bandwidth Internet access, security, redundancy, data storage. The servers themselves often are custom-designed and manufactured for the operator of the data centre, to achieve high performance and low energy consumption.

A data centre, compared to the option of hosting one's own servers in a company, provides the following features:

- Completely delegated management of the physical, environmental, reliability and security aspects of the server;
- Lower and better controlled costs, because of the mutualisation of resources (specifically: of the redundant capacity needed to achieve high availability) and of the subscription business model.

Main areas of usage are:

- Data centres are used to supply all forms of on-line Internet-based services:
- E-commerce;
- Information sharing and on-line presence of institutions, companies and NGOs;
- Collaborative work;
- Audio and video streaming;
- Social media, etc.

NACE codes

Data centres are registered under NACE rev.2 code 63.1 Data processing, hosting and related activities; web portals.

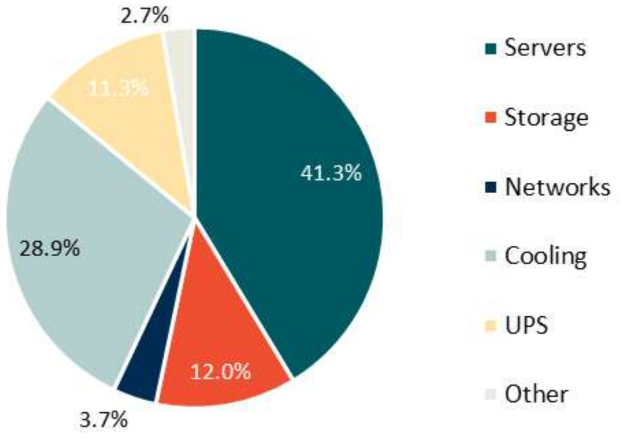
Prrocess

Data centres produce data processing power, in a continuous mode. The main energy consuming units are[160]:

- the servers, which contain the central processor (CPU) and the memory (RAM): 41.3% of total energy consumption of the sector in the EU27 in 2018 (in an upward trend since 2010, when they represented only 33.7% of the total);
- the cooling, which prevents the damaging of the servers by evacuating their excess heat: 28.9% of total energy consumption of the sector in the EU in 2018 (in an downward trend since 2010, when they represented only 32.8% of the total);
- the uninterrupted power supply - UPS - which ensure that the servers are permanently fed with electric power, including in case of micro-interruptions of the network supply: 11.3% of total energy consumption of the sector in the EU in 2018 (in a slow downward trend since 2010, when they represented only 15.0% of the total);
- the data storage (generally as hard disk drives): 12% of total energy consumption of the sector in the EU (constant over time);
- the connection to the network: 3.7% of total energy consumption of the sector in the EU (constant over time).

This evolution over time shows an increased technical efficiency of data centres, whereby a growing fraction of the energy consumption is used by the productive units (the servers, the storage and the communication network), and a decreasing part by the ancillary services that address the inefficiencies of the system, namely overheating and power interruptions (respectively: the cooling system and the UPS).

Figure D-1 Share of energy consumption of EU data centres per function (2018)



Electricity costs of the sector

The energy costs of the sector are estimated by multiplying:

[160] Source: Montevecchi, F., Stickler, T., Hintemann, R., Hinterholzer, S. (upcoming). Energy-efficient Cloud Computing Technologies and Policies for an Eco-friendly Cloud Market—SMART 2018/0028, carried out for the European Commission by Environment Austria and Borderstep Institute. The study will be published in November 2020.

- The electricity consumption of data centres in selected Member States of the EU27 (Germany, France, and the Netherlands), in the remaining countries of the EU27 and in the United Kingdom[161]; by
- The price of electricity as delivered to large-scale industrial users in the same selected Member States, on average in all EU27 Member States and in the United Kingdom, as per the following calculation.

Based on data cited by DG ENER [162], the number of data centres (colocation, from service providers) can be evaluated as follow, from which an average energy consumption per data centre can be computed.

Table D-1 Number of data centres (colocation, from service providers) and average energy consumption.

Country	Number of data centres (colocation) - 2019	Total energy consumption (TWh / year) -2018	Estimation of average power consumption per data centre (MWh / year)
Germany	425	14,02	32.988
France	250	10,96	43.840
Netherlands	250	5,68	22.720
Rest of EU27	889	33,88	38.110
Total EU 27	1814	76,85	42.365
UK	423	12,31	

Source: own elaboration based on Cloudscene cited by DG ENER, and DG CNECT

From this, we conclude that the price band to be used is Band IE, consumption between 20 and 70 MWh/year[163].

We used the average price of electricity delivered to industrial clients for all EU27 Member States, which is provided by Eurostat, as an approximation of the average price of electricity delivered to industrial clients in the EU27 Member States other than Germany, France and the Netherlands, which is unavailable.

Table D-2 Estimation of the electricity costs of the sector of Data Centres in the EU27 and the UK (2010-2018) in M EUR / year

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Germany	885,4	1.063,9	1.009,3	1.142,7	1.214,6	1.165,7	1.054,8	1.326,7	1.256,2
France	462,1	491,9	529,3	543,4	569,8	595,7	553,2	552,3	632,4
The Netherlands	306,1	323,4	324,3	367,3	367,1	367,1	327,7	293,8	320,4
Rest of EU27	1.746,1	1.941,3	2.071,5	2.202,6	2.259,0	2.286,0	2.153,5	2.338,5	2.412,3
Total EU 27	3.399,8	3.820,4	3.934,5	4.256,0	4.410,5	4.414,5	4.089,2	4.511,3	4.621,2

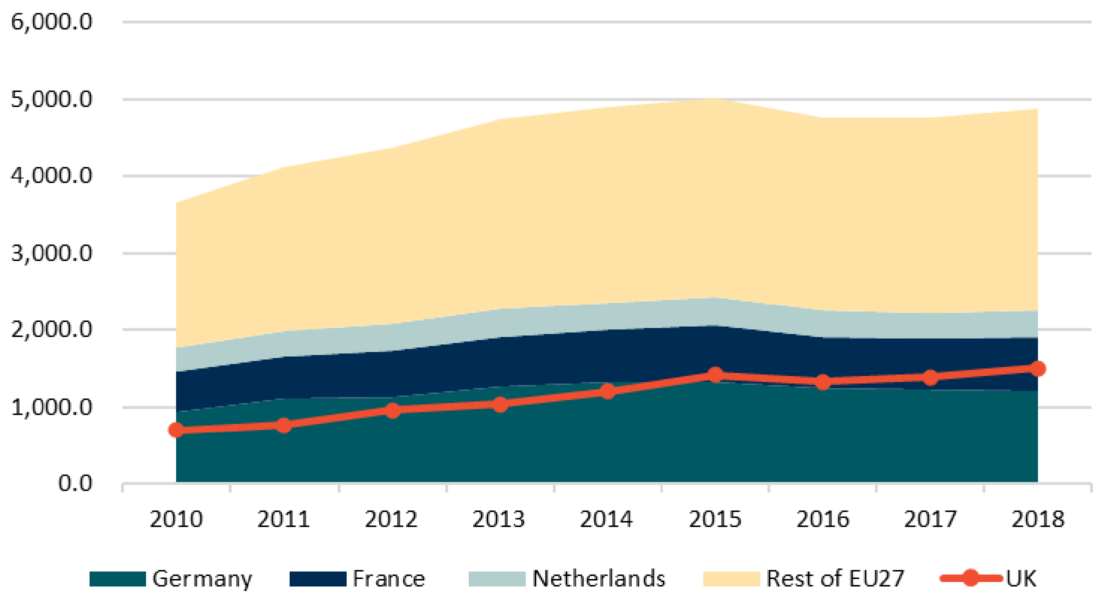
[161] As provided by Montevecchi, F., Stickler, T., Hintemann, R., Hinterholzer, S. (upcoming). Energy-efficient Cloud Computing Technologies and Policies for an Eco-friendly Cloud Market—SMART 2018/0028, carried out for the European Commission by Environment Austria and Borderstep Institute. The study will be published in November 2020

[162] ICT Impact study (2020, upcoming), study prepared by VHK and Viegand Maagøe for the European Commission, DG ENER

[163] As provided by Eurostat, "Electricity prices for non-household consumers - bi-annual data (from 2007 onwards) [nrg_pc_205]", prices in EUR / kWh, excluding VAT and other recoverable taxes and levies, for Band IE : 20 000 MWh < Consumption < 70 000 MWh.

UK	689,7	741,4	913,0	1.014,8	1.165,8	1.385,0	1.308,7	1.366,6	1.444,0

Figure D-2 Estimation of the electricity costs of the sector of Data Centres in the EU28 (2010-2018) in M EUR / year



Under these assumptions and approximations, we see that the electricity costs of the sector of Data Centres in the EU27 has been rising sharply over the years 2010 – 2015 (from 3,640 M€ in 2010 to 5,020M€ in 2015), and has remained stable over the years 2015 to 2018. This evolution is essentially related to the evolution of the prices for electricity for large industrial users, which followed the same pattern. Electricity costs in the UK display similar evolutions.

The share of the electricity costs to the total purchases of goods and services of the sector in the EU27 is then estimated by comparing this estimation with the figures provided by Eurostat – SBS data on the production costs and turnover of the sector.

Table D-3 Contribution of electricity costs in the total production costs of the EU27 sector of data centres (2010 - 2017)

EUR bio / year	2010	2011	2012	2013	2014	2015	2016	2017
Estimated electricity costs	3,6	4,1	4,4	4,7	4,9	5,0	4,8	4,8
Other purchases of goods and services	11,9	17,2	15,0	15,5	15,9	18,5	22,1	23,9
Personnel costs	10,1	11,4	12,1	13,1	12,6	13,7	14,5	15,3
Share of electricity costs in total production costs	14,2%	12,5%	13,9%	14,2%	14,7%	13,5%	11,5%	10,8%
Production value	30,7	37,7	37,6	39,5	40,7	44,9	48,3	52,3
Share of electricity costs in production value	11,9%	10,9%	11,6%	12,0%	12,0%	11,2%	9,9%	9,1%

The estimated electricity costs represent a large share of the overall production costs of the EU27 sector of data centres, comparable to that of the other energy-intensive industries: between 10.8 and 14.7% over the years 2010 – 2017. They also represent an important fraction of the production value of the sector: between 9.1 and 12.0%. These fractions have reached their peak in 2014 and decreased between then and 2018.

Flat glass

Introduction

Characteristics of the product

Based on input by industry association Glass for Europe[164], the main features of flat glass are that:

- It is transparent;
- It insulates from noise and temperature;
- It is unalterable and easy to maintain;
- It lasts for decades;
- It endures all weather conditions;
- It is inert;
- It is fully and endlessly recyclable.

Main areas of usage

The main areas of usage of flat glass are:

- In construction, for windows, but also for facades, floors, and greenhouses;
- In the automotive sector, for windshields, side screens and sun roofs;
- In all other passenger transport vehicles: trains, tramways, boats, busses;
- For solar energy: to protect photovoltaic cells, to build solar thermal collectors, and in concentrated solar power mirrors;
- In domestic appliances (oven doors, stove plates, refrigerator shelves);
- In the screen of electronic devices.

NACE codes

Flat glass products appears under two NACE rev.2 codes:

- "23.11 Manufacture of flat glass";
- "23.12 Shaping and processing of flat glass".

Products under 23.12 are flat glass sheets, which have been transformed during a downstream process to give specific properties to these products (insulation, increased resistance, special shape, etc. *Although 23.12 activities use significant amounts of energy, these activities are not energy-intensive in the meaning of the EU ETS directive*.

The energy-intensive part of the process is the manufacture of flat glass sheets whereby raw materials and recycled glass is melted into large sheets of flat glass. This production is reported under NACE code 23.11 and is the subject of this energy cost study investigation.

Stages in the production process

Flat glass is essentially produced using the float process, which consists in the following stages:

- Smelting the materials together, namely sand, soda ash (sodium carbonate), dolomite, limestone, and salt cake (sodium sulfate), at a temperature of 1,500°C;
- Letting the molten glass (at a temperature of 1,200°C) float on a bath of molten tin, so as to control thickness and to form an uniform sheet with perfectly smooth surfaces on both sides;
- As the glass floats along the tin bath, the temperature is gradually reduced from 1100°C until at approximately 600°C the sheet can be lifted from the tin onto rollers that feed it into a cooling kiln to reach ambient temperature without cracking due to remaining internal strain.

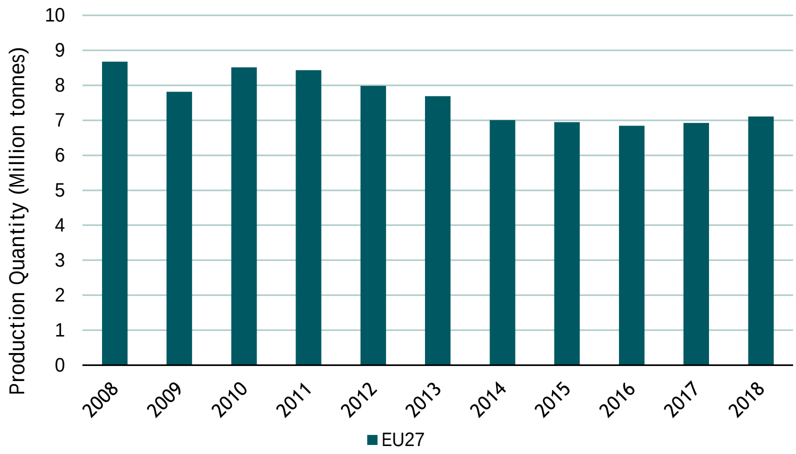
[164] https://glassforeurope.com/

The whole process is energy-intensive, due to the high temperatures needed to melt glass without remaining impurities.

Economic situation of the sector

The production quantity of flat glass has decreased from around 8.7 million tonnes in 2008 to around 7.1 million tonnes in 2018. Production quantity gradually decreased from 2010 on before levelling to around 69 million tonnes between 2015-2017. Between 2017 and 2018 production quantity rose for the first time since 2010, increasing by 1.8 million tonnes.

Figure D-3 Trends in production quantity of flat glass in the EU27 Member States (tonnes).



Source: Glass for Europe based on COMEXT DS 056120 (2020).

Note: Production value was collected in m2 as reported in COMEXT codes 23.11.12.12, 23.11.12.14, 23.11.12.17, 23.11.12.30, 23.11.12.90. A conversion factor of 10kg/m² (0.01t/m²) was used, as advised by Glass Europe.

The average production value of flat glass between 2008-2018 was 2.6 billion Euros. From 2008 to 2009, its value fell sharply from 3.4 to 2.4 billion Euros. Value was recovered in 2010 and 2011 before declining steadily and bottoming out in 2015 at 2.3 billion Euros alongside a decline in production volumes. Since 2015, flat glass production value increased under the result of recovery in the EU market leading to increased prices (at constant volume) and reached 2.8 billion Euros in 2018.

Figure D-4 Trends in production value **of flat glass in the EU27 (M€)**.

Source: PRODCOM (2020).
Notes: Sum of PRODCOM codes 23.11.12.12, 23.11.12.14, 23.11.12.17, 23.11.12.30 and 23.11.12.90.

When analysing production data per country in the PRODCOM database, data are incoherent: production missing in important countries, e.g. Czech Republic or Bulgaria, production reported in others with no production sites, e.g. Finland, Estonia, and total value below overall EU production.

Public datasets being unreliable, breakdown in production can only be derived from the number of production sites in the different EU countries and information provided by Glass for Europe. Production sites in the EU flat glass sector are concentrated in a limited number of Member States, as listed below.

Table D-4 Number of industrial sites and float production lines in the EU flat glass sector by Member State (2019).

Country	Number of sites	Number of float lines
Belgium	2	5
Bulgaria	1	2
Czech Republic	2	3
France	6	7
Germany	11	12
Hungary	1	1
Italy	6	6
Luxembourg	2	2
Poland	5	6
Romania	1	1
Spain	5	5

Source: Glass for Europe.

Glass for Europe, on its website, https://glassforeurope.com/the-sector/key-data/, estimates that 25% of the EU 28 production is manufactured in Germany, followed by France (13%), Poland, Spain and Italy (10% each) and Belgium (8%). Other producing countries are the Czech Republic, Luxembourg, Bulgaria, Hungary, Romania and the UK at the immediate EU borders.

Trade situation of the sector

The EU27 is a net exporter of flat glass in value (but not in quantity). In terms of imports of flat glass, there is an increasing import trend since 2014 when 140 million Euros worth of flat glass were imported up to 2018 when imports reached 270 million Euros. In terms of exports of flat glass, there was a decreasing export trend since 2010 when 553 million Euros worth of flat glass were exported down to 2015 with 418 million Euros. Since 2016 there has been a slight increase in exports value of flat glass, reaching 466 million Euros in 2018.

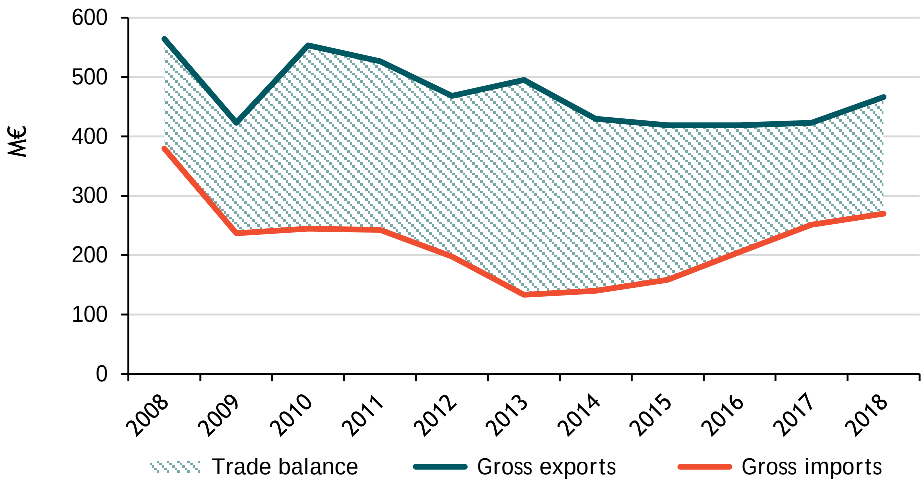
The trade balance range reached its peak at 361 million Euros in 2013 and has decreased since then to 196 million Euros in 2018. This evolution can be connected to the phase of over-capacity experienced by the EU flat glass industry over the years 2011 to 2015 inclusive: during that time, the volume and, even more so, the value, of the EU internal market for flat glass has plummeted therefore imports from outside EU were at unprecedented low levels. At the same time, the value of extra-EU exports remained more or less constant. Since 2016, the external competitive position of the EU flat glass sector seems to deteriorate slightly: the trade balance of the sector, while remaining robustly positive, has been declining.

According to Glass for Europe and when looking at evolutions in imports in quantities, variations of imports over 2008-2012 can be attributed to the 2008 financial crisis and the volatility that followed. The crisis caused a reduction of flat glass consumption in the EU and abroad, leading to production overcapacity and to low levels of product prices in the EU. Non-EU glass producers – especially China and the Middle East – were less incentivised to export their products to EU nations. The market has stabilised and started a slow recovery since 2013 such that prices have increased; consequently, imports into the EU have also increased.[165]

Over the last five years, imports of flat glass from outside the EU substantially increased (growing by 90% between 2012 and 2017). This is due to expanded production capacity at EU borders, e.g., the construction of float lines in Egypt, Algeria, Turkey and Belarus, which were built to target the EU market. Pressure from external competition is likely to ramp up in the coming years provided the EU market remains strong, and production over-capacity in China will require careful monitoring.[166]

Imported products are primarily 'common' products for use in buildings, solar glass and furniture, that are also manufactured in the EU (e.g., basic float glass). In contrast, EU exports are mostly characterised by high value-added products: extra thin glass, extra thick glass, specific coated glass etc.[167]

Figure D-5 **Trends in trade balance of flat glass in the EU27 Member States (M€).**



Source: COMEXT (2020).
Notes: Includes COMEXT categories under code 7005.

The EU flat glass sector is exposed to international trade and this exposure grows alongside growth in extra EU imports. The share of the internal consumption served by extra-EU imports remains in the range 10 to 15% at times of a depressed EU market but grows above 15% when the market recovers (up to 17% pre 2008 crisis, 15% reached in 2017). The share of production value dedicated to extra-EU exports had remained under 30% over the last 10 years. It should be noted that the EU exports are mainly high-added value products, which indicates the share of the production quantity of flat glass products dedicated to exports is rather small.

[165] Consultation with Glass for Europe, 15 July 2020.
[166] Ibidem.
[167] Ibidem.

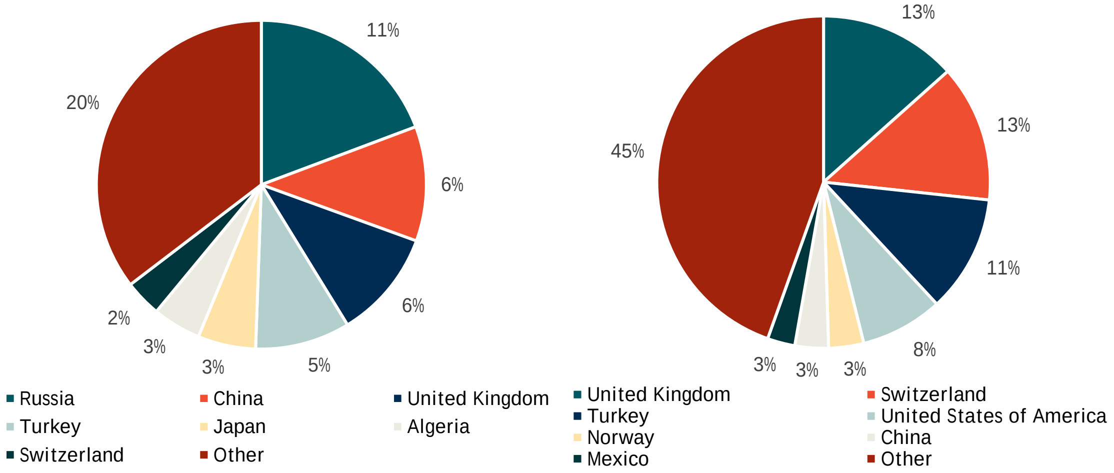
Table D-5 Exposure of flat glass in the EU27 to international trade.

Indicator	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross exports (M€)	564	423	553	527	468	495	429	418	419	423	466
Gross imports (M€)	379	237	245	242	198	133	140	159	206	251	270
Production value (M€)	3,424	2,442	2,725	2,780	2,446	2,303	2,301	2,276	2,467	2,745	2,828
Internal consumption (M€)	3,239	2,256	2,417	2,496	2,176	1,941	2,011	2,016	2,254	2,574	2,632
Share of internal consumption served by extra-EU imports	11.7%	10.5%	10.1%	9.7%	9.1%	6.9%	6.9%	7.9%	9.1%	9.8%	10.3%
Share of production dedicated to extra-EU exports	16.5%	17.3%	20.3%	18.9%	19.1%	21.5%	18.7%	18.4%	17.0%	15.4%	16.5%

Source Comext and PRODCOM.

The main three extra-EU import sources are Russia, China and the UK which together account for 23% of imports between years 2016 to 2018; while the main three extra-EU export destinations are the UK, Switzerland and Turkey accounting for 38% of exports in the same period. That being said, it must be specified that, as part of the EU single market, the UK was completely integrated within the EU float glass market hence the important trade. For instance, the vast majority of the Irish glass market is traditionally supplied from the UK for proximity and logistics reasons while Ireland has no production facility. Float glass trade with the UK could evolve depending on future trade conditions between the UK and the EU.

Figure D-6 Distribution of imports (left) and exports (right) of flat glass in the EU27 Member States.



Source: COMEXT (2020).
Notes: based in the average of years 2016-2018.

Sample statistics

The sample consists of 40 installations in Europe (EU27 and UK), out of a total number of 60[168] (the most updated number of flat glass production in the EU). The sample is spread in 11 out of the 12 Member States with installations in Europe. Due to confidentiality reasons, the countries included in the sample cannot be exposed. The regional spread of the surveyed plants was as follows: 19 plants in the North Western Europe (NWE)[169] region, 7 plants in the Central Eastern Europe (CEE)[170] region and 10 in

[168] Glass of Europe, 2020. https://glassforeurope.com/the-sector/key-data/
[169] North Western Europe (NWE): Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden.
[170] Central Eastern Europe (CEE): Lithuania, Romania, Bulgaria, Czech Republic, Hungary, Estonia, Latvia, Slovakia and Poland.

the Southern Europe (SE)[171] region (see Table D-6). There were also 4 questionnaires received for plants in the non-EU NWE[172] region.

Table D-6 Flat Glass plants participating in the survey

Geographical regions	Questionnaires collected
North Western Europe (NWE)	19
Central Eastern Europe (CEE)	7
Southern Europe (SE)	10
Non-EU NWE	4
Total	40

Between 2014 and 2019 the production output by sampled plants represented at least 74% of the overall sectoral production output at the EU27 level (Table D-7). However, it is worth stressing that several plants included in the sample did not disclose their production output on years 2014-2015; therefore, the sample certainly represents a larger share of the total quantity of production sold by EU producers of flat glass.

Table D-7 Production output of sampled plants out of total value of production sold by EU27 producers (%).

Flat glass	2014	2015	2016	2017	2018	2019
Production output%	74%	76%	111%	109%	108%	n.a.
Plants disclosing their production output	27	27	35	35	36	36

Source: Own elaboration with data collected at the plant level and from COMEXT via Glass Europe.
Note: COMEXT values for 2019 are not available.

Table D-8 describes the ranges of installed capacity from the 34 plants that provided information on annual production capacity. In 2017 and 2018, the plants reported production levels higher than Eurostat reports; this inconsistency was explained by Glass for Europe, which explained that while Eurostat's data accurately parallels trends in the flat glass sector, they do not always reflect full production quantities of the sector.

Note that the table presents only the production capacity of molten glass, and not of actual production output of saleable products. For confidentiality reasons it is not possible to present production capacities for individual plants in the sample. Plants manufacturing flat glass are built around one or several furnaces, so that the differences in production capacity per plant essentially reflect the number of furnaces in each plant. Typically, a single furnace produces 600 to 650 tonnes of molten glass per day, i.e. between 210 and 235 thousand tonnes per year.

Table D-8 Plant capacity range of the sample. Source: Own elaboration with data from flat glass companies.

Capacity range (thousand tonnes/year)	Share of plants in sample
<250	47%
250-500	33%
>500	14%

[171] Southern Europe (SE): Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, and Spain.
[172] Non-EU NWE region: The United Kingdom (UK) and Norway

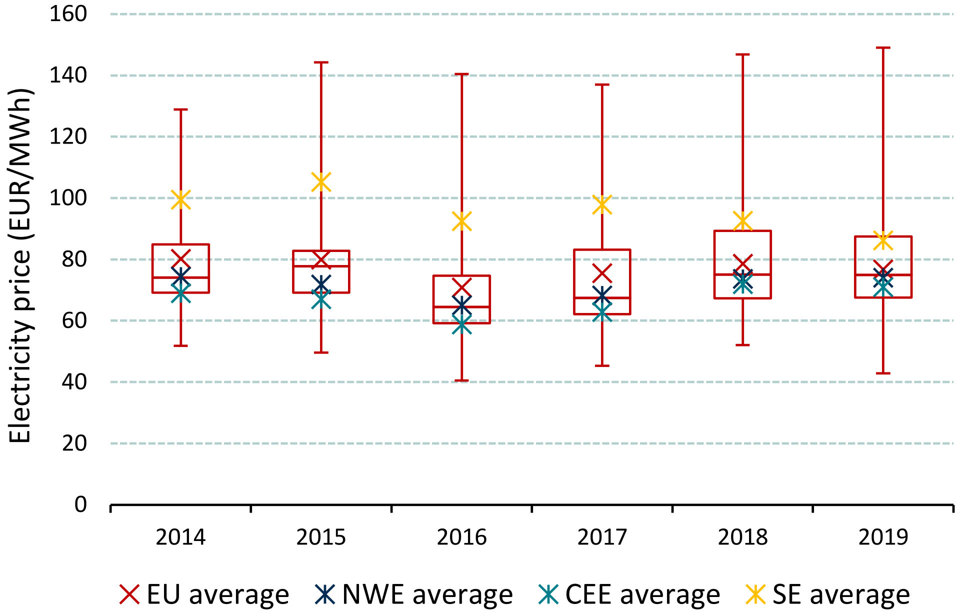
Evolution of energy prices

Electricity price

Electricity prices in €/MWh paid by EU flat glass producers varied over the 2014-2019 period, with a peak in 2014 and then decreased in 2016 to their lowest value during the period observed (simple average of €70.9/MWh. From 2017 on electricity prices went on the rise again, but without reaching pre-2016 levels (Table D-9 ,Figure D-7).

Electricity prices appear to be consistently higher in the SE region than in the NWE and CEE regions, while CEE region tends to have lower prices than the other regions. However, in recent years there seems to be a convergence in electricity prices observed in the different regions, with prices in SE falling to €86.3/MWh in 2019, and CEE going up to €71/MWh in 2019 (simple averages).

Figure D-7 **Electricity prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration with data from flat glass companies.

Table D-9 **Descriptive statistics for electricity prices paid by sampled EU flat glass producers (€/MWh) -** simple averages.

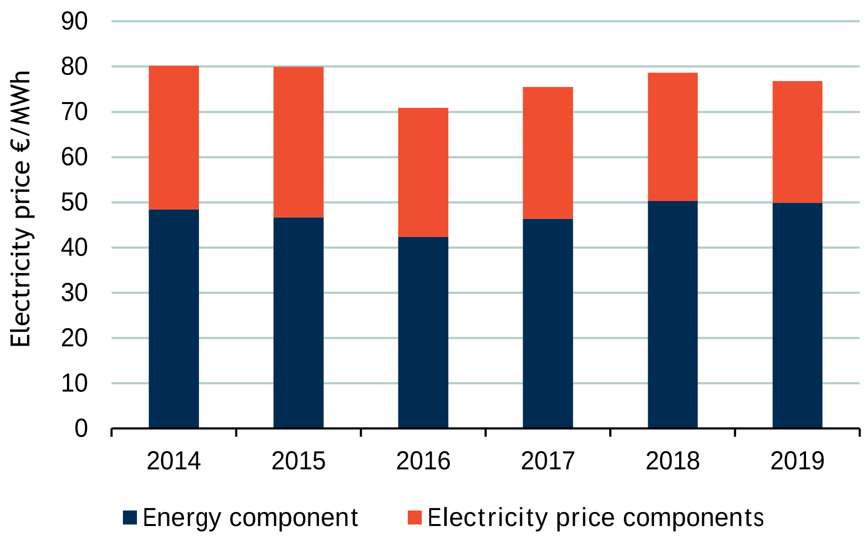
Electricity prices (€/MWh)	2014	2015	2016	2017	2018	2019
EU	80.2	79.9	70.9	75.5	78.6	76.8
NWE	74.5	71.9	65.1	68.3	73.7	74.0
CEE	69.1	67.1	58.9	62.9	72.0	71.0
SE	99.5	105.3	92.5	98.0	92.7	86.3

Source: Own elaboration with data from flat glass companies.

Components of electricity price

Figure D-8 shows the components of electricity price for producers of flat glass in the EU between years 2014 to 2019. These are split between energy component and electricity price components. Electricity price components refer to: network costs - Transmission System Operator (TSO) and Distribution System Operator (DSO) - if applicable, levies, taxes, interruptability discounts and CO_2 retributions but excluding VAT. Average electricity price components have remained somewhat constant during the period observed, varying between €42-€50 per MWh, with the highest observation in 2018. The energy components of the electricity price have been increasing since 2017, reaching 50 €/MWh in 2018 and 2019. In terms of relative shares of the electricity price, price components peaked in 2015 when they accounted for 42% of electricity price. The following years the price components share decreased down to 35% in 2019.

Figure D-8 Components **of the electricity price (€/MWh, EU)** - Simple averages.



Source: Own elaboration with data from flat glass companies.

Figure D-9 below shows the electricity price components as a share of the total electricity price in the different regions of the EU. In 2014 the price component shares for the three regions were aligned between 35-39%, but they started diverging in the following years. By 2019 the electricity price component accounted for 45% in the NWE region, whereas in the CEE and SE regions it went down to 24% and 19% respectively.

Figure D-9 Evolution of the electricity price components as a share of the total electricity price - Simple averages.

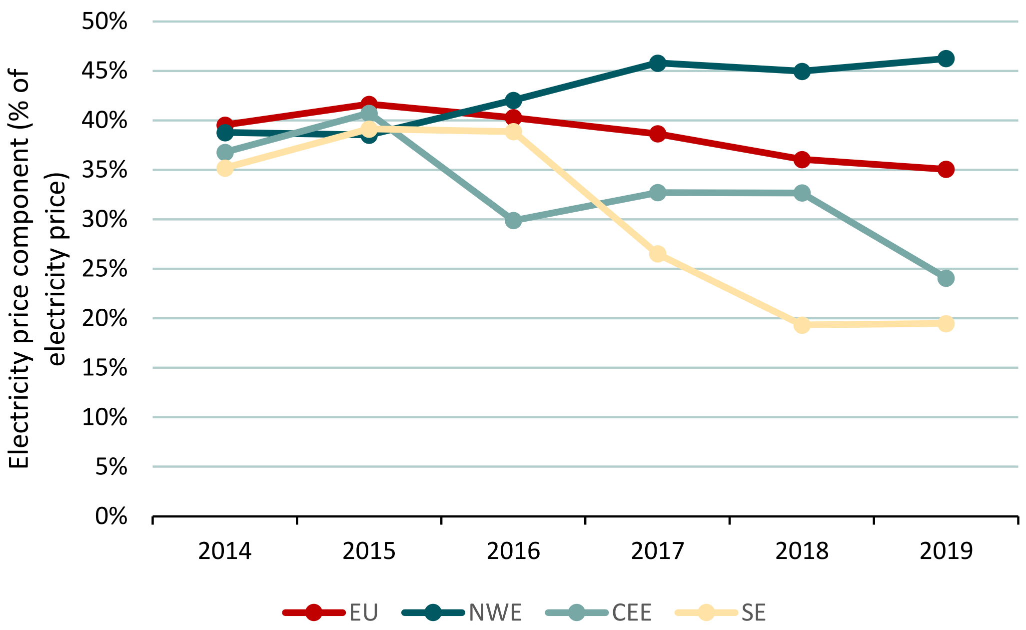


Table D-10 **Components of electricity price: energy component (€/MWh)** - Simple averages.

Energy **component (€/MWh)**	2014	2015	2016	2017	2018	2019
EU	48.5	46.7	42.3	46.3	50.3	49.9
NWE	45.6	44.2	37.7	37.0	40.6	39.8
CEE	43.7	39.7	41.3	42.3	48.5	53.9
SE	64.5	64.1	56.5	72.0	74.7	69.5

Source: Own elaboration with data from flat glass companies.

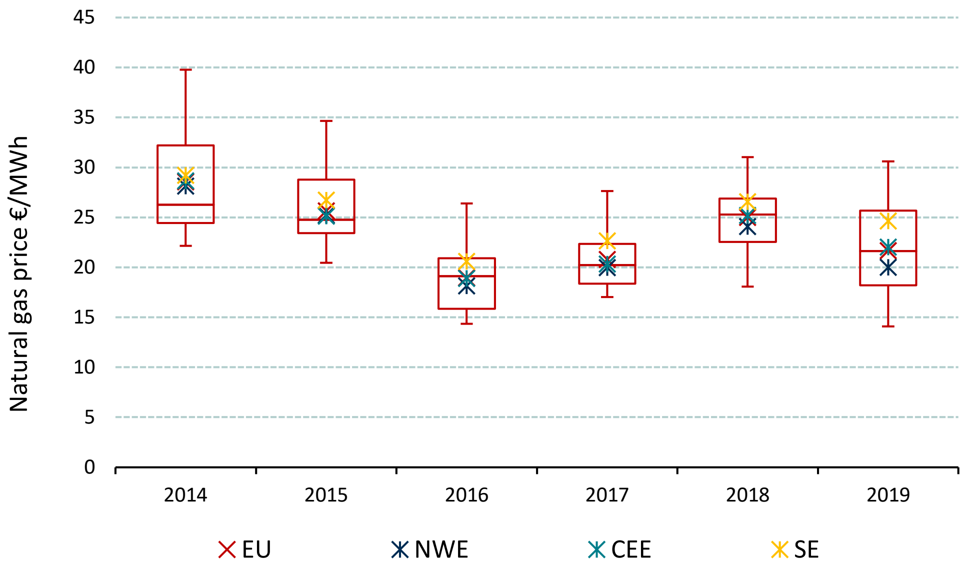
Table D-11 **Components of electricity price: electricity price component (€/MWh)** - Simple averages.

Electricity price component (€/MWh)	2014	2015	2016	2017	2018	2019
EU	31.7	33.3	28.5	29.2	28.4	26.9
NWE	28.9	27.7	27.4	31.3	33.1	34.2
CEE	25.4	27.3	17.6	20.6	23.5	17.1
SE	35.0	41.2	36.0	26.0	17.9	16.8

Natural gas price

Figure D-10 and Table D-12 show that after a decreasing trend from 2014 to 2016, the average price paid by producers of flat glass for natural gas prices started an increasing again, reaching 25 €/MWh (EU simple average) in 2018. The price of natural gas reported by most EU plants did not deviate significantly from the mean. Plants in the SE region reported on average slightly higher natural gas prices than the NWE and CEE region.

Figure D-10 **Natural gas prices (€/MWh)** - Box plots and simple averages.



Source: Own elaboration with data from flat glass companies.

Table D-12 **Natural gas prices paid by sampled EU flat glass producers (€/MWh)** - simple averages.

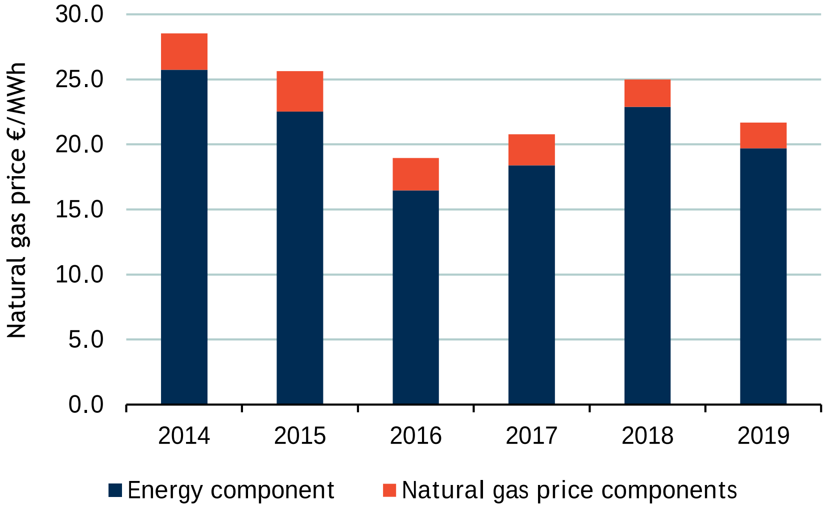
Natural gas price (€/MWh)	2014	2015	2016	2017	2018	2019
EU	28.5	25.6	19.0	20.8	25.0	21.7
NWE	28.1	25.2	18.1	20.0	24.1	20.0
CEE	28.7	25.1	18.9	20.3	25.2	22.0
SE	29.2	26.7	20.6	22.6	26.5	24.6

Source: Own elaboration with data from flat glass companies.

Components of natural gas price

The energy component of the natural gas price registered its lowest point in 2016, with 16.5 €/MWh, after which they increased 22.9 €/MWh in 2018 (Figure D-11). In contrast, the price components of natural gas (network costs, levies and taxes, except for VAT). reached its highest point in 2015 at 3.1 €/MWh but for the rest of the period it maintained a decreasing trend, reaching its lowest point in 2019 at 2 €/MWh.

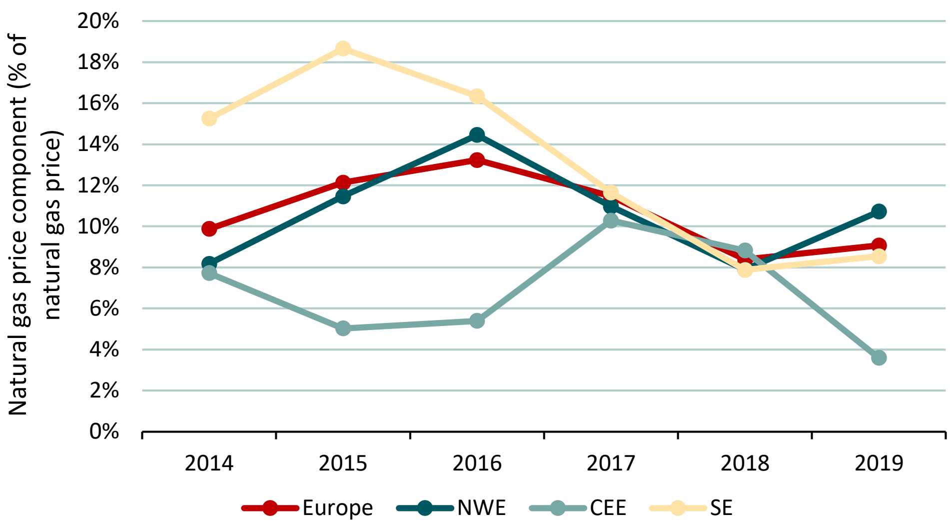
Figure D-11 Components of the natural gas price (€/MWh, EU) - Simple averages.



Source: Own elaboration with data from flat glass companies.

A regional comparison between the natural gas price components, as a share of the total natural gas price shows that NWE and SE regions followed a similar trend during the observed period. By 2016 the price components in the NWE and CEE regions accounted for 14% and 16% of the natural gas prices, respectively. The CEE region experienced the opposite behaviour during the earlier years, going as low as 5% in 2015 and 2016. In 2017 and 2018 the shares of all regions were somehow homogeneous; they all went from 10-11% in 2017 to 8-9% in 2018. However, in 2019 the three regions start to diverge from each other, the price components in the NWE region rose to 11%, they maintained at 9% in SE, while in the CEE they went further down to 4%.

Figure D-12 Regional comparison of natural gas price component as a share of natural gas price.



Source: Own elaboration with data from flat glass companies.

Table D-13 **Components of natural gas price: energy component (€/MWh) -** Simple averages.

Energy component €/MWh	2014	2015	2016	2017	2018	2019
Europe	25.7	22.5	16.5	18.4	22.9	19.7
NWE	25.8	22.3	15.5	17.8	22.2	17.9
CEE	26.5	23.9	17.9	18.2	23.0	21.2
SE	24.8	21.7	17.2	20.0	24.5	22.5

Source: Own elaboration with data from flat glass companies.

Table D-14 **Components of natural gas price: price component (€/MWh) -** Simple averages.

Natural gas price component €/MWh	2014	2015	2016	2017	2018	2019
Europe	2.8	3.1	2.5	2.4	2.1	2.0
NWE	2.3	2.9	2.6	2.2	1.9	2.1
CEE	2.2	1.3	1.0	2.1	2.2	0.8
SE	4.5	5.0	3.4	2.6	2.1	2.1

Source: Own elaboration with data from flat glass companies.

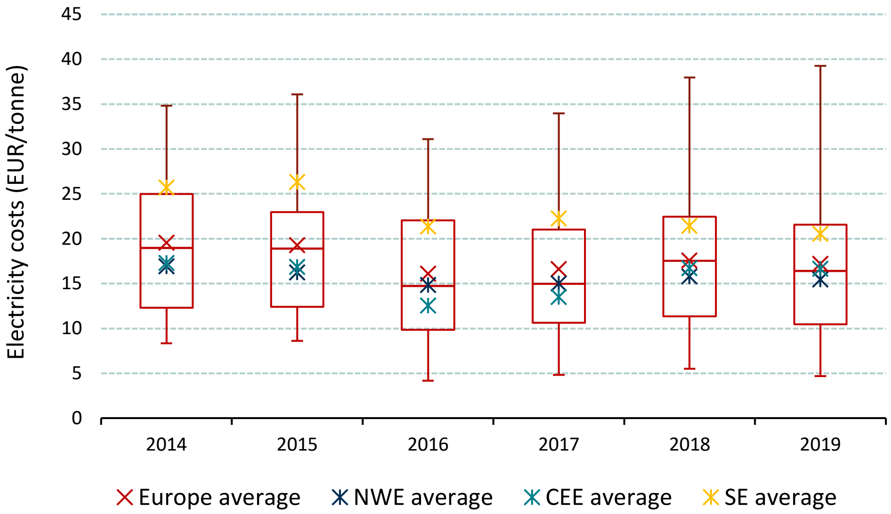
Evolution of energy costs

Electricity costs

On average, EU producers of flat glass faced electricity costs between €20 and €16/tonne of saleable glass[173] over the period under observation (Figure D-13 and Table D-15). This indicator fluctuated across the years, decreasing to its lowest point in 2016 at €16.1/tonne. Afterwards it increased slightly up to €17.6/tonne in 2018. This is in line with the behaviour of electricity prices in €/MWh.

There was no difference in this sector between electricity prices and costs in €/MWh for three reasons: i) self-generation of electricity is not relevant[174]; ii) no plant was taking part in interruptability schemes, and iii) no plant registered ex post CO_2 retributions. Only seven plants bought electricity in the wholesale market.

Figure D-13 Electricity costs - Box plots and simple averages.



Source: Own elaboration with data from flat glass companies.

[173] Please note that we refer here to tonnes of saleable product, not of molten glass, which is a metric used in several other studies bearing on the sector. These two figures differ for the following reasons: once floated over the bed of molten tin, the flat glass is being cut at the sides of the ribbon, and also around defaults. The glass being thus cut away from the production flow is re-melted (so that the material does not get lost), but is not counted as "saleable", whereas it has indeed been molten (and counts as such).

[174] Only one plant reported self-generated electricity, which was too small to make a difference in the overall average electricity cost.

Table D-15 **Electricity costs (€/tonne) -** Simple averages.

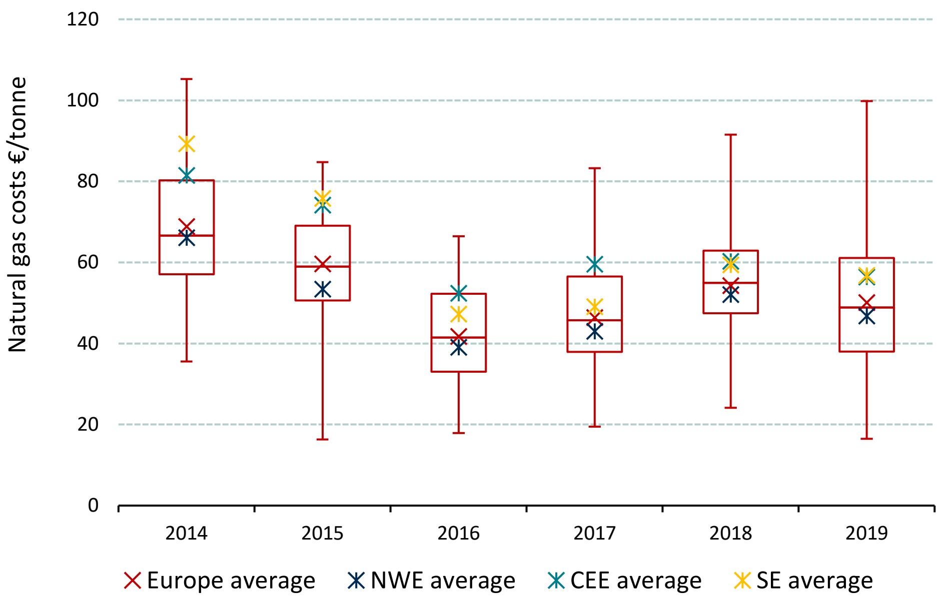
Electricity costs (EUR/tonne)	2014	2015	2016	2017	2018	2019
Europe average	19.6	19.3	16.1	16.6	17.6	17.2
NWE average	16.9	16.2	14.8	15.0	15.8	15.5
CEE average	17.3	16.8	12.5	13.5	16.7	16.6
SE average	25.7	26.3	21.3	22.3	21.4	20.5

Source: Own elaboration with data from flat glass companies.

Natural gas costs

Figure D-14 and Table D-16 show natural gas costs borne by producers of flat glass in the EU in €/tonne. In the beginning of the period studied SE plants bore higher natural gas cots per tonne produced, followed closely by the CEE region. While plants across the EU reduced their natural gas costs, the SE region experienced the largest decline in 2016. During the whole period NWE plants have maintained lower natural gas costs per tonne produced than plants in other regions. Overall, the trends in natural gas in €/MWh and €/tonne are similar: both indicators decreased between 2014 and 2016, increased again in the 2017-2018 period, and slightly decreased in 2019.

Figure D-14 Natural gas - Box plots and simple averages.



Source: Own elaboration with data from flat glass companies.

Table D-16 **Natural gas (€/tonne) -** Simple averages.

Natural gas costs (EUR/tonnes)	2014	2015	2016	2017	2018	2019
Europe average	68.8	59.6	41.7	46.3	54.3	50.1
NWE average	66.1	53.4	39.0	43.0	52.1	46.8
CEE average	81.5	74.1	52.4	59.6	60.2	56.3
SE average	89.2	75.8	47.2	49.1	59.3	56.7

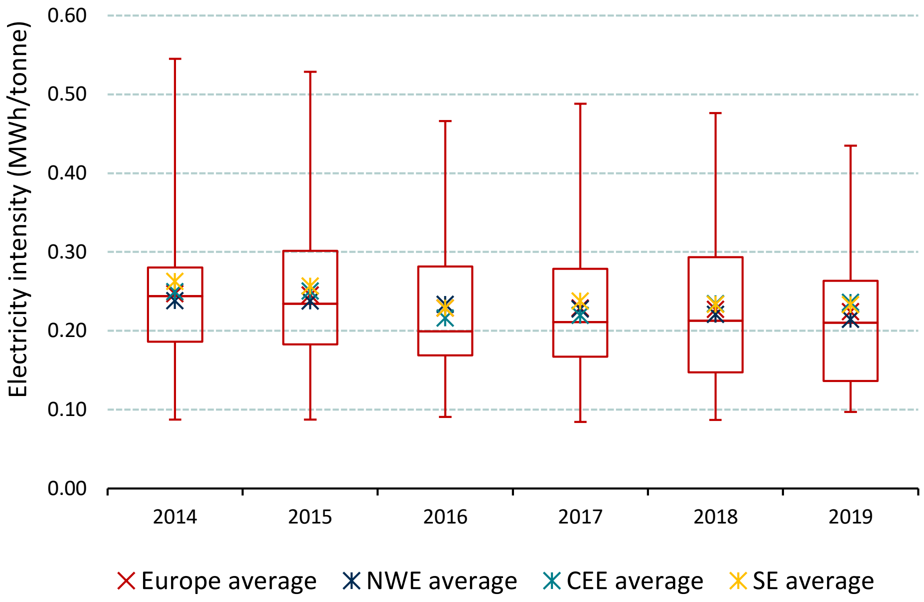
Source: Own elaboration with data from flat glass companies.

Energy intensity

Electricity intensity

On average, the EU flat glass industry experienced a decline in electricity intensity in terms of MWh/tonne during the period observed (Figure D-15 and Table D-17). Electricity intensity went from 0.25 MWh to 0.22 MWh/tonne between 2014 and 2019 (simple averages). The largest improvement in terms of electricity intensity was observed in the SE region, reducing its electricity intensity by 11% between 2014 and 2019. This was likely the result of the higher electricity prices registered in the region, compared to the rest of the EU.

Figure D-15 Electricity intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration with data from flat glass companies.

Table D-17 Electricity intensity (MWh/tonne) - Simple averages.

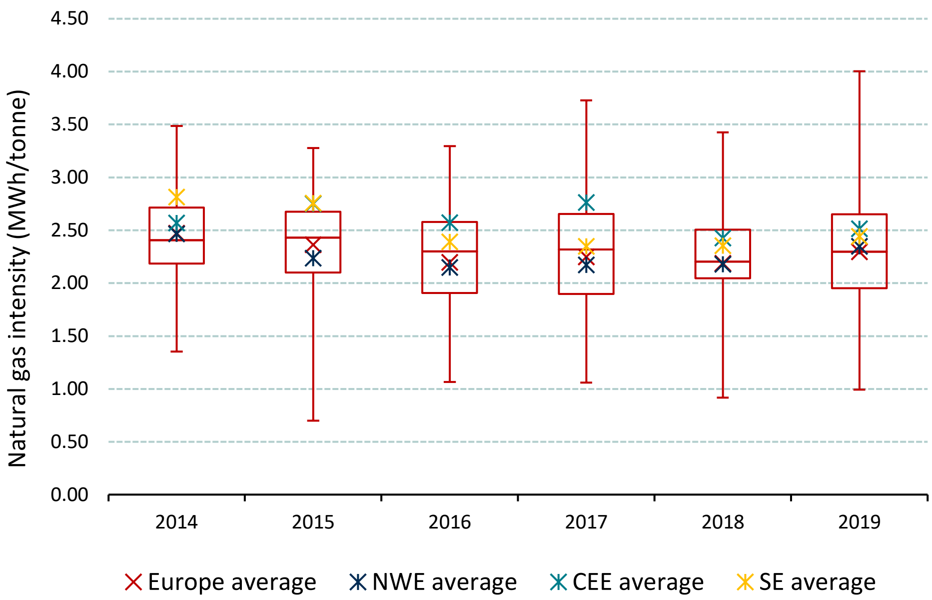
Electricity intensity (MWh/tonne)	2014	2015	2016	2017	2018	2019
Europe average	0.25	0.25	0.23	0.23	0.23	0.22
NWE average	0.24	0.24	0.23	0.23	0.22	0.21
CEE average	0.25	0.25	0.22	0.22	0.23	0.24
SE average	0.26	0.26	0.23	0.24	0.23	0.23

Source: Own elaboration with data from flat glass companies.

Natural gas intensity

The natural gas intensity of flat glass production in the EU is significantly higher than the electricity intensity presented above. Figure D-16 and Table D-18 indicate natural gas intensity at the EU level decreased slightly throughout the period observed, going from 2.5 MWh/tonne in 2014 to 2.3 MWh/tonne in 2019. Similar to the trends observed in electricity intensity, the plants in the SE region decreased their natural gas intensity the most, with a 13% reduction between 2014 and 2019.

Figure D-16 Natural gas intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration with data from flat glass companies.

Table D-18 Natural gas intensity (MWh/tonne) - Simple averages.

Natural gas intensity (MWh/tonne)	2014	2015	2016	2017	2018	2019
Europe average	2.47	2.36	2.20	2.25	2.19	2.30
NWE average	2.47	2.24	2.15	2.17	2.18	2.35
CEE average	2.57	2.75	2.57	2.76	2.43	2.52
SE average	2.81	2.76	2.39	2.35	2.36	2.44

Source: Own elaboration with data from flat glass companies.

Competitiveness of the sector

Table D-19 presents an overview of the indicators used int his section to analyse the competitiveness of the flat glass sector.

Table D-19 Overview of energy costs as a share of production costs, and energy costs as a share of turnover **(€/tonne, EU)** - Simple averages.

Indicator	2014	2015	2016	2017	2018	2019
Electricity cost €/tonne	20	19	16	17	18	17
Natural gas cost €/tonne	69	60	42	46	54	50
Other production costs €/tonne	242	261	296	269	260	277
Gross operating surplus €/tonne	70	69	113	112	101	95
Turnover €/tonne	400	409	467	443	433	439
Electricity costs as a share of production costs	7%	6%	5%	6%	6%	6%
Natural gas costs as a share of production costs	24%	20%	15%	17%	19%	18%
Energy costs as a share of production costs	31%	26%	20%	22%	25%	24%
Energy costs as a share of turnover	26%	22%	15%	17%	19%	18%

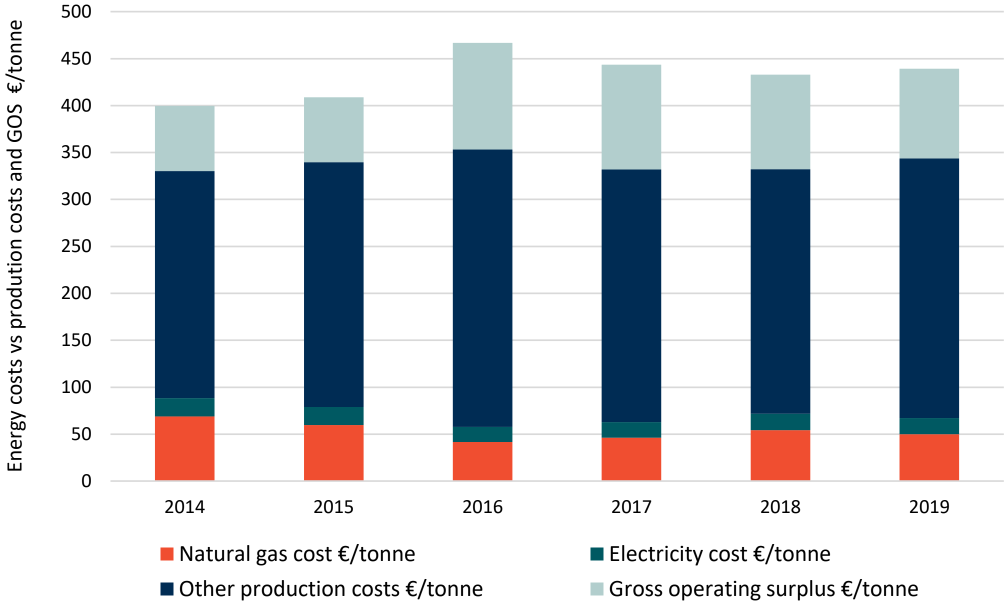
Source: Own elaboration based on data from flat glass companies.

Profitability

The flat glass sector has experienced a contrasted evolution of its profitability over the last ten years (Table D-19 and Figure D-17):

- From 2011 to 2015 included, profitability is low, with gross operating surplus in the range of 70 €/tonne. This corresponds to a period of decline in production volume (Figure D-3), and hence of restructuring. Under these circumstances, with high fixed costs, the players most probably engaged in strong price competition to maintain volume (at the detriment of price);
- In 2016, profitability rebounds strongly (gross operating surplus changes from 69 to 113 € / tonne), due to the combination of two effects:
  - A strong decrease in energy costs (from 79 to 58 € / tonne);
  - An even stronger increase in the turnover / tonne, i.e. the selling price (from 409 to 467 € / tonne), probably related to the stabilisation of production volume after the restructuring period.
- Since 2017, profitability remains in the higher range, despite a fall in selling price (back to ca. 430 € / tonne), because the production costs (other than energy) decrease strongly (from a peak at 296 € / tonne in 2016 to ca. 270 € / tonne), while energy costs remain at their low level.

Figure D-17 **Energy costs, other production costs and Gross Operating Surplus of the flat glass industry (€/tonne,** EU), simple averages.



Source: Own elaboration with data from flat glass companies.

Impact of energy costs on competitiveness of the sector

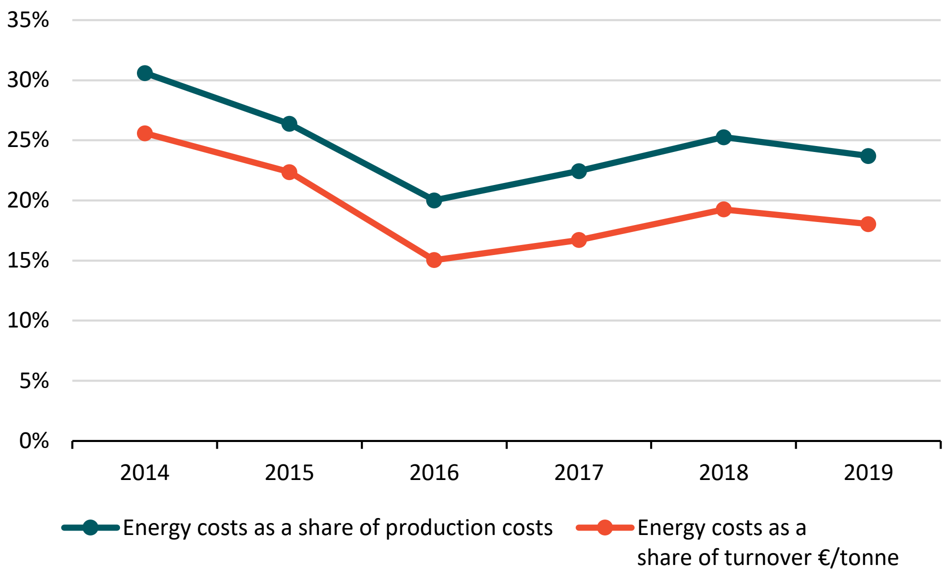
Considering that:

- the energy costs represent an important fraction (in the range of 25%) of the total production costs of the companies in the sample;
- the energy costs per tonne declined sharply between 2014 and 2016 and stabilised since then at a lower level;
- the slow deterioration in the trade balance of the EU flat glass sector vs. other countries experienced over the years 2015 - 2018 has taken place in times of steady energy costs and gross operating profits per tonne.

we can conclude that energy costs have:

- contributed positively to the restoration of the sector's profitability since 2016; but
- had an overall limited impact on the external competitiveness of the EU flat glass sector vis-à-vis its extra-EU competitors.

Figure D-18 Energy costs as a share of production costs vs energy costs as a share of turnover for the flat glass **industry (€/tonne, EU), simple averages.**



Source: Own elaboration with data from flat glass companies.

Comparison of energy costs in the EU compared to extra-EU competitors

There is very little data available on the energy costs of flat glass manufacturers outside the EU27. We have been able to collect data for the following countries:

- Russia, based on the Cumulative Cost Assessment of the Glass industry[175];
- European countries outside of the EU, based on the data received from plants located there, essentially the United-Kingdom.

The only data available for China is related to the energy consumption per tonne of the sector in 2007[176], with no indication of costs.

Russia is as an example of countries with access to very low-cost energy sources, particularly natural gas which they extract from their soil and hydroelectricity. Non-EU Europe on the other hand may be considered as an example of industrialised nations with no specific access to low-cost energy.

The absolute energy costs of the flat glass sector in Russia in 2015 were much lower than in the EU27: about half the cost for electricity (8 €/tonne in Russia vs. 19 €/tonne in the EU27), and about one quarter of the cost for natural gas (14 € /tonne in Russia vs. 60 €/tonne in the EU27, which is approximately the ratio for retail prices of natural gas for industry that year 7.3 €/MWh in Russia vs. 30 €/MWh average in the EU27[177]). They were also lower in relative terms: energy costs represented 15% of production costs in Russia vs. 26% in the EU27.

[175] CEPS and Ecorys: "Cumulative Cost Assessment (CCA) of the EU Glass Industry - Final Report" (2017), study for the DG GROW

[176] IEA and OECD: "Tracking Industrial Energy Efficiency and CO2 Emissions" (2007)

[177] Based on the present study, Task 1 "Energy prices"

The competitive position of the EU27 compared to the UK is more favourable. Electricity costs in the EU27 have been consistently lower than in the UK between 2014 and 2019, by a margin varying between 0 and 8 €/tonne. Same goes for the costs of natural gas, by an even wider margin, varying between 10 and 28€ /tonne.

The trend provided by these two examples tend to show that the flat glass sector in the EU27 fares reasonably well vs. competitors with the same set of comparative advantages, but is at a strong cost disadvantage compared to competitors with a low-cost access to natural resources such as natural gas. It must be stressed that it is precisely from these countries that extra EU imports are high with increased production capacities (e.g. Russia, Belarus, Algeria, Turkey, Egypt). It can unfortunately not rely on higher energy efficiency of its processes to compensate for the difference in energy prices and must therefore compete on the technical quality of its products.

Table D-20 Overview of energy costs in some non-EU27 countries.

Country or group of countries	Indicator	2014	2015	2016	2017	2018	2019
EU27	Electricity cost €/tonne	20	19	16	17	18	17
	Natural gas cost €/tonne	69	60	42	46	54	50
	Other production costs €/tonne	242	261	296	269	260	277
	Electricity costs as a share of production costs	7%	6%	5%	6%	6%	6%
	Natural gas costs as a share of production costs	24%	20%	15%	17%	19%	18%
	Energy costs as a share of production costs	31%	26%	20%	22%	25%	24%
Russia	Electricity cost €/tonne	-	8	-	-	-	-
	Natural gas cost €/tonne	-	14	-	-	-	-
	Other production costs €/tonne	-	123	-	-	-	-
	Electricity costs as a share of production costs	-	6%	-	-	-	-
	Natural gas costs as a share of production costs	-	9%	-	-	-	-
	Energy costs as a share of production costs	-	15%	-	-	-	-
North-West Europe, non-EU27	Electricity cost €/tonne	23	24	23	17	21	25
	Natural gas cost €/tonne	97	86	70	62	79	60
	Other production costs €/tonne	272	374	325	316	306	316
	Electricity costs as a share of production costs	6%	6%	6%	4%	5%	6%
	Natural gas costs as a share of production costs	25%	22%	18%	16%	20%	15%
	Energy costs as a share of production costs	31%	28%	24%	20%	25%	22%

Source: Own elaboration based on data from flat glass companies and on the CCA for the glass industry (2017)

Consequences of COVID-19 crisis for the flat glass sector

Glass for Europe has confirmed that because of the COVID-19 lockdown measures implemented throughout the EU in March 2020, the consumption of flat glass products significantly decreased in both building and automotive applications. During this period, 50% of the flat glass manufacturing sites were put on "hot hold" - i.e., the flat glass furnace temperature at these sites was lowered to 1200°C (normally 1500-1600°C). This reduced site energy consumption, but nullified site production.[178] The "hot hold" is a means through which to avoid shutting down furnaces, as furnaces need to be completely rebuilt after full shutdowns, at the cost of tens of millions of euros and several months dedicated to the rebuild.[179]

The EU anticipates that a substantial economic crisis will follow the COVID-19 lockdown, impacting at least for the 3rd and 4th trimesters of 2020. Therefore many flat glass production sites will remain on "hot hold" during this period. It is likely that energy costs per tonne of product in 2020 will spike compared to previous years, reaching levels 20 to 40% higher than 2019 levels.[180]

Zinc

Introduction

- The refining processes of Zinc are as follows:The roasting of the concentrated natural ore to obtain the metal oxide;
- Dissolution of the metal in an acid electrolyte;
- The electrolysis to obtain the pure metal.

in which the electrolysis part is by far the most energy-intensive step. The energy intensity of refining of the natural ore varies per metal and per ore, as described in the metal-specific sections below.

Characteristics of the product

(based on input by International Zinc Association[181]):

The main functional features of zinc are that:

- It oxides much more easily than many metals (particularly: steel), forms a very robust and corrosion-resistant passivation layer;
- It combines into very ductile alloys (e.g. zamak, brass and bronze).

Main areas of usage

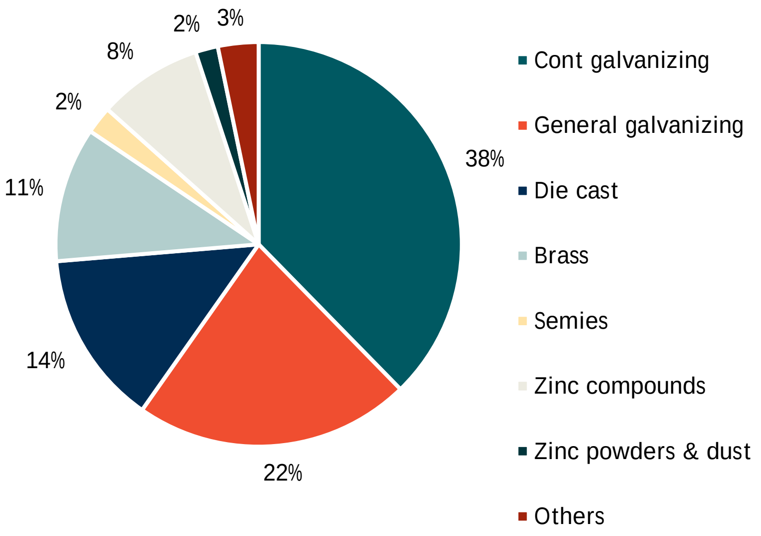
(based on input by International Zinc Association)

The main usages of zinc are:

- To protect steel against corrosion, by attracting the oxidation to itself and building a protective barrier of zinc hydroxide (8,313 ktonnes in 2015, i.e. 60% of world-wide volumes[182]);
- To make die-cast thin mechanical pieces at high speed and low processing costs, in several alloys with aluminium (1,940 ktonnes in 2015, i.e. 14% of world-wide volumes);
- To constitute with copper an alloy called brass, used in communication equipment and water valves (1,500 ktonnes in 2015, i.e. 11% of world-wide volumes);
- As sheets, for roofing and cladding of buildings, or as wires (305 ktonnes in 2015, i.e. 2% of world-wide volumes);
- As chemical compounds, essentially zinc oxide used as a vulcanising agent in the production of rubber tyres and as a white pigment (1,1160 ktonnes in 2015, i.e. 8% of world-wide volumes).

[178] Consultation with Glass for Europe, 15 July 2020.
[179] For more details please refer to https://glassforeurope.com/wp-content/uploads/2020/04/Hot-holds-Operations-GfE-paper-April2020.pdf.
[180] Consultation with Glass for Europe, 15 July 2020.
[181] https://www.zinc.org/
[182] Source: International Zinc Association

Figure D-19 Main usages of zinc - share of world-wide applications in tonnes.



Source: International Zinc Association (2015).

NACE codes

The manufacture of zinc is classified under the following NACE rev.2 code: 24.43 Lead, zinc and tin production.

Stages in the production process

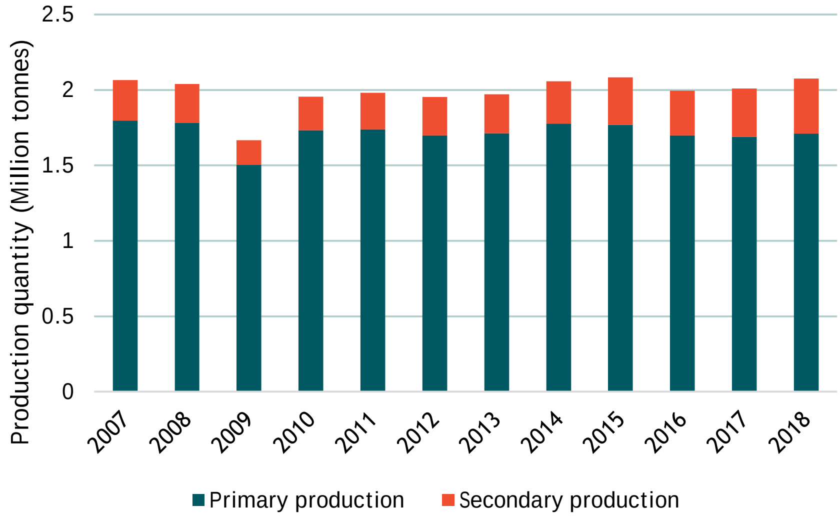
- Concentration: The most common natural zinc ore is zinc sulphide, which is concentrated using the froth flotation method;
- Roasting is an exothermic process of transforming zinc sulphide concentrates at high temperatures (850°C to 950°C) into zinc oxide concentrates, called "Zinc Calcine";
- Leaching purifies the calcine by treating it with sulphuric acid to convert the zinc within into soluble zinc sulphates while many impurities remain insoluble;
- Cementation further purifies the zinc sulphate, by precipitation of the ions of impurity metals (copper, cobalt, nickel or cadmium) that were dissolved during leaching;
- Electrolysis finally transforms the zinc sulphate solution into high-purity zinc metal. The depleted acid electrolyte returns to the leaching process.

Among these, the only energy-intensive stage of the process is the electrolysis.
The roasting stage, despite taking place at high temperatures, is exothermic and generates more energy than it consumes. Therefore, it consumes no external energy and cannot be considered as energy-intensive.

Economic situation of the sector

The production quantity of zinc has remained at around 2 million tonnes during the 2007 - 2018 period. As the result of the temporary closure of a large zinc plant in 2009 it dropped to its lowest point at 1.67 million tonnes, but from 2010 onwards it steadily recovered, reaching its peak at 2.08 million tonnes in 2015. In 2016 and 2017 it experienced a slight decrease to around 2 million tonnes per year, but by 2018it slightly increased again to 2.07 million tonnes. The increase in production volume was realised by smaller debottlenecking investments to reduce the capex part of the capital intensive process for generating better profit margins.

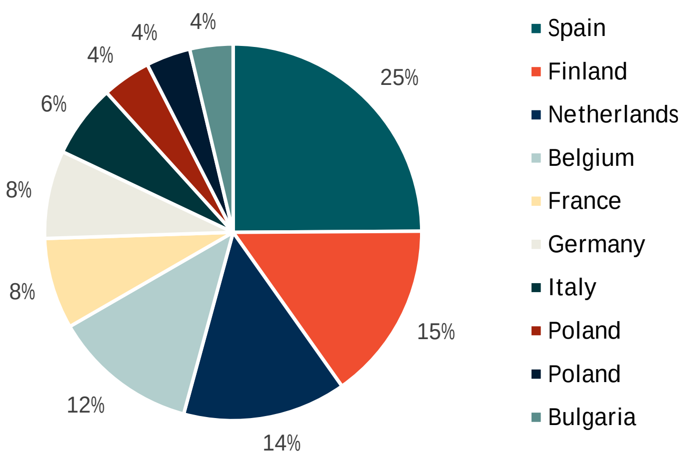
Figure D-20 Trends in production quantity of zinc in the EU27 Member States (million tonnes).



Source: Data from International zinc lead study group (IZLSG, 2020).

Based on production quantity data from IZLG, 90% of all EU zinc production is concentrated in seven Member States: Spain, Finland, the Netherlands, Belgium, Poland, France and Germany. Spain is the Member State with the largest production of zinc, accounting for 25% of the EU27 production, followed by Finland (15%), Netherlands (14%), Belgium (12%), Poland (8%), France (7.8%) and Germany (7.6%). Besides these Member States, there is also production in Italy (6.3%) and Bulgaria (3.7%).

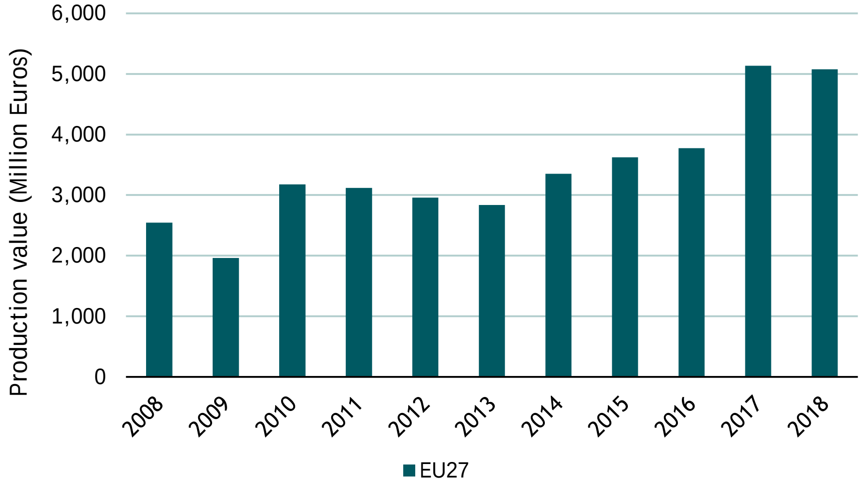
Figure D-21 Distribution of production quantity of zinc in the EU27 Member States.



Source: Data from International zinc lead study group (IZLSG, 2020).
Notes: based in the sum of IZLSG data (2020). for years 2010-2018.

Production value of zinc has been mostly increasing since 2009 from 2.5 billion Euros to 5.14 billion Euros in 2017.

Figure D-22 Trends in production value of zinc **in the EU27 (M€).**



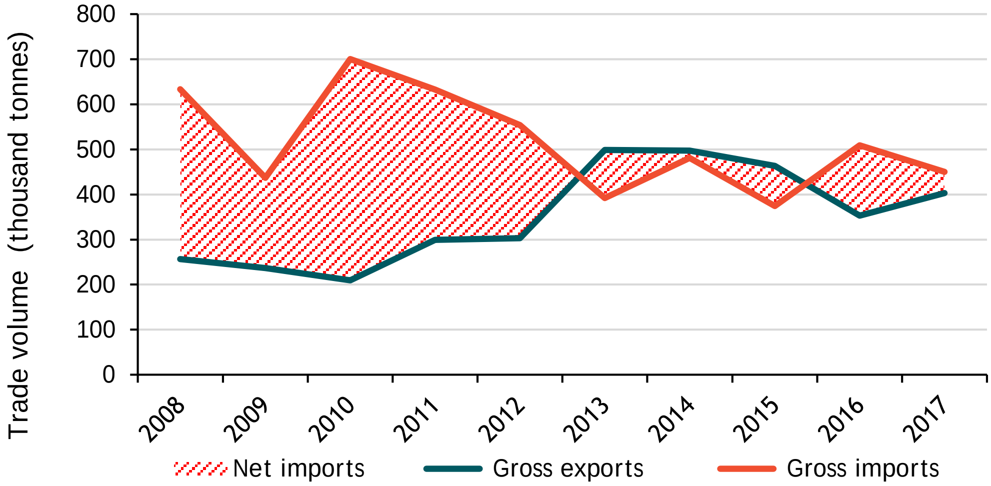
Source: production volumes from IZLSG and the yearly average London Metal Exchange (LME) zinc quotation via International Zinc Association.

The production value of zinc in the EU 27 has strongly increased over the last few years, at almost constant production volumes. This is due to an increase in the internationally-traded price of zinc metal.

Trade situation of the sector

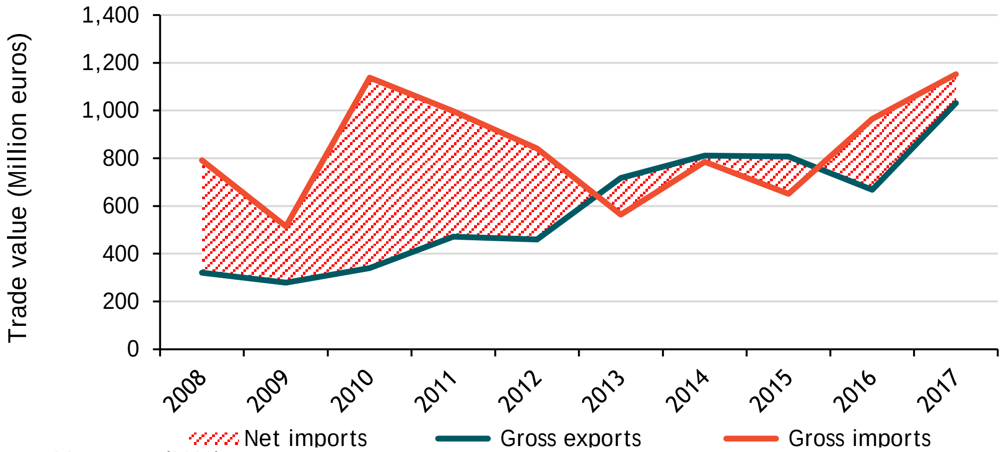
The EU 27 has been a net importer of zinc from 2008 to 2012, with export volumes at a level of about one half of import volumes. Starting in 2013, the trade situation has become much more balanced, with imports and exports matching each other: the EU27 was a net exporter by a small margin in the years 2013 to 2015 included and a net importer by an equally small margin between 50 and 100 ktonnes in the years 2016 and 2017. These trends in the trade volumes appear also in the trade values, with these values increasing sharply in 2016 and 2017 despite roughly constant volumes, due to a sharp rise in the internationally-traded price of zinc.

Figure D-23 Trends in trade balance of zinc in the EU27 Member States (Thousand tonnes).



Source: UN COMTRADE (2020).
Notes: these trade figures describe extra-EU27 trade only, and exclude EU27 internal trade. Based in COMTRADE HS codes 790111, 790112 and 790120.

Figure D-24 Trends in trade balance of zinc in the EU27 Member States (Million Euros).



Source: UN COMTRADE (2020).
Notes: these trade figures describe extra-EU27 trade only and exclude EU27 internal trade. Based in COMTRADE HS codes 790111, 790112 and 790120.

The EU zinc sector is strongly exposed to international trade. The share of internal consumption in the EU market served by extra-EU imports has consistently been above 18.8%, with a peak at 28.6% in 2010. The market share of extra-EU imports in the EU internal market has been decreasing over the years 2013 - 2017, showing a strong international competitiveness of EU players. Similarly, the share of the EU production of zinc dedicated to extra-EU exports has grown from 12.6% in 2008 to 20.1% in 2017 .

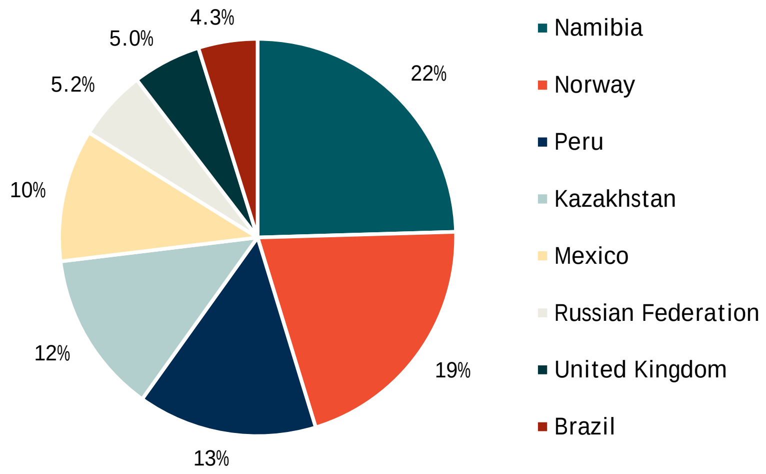
Table D-21 Exposure of zinc in the EU27 to international trade.

Indicator	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gross exports (M€)	321	279	340	471	459	717	811	807	668	1 030
Gross imports (M€)	791	514	1 138	997	840	564	784	651	964	1 152
Production value (M€)	2,547.5	1,962.4	3,177.4	3,120.3	2,960.8	2,834.8	3,354.2	3,624.7	3,775.3	5,136.4
Internal consumption (M)	3,018	2,198	3,975	3,647	3,342	2,682	3,328	3,469	4,072	5,258
Share of internal consumption served by extra-EU imports	26.2%	23.4%	28.6%	27.3%	25.1%	21.0%	23.6%	18.8%	23.7%	21.9%
Share of production dedicated to extra-EU exports	12.6%	14.2%	10.7%	15.1%	15.5%	25.3%	24.2%	22.3%	17.7%	20.1%

Source IZLSG, UN COMTRADE and Eurostat SBS.
Notes: Production and trade volumes (tonnes) converted to Euros using yearly average LME rates.

Figure D-25 presents the distribution of EU27 imports of zinc, the countries listed account for 90% of the EU27 imports of zinc. The main five extra-EU import sources are Namibia, Norway, Peru, Kazakhstan and Mexico, which together account for 76% of imports. The EU27 also imports from Russia (5%), Brazil (4%) and the UK (5%), however, the UK has no production of zinc, therefore these account for zinc imported by the UK and sold to the EU.

Figure D-25 Distribution of imports of zinc in the EU27 Member States.



Source: COMTRADE(2020).
Notes: based in the sum of years 2008-2017 of COMTRADE HS codes 790111, 790112 and 790120.

Sample statistics

The sample consists of nine installations in Europe (EU27 and NO). The sample is spread across eight Member States with installations which together account for 97% of zinc's production value and turnover in the EU. Due to confidentiality reasons, the countries included in the sample cannot be delineated. The regional spread of the surveyed plants was as follows: five plants in the North Western Europe (NWE)[183] region, one plant in the Central Eastern Europe (CEE)[184] region and two in the Southern Europe (SE)[185] region (see Table D-6). [186]

Table D-22 Zinc plants participating in the survey

Geographical regions	Questionnaires collected
North Western Europe (NWE)	5
Central Eastern Europe (CEE)	1
Southern Europe (SE)	2
Total	8

Table D-23 describes the ranges of installed capacity from the 9 plants that provided information on annual production capacity of zinc. For confidentiality reasons it is not possible to present production capacities for individual plants in the sample.

Table D-23 Plant capacity range of the sample. Source: Own elaboration with data from zinc companies.

Capacity range (thousand tonnes/year)	Share of plants in sample
<200	50%
200-400	37.5%
>400	12.5%

[183] North Western Europe (NWE): Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden.
[184] Central Eastern Europe (CEE): Lithuania, Romania, Bulgaria, Czech Republic, Hungary, Estonia, Latvia, Slovakia and Poland.
[185] Southern Europe (SE): Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, and Spain.
[186] There was also 1 questionnaire received for plants in the non-EU NWE region, however this was excluded from the analysis as at least three plants from three different companies are required in order to provide an average for the region.

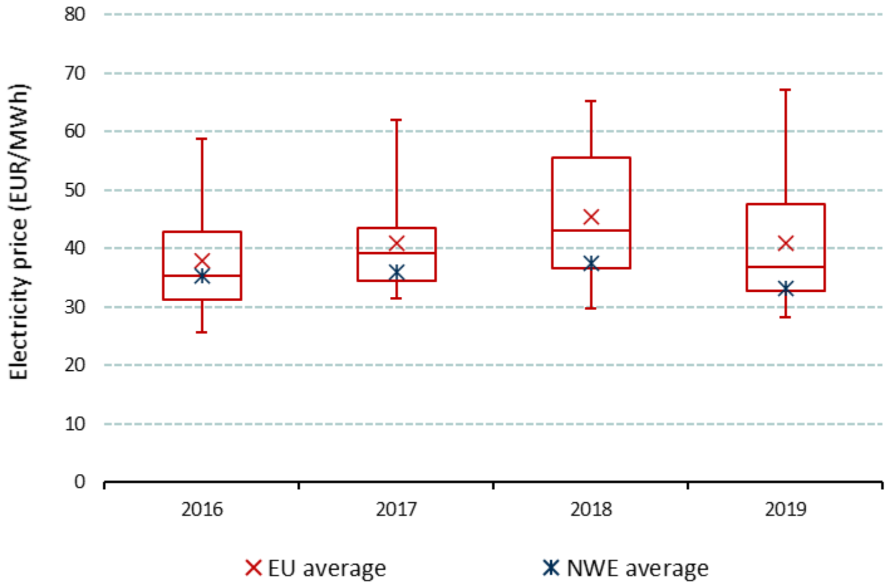
Evolution of energy prices

Electricity price

Electricity prices in €/MWh paid by EU zinc producers on average increased between 2016-2019, peaking in 2018 before decreasing slightly in 2019 to 41.0 €/MWh (Table D-24,Figure D-26). It should be noted that these electricity price include the following price components: network costs - Transmission System Operator (TSO) and Distribution System Operator (DSO) - if applicable, levies, taxes, interruptability discounts and CO2 retributions but excluding VAT.

Average electricity prices can only be presented at a regional level for NWE, where data was provided by more than three zinc production plants. Between 2016-2019, average prices paid by zinc producers in NWE were consistently lower than average EU prices, with the gap widening in 2018 and 2019.

Figure D-26 **Electricity prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration with data from zinc companies.

Table D-24 Descriptive statistics for electricity prices paid by sampled EU zinc **producers (€/MWh) -** simple averages.

Electricity prices (€/MWh)	2016	2017	2018	2019
EU	38.0	41.0	45.6	41.1
NWE	35.4	36.1	37.4	33.1

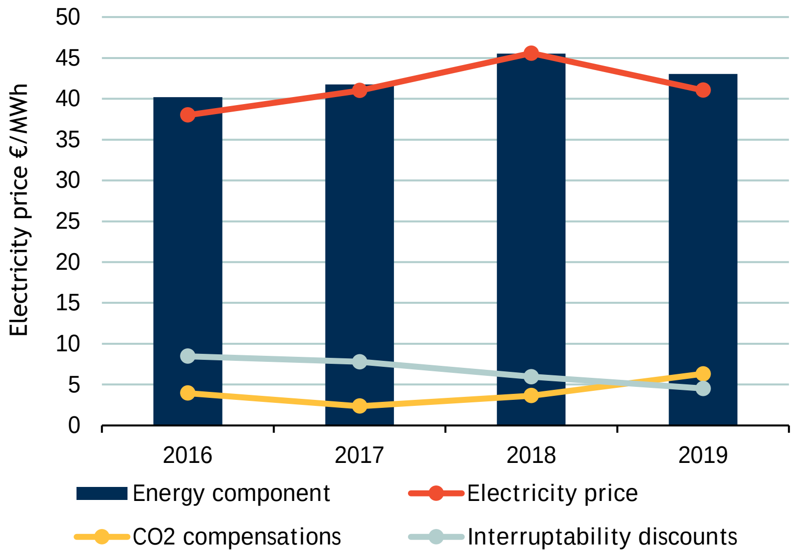
Source: Own elaboration with data from zinc companies.

Components of electricity price

Figure D-27 shows the evolution of some components of electricity price paid by producers of zinc in the EU between years 2016 to 2019 - simple averages. These are split between energy component, CO_2 compensations and Interruptability discounts. The average energy component of the electricity price in the EU has slightly increased since 2014, reaching 46 €/MWh in 2018. However, the final price of electricity paid by zinc producers was often lower than the energy component, as producers in this received CO_2 compensations, and most plants received discounts for interruptability services. Together, these compensations were bigger than the electricity grid costs for most plants. It should be noted that in the cases of plants in the NWE region, interruptability discounts accounted only for 1.54 €/MWh on average from 2016 to 2019.

Finally, four EU plants bought all their electricity in the wholesale market, while three plants bought some of their electricity in the wholesale market. Only one EU plant did not report buying electricity in the wholesale market.

Figure D-27 Components of the electricity **price (€/MWh, EU) -** Simple averages.



Source: Own elaboration with data from zinc companies

Table D-25 Components of the electricity **price (€/MWh, EU) -** Simple averages.

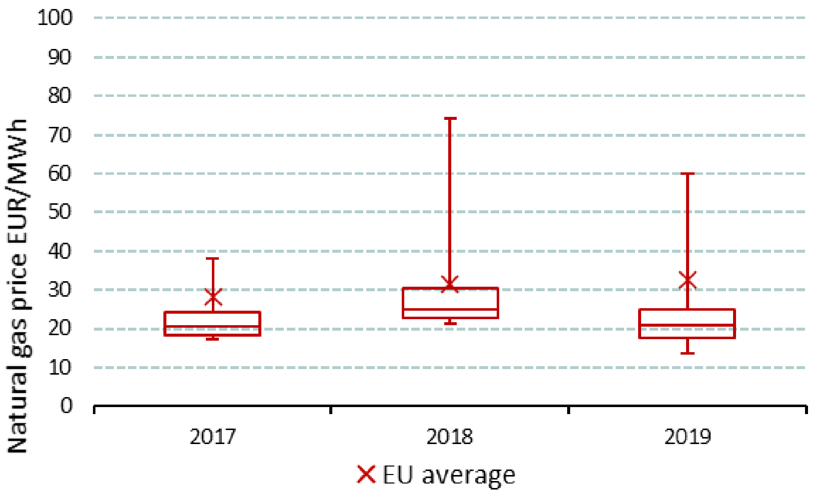
Simple averages	2016	2017	2018	2019
Energy component	40	42	46	43
Electricity price	38	41	46	41
CO2 compensations	4	2	4	6
Interruptability discounts	8	8	6	5

Source: Own elaboration with data from zinc companies.

Natural gas trends

Figure D-28 and Table D-26Table D-12 show that from 2017 to 2019, the average price paid by producers of zinc for natural gas prices remained relatively steady even while the maximum prices paid increased. By 2019, the reported lowest and highest prices paid for natural gas by zinc producers deviated widely, though most producers paid similar prices generally lower than the simple EU average price. Average regional prices for natural gas cannot be reported due to lower sample sizes at regional levels.

Figure D-28 **Natural gas prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration with data from zinc companies.

Table D-26 Natural gas prices paid by sampled EU zinc **producers (€/MWh)** - simple averages.

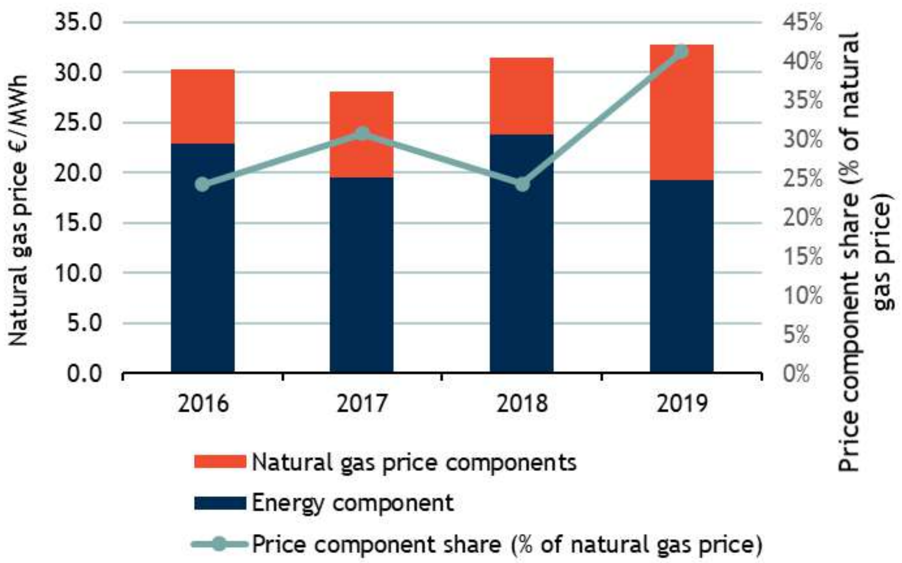
Natural gas price (€/MWh)	2017	2018	2019
EU	28.1	31.5	32.8

Source: Own elaboration with data from zinc companies.

Components of natural gas price

The energy component of the natural gas price remained relatively steady between 2016-2018 before decreasing in 2019 (Figure D-29). In contrast, the price component of natural gas (network costs, levies and taxes, except for VAT) reached its peak in 2019, at 13.5 €/MWh. The price component share of natural gas prices for the zinc sector increased from 24% in 2016 to 41% in 2019.

Figure D-29 **Components of the natural gas price (€/MWh, EU) -** Simple averages.



Source: Own elaboration with data from zinc companies.

A regional comparison of natural gas price components cannot be presented due to lower sample sizes at regional levels.

Table D-27 Components of natural gas price: energy and price components **(€/MWh) -** Simple averages.

EU simple averages	2016	2017	2018	2019
Energy component €/MWh	22.9	19.5	23.8	19.3
Natural gas price component €/MWh	7.3	8.7	7.7	13.5

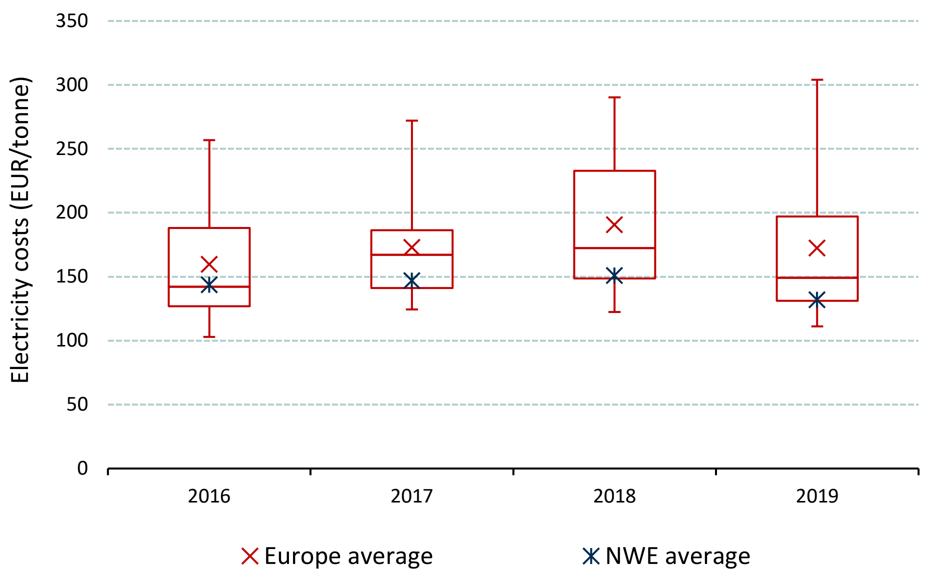
Source: Own elaboration with data from zinc companies.

Evolution of energy costs

Electricity costs

On average, EU producers of zinc faced electricity costs between €159.7 and €190.6 per tonne of production output over the period under observation (cf. Figure D-30 and Table D-28). The range of costs paid by different zinc producers varied widely during this time, peaking in 2018 at €190.6 per tonne.

Figure D-30 Electricity costs - Box plots and simple averages.



Source: Own elaboration with data from zinc companies.

Table D-28 **Electricity costs (€/tonne)** - Simple averages.

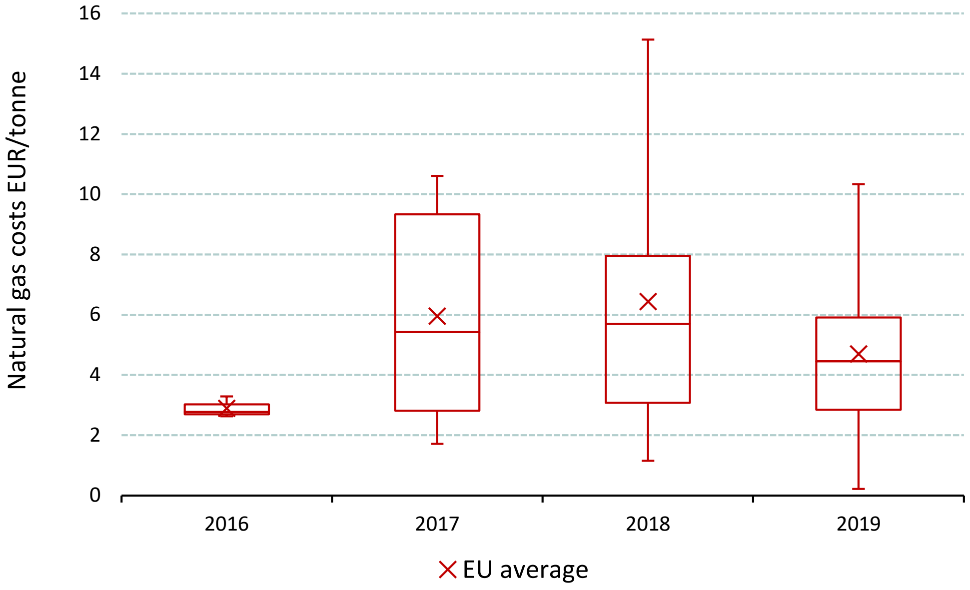
Electricity costs (EUR/tonne)	2016	2017	2018	2019
Europe average	159.7	172.9	190.6	172.4
NWE average	143.6	146.8	150.8	131.9

Source: Own elaboration with data from zinc companies.

Natural gas costs

Figure D-31 and Table D-29 show natural gas costs borne by producers of zinc in the EU in €/tonne. Overall, the trends in natural gas in €/MWh and €/tonne are similar: both indicators increased between 2016-2018 before decreasingly slightly in 2019.

Figure D-31 Natural gas - Box plots and simple averages.



Source: Own elaboration with data from zinc companies.

Table D-29 **Natural gas (€/tonne)** - Simple averages.

Natural gas costs (EUR/tonnes)	2016	2017	2018	2019
Europe average	2.89	6.17	6.5	4.79

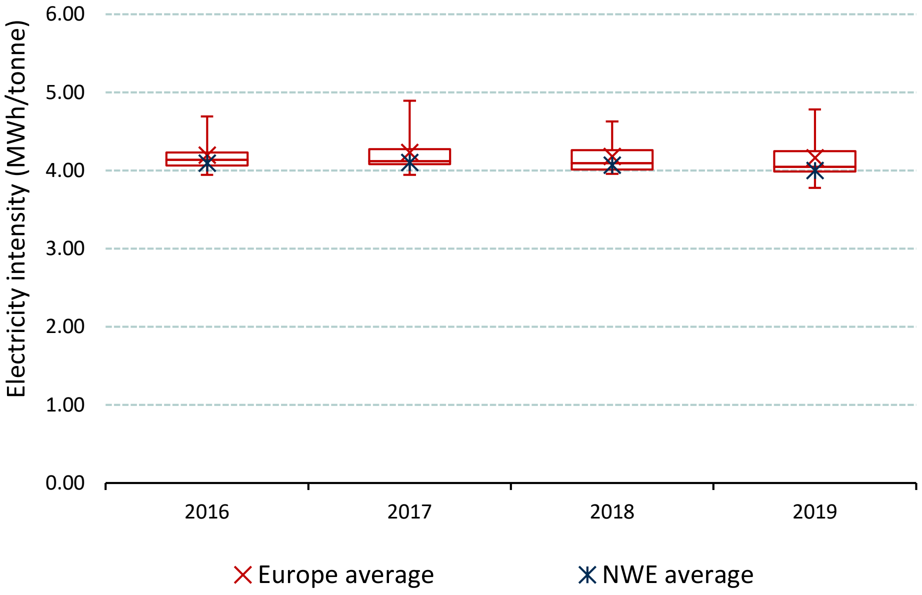
Source: Own elaboration with data from zinc companies.

Energy intensity

Electricity intensity

The electricity intensity (MWh/tonne) of EU zinc production did not significantly vary between 2016-2019 (Figure D-32 andTable D-30). Electricity intensity slightly decreased from 4.20 MWh/tonne in 2016 to 4.16 MWh/tonne in 2019 (simple averages). Electricity intensity for producers in NWE also decreased slightly during the period, going from 4.09 MWh/tonne in 2016 down to 4 MWh/tonne in 2019, slightly lower than the EU average. The values for electricity intensity reported by companies are remarkably concentrated, showing that all the plants in the sample share very comparable technical performance in their production process.

Figure D-32 Electricity intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration with data from zinc companies.

Table D-30 Electricity intensity (MWh/tonne) - Simple averages.

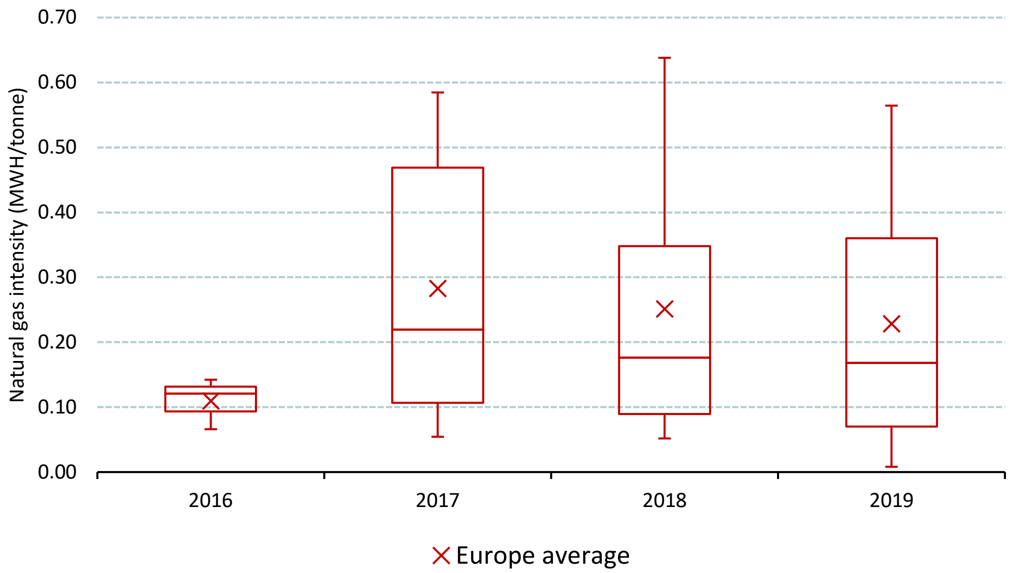
Electricity intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	4.20	4.23	4.18	4.16
NWE average	4.09	4.10	4.07	4.00

Source: Own elaboration with data from zinc companies.

Natural gas intensity

The natural gas intensity of zinc production in the EU was much lower than the electricity intensity presented above. Figure D-33 and Table D-31 indicate that natural gas intensity at an EU level increased in 2017 before decreasing steadily until 2019.

Figure D-33 Natural gas intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration with data from zinc companies.

Table D-31 Natural gas intensity (MWh/tonne) - Simple averages.

Natural gas intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	0.11	0.28	0.25	0.23

Source: Own elaboration with data from zinc companies.

Competitiveness of the sector

Table D-32 presents an overview of the indicators used in this section to analyse the competitiveness of the zinc sector.

Table D-32 Overview of energy costs as a share of production costs, and energy costs as a share of turnover **(€/tonne, EU)** - Simple averages..

Indicator	2016	2017	2018	2019
Electricity cost €/tonne	159.69	172.88	190.56	172.36
Natural gas cost €/tonne	2.89	6.17	6.54	4.79
Personnel costs €/tonne	122.79	125.41	132.13	139.81
Other production costs €/tonne	505.87	603.73	638.42	619.80
Gross operating surplus €/tonne	405.20	344.55	288.12	404.01
Turnover €/tonne	1073.65	1127.34	1123.64	1200.96
Electricity costs as a share of production costs	26.9%	28.6%	30.6%	26.7%
Natural gas costs as a share of production costs	0.4%	0.3%	0.3%	0.3%
Energy costs as a share of production costs	27.3%	28.9%	31.0%	27.0%
Energy costs as a share of turnover	19.4%	22.1%	25.9%	21.0%

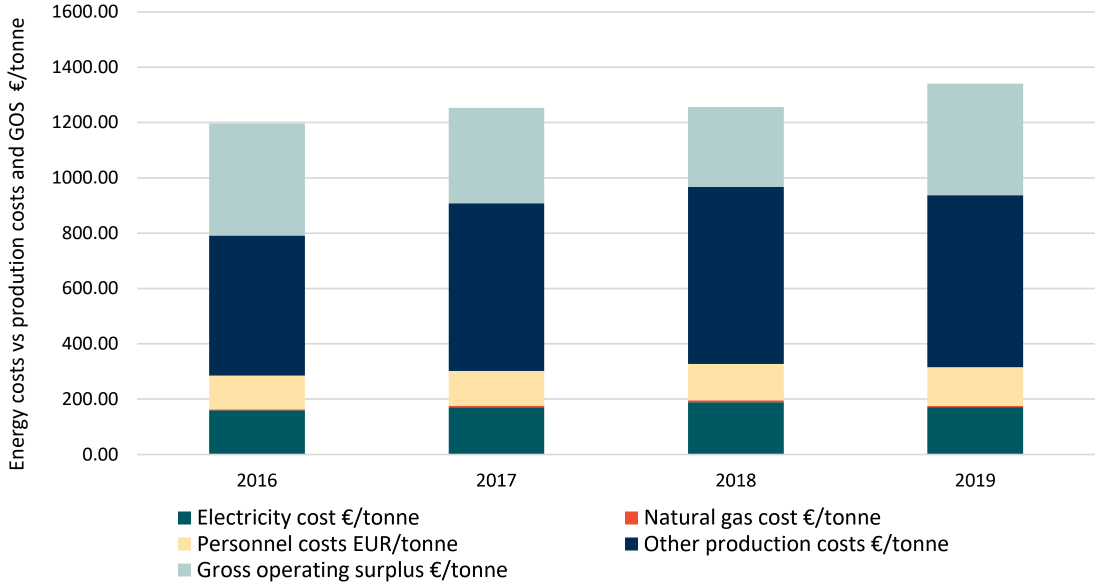
Source: Own elaboration based on data from zinc companies

Profitability

The zinc sector experienced a gradual decline in profitability between 2016-2018 before recovering in 2019 to again reach its 2016 gross operating surplus level (Table D-32 and Figure D-17):

- From 2016-2018, GOS was reduced by 25%, from 405 €/tonne to 288 €/tonne, partly due to a slight increase in electricity costs and primarily due to an increase in other production costs;
- The GOS of zinc companies increased again in 2019 to 404 €/tonne, when electricity costs decreased and the turnover per tonne (i.e. the selling price) increased sharply from 1,124 € / tonne to 1,201 € / tonne.

Figure D-34 Energy costs, other production costs and Gross Operating Surplus of the zinc **industry (€/tonne, EU),** simple averages.



Source: Own elaboration with data from zinc companies.

Impact of energy costs on competitiveness of the sector

The electricity costs represent a very significant share of the production costs of the zinc sector, consistently above 27% over the years 2016 to 2019, peaking at 31% in 2018. Similarly, electricity costs represent an important share of the turnover of the sector (above 19%). The costs of natural gas, on the other hand, are extremely minor (less than 0.5% of production costs).

The international competitiveness of zinc companies is difficult to assess from trade balance, which essentially mirrors the variations in the geographic location of demand compared to the rather fixed geographic location of zinc producers. Since all zinc is sold at the same price, established by international trading platforms such as the London Metal Exchange (LME), and all zinc produced is being sold (be it only to warehouses of the LME), the differences in competitiveness only appear as differences in the profitability of companies, or in the rare cases when the internationally-traded price falls below the production costs of some plants. In that latter situation, the least competitive companies stop producing and lose international market share.

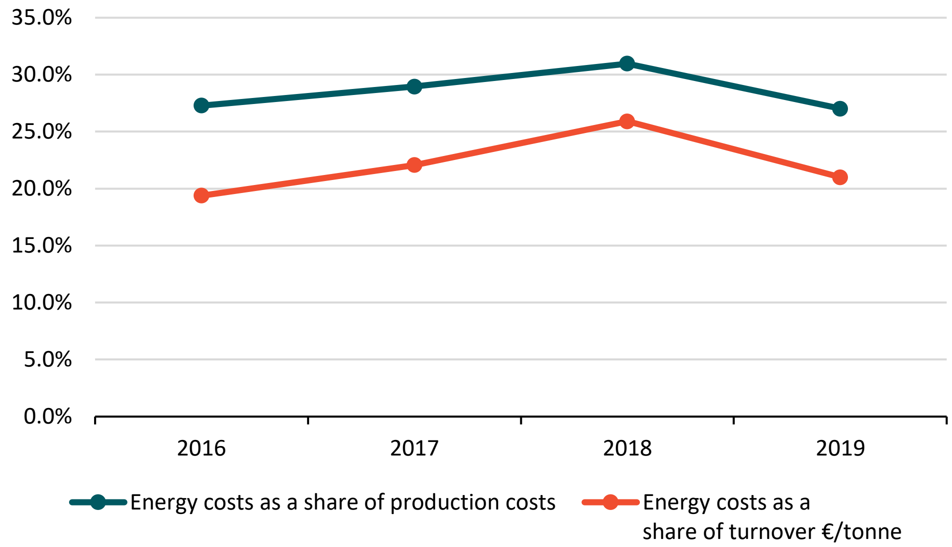
This is the reason why the international competitiveness of companies in the zinc sector can only be assessed by knowing the full cost structure of plants, in the EU27 and elsewhere.

A previous study performed by the JRC and covering the years 2012 and 2013 concluded that the costs of the sector in the EU27 were lower than those of many of its main competitors (China, Russia, Norway and Namibia), Kazakhstan being the only exception among the countries being investigated[187]. Based on oral communication with the International Zinc Association, it appears that the situation has evolved since then. The EU production costs are reported as being rather dispersed, and in more recent years very much in the average of international values - and actually rather in the higher half of the distribution of world-wide production costs. Therefore, it is likely that the rather favourable picture

[187] Aikaterini Boulamanti, Jose Antonio Moya, "Production costs of the non-ferrous metals in the EU and other countries: Copper and zinc", Resources Policy, Volume 49, 2016, Pages 112-118, https://doi.org/10.1016/j.resourpol.2016.04.011 .

outlined by the JRC study may need to be significantly reviewed, in the direction of a less rosy landscape.

Figure D-35 Energy costs as a share of production costs vs energy costs as a share of turnover for the zinc industry **(€/tonne, EU), simple averages.**



Source: Own elaboration with data from zinc companies.

Consequences of COVID-19 crisis for the zinc sector

In general, companies were able to continue their operations, despite sometimes staffing problems. However, the consumers of zinc often stopped their operations, resulting in depressed demand and to large stockpiling of zinc. It is still impossible to know whether this missed turnover will be compensated in the months to come. Expectations are that the output will fall by ca. 15% in 2020.

Ferro-alloys and silicon

Introduction

This section is based on the Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries[188] published by the European Commission, JRC, European Integrated Pollution Prevention and Control (IPPC) Bureau (EIPPCB).

This report has been developed in consultation with EuroAlliages, the Association of European Ferro-alloy Producers.

Characteristics of the product

Ferro-alloys are master alloys that contain some iron and one or more non-ferrous metals as alloying elements. Silicon metal is produced in the same metallurgical process as ferro-silicon and is therefore considered a ferro-alloy, though its iron content is minimal. Ferro-alloys are used for various purposes in steelmaking, enabling alloying elements such as chromium, silicon, manganese, nickel, vanadium and molybdenum to be safely and economically introduced into metallurgical processes, thus giving certain desirable properties to the alloyed metal. These include increased corrosion resistance, strength,

[188] https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-01/JRC107041_NFM_bref2017.pdf

hardness, wear resistance and electrical conductivity. Ferro-alloys are also widely used to remove impurities from steel, especially oxygen and sulphur.

The importance of ferro-alloys increased with the progress of steel metallurgy, which demanded diversified alloying elements to achieve better controlled quantities in purer and more advanced steel qualities. The ferro-alloy industry has become a key supplier of the steel industry.

Silicon metal is used as an alloying element in the manufacturing of aluminium, in the silicone and electronic industries, and in the manufacturing of solar cells.

Ferro-alloys are usually classified in two groups:

- bulk ferro-alloys (ferro-chrome, ferro-silicon together with silicon metal, ferro-manganese, silico-manganese and ferro-nickel), which are produced in large quantities in electric arc furnaces. The questionnaire answered by industry during the present study, covers these bulk ferro-alloys (except ferro-nickel);
- special ferro-alloys (ferro-titanium, ferro-vanadium, ferro-tungsten, ferro-niobium, ferro-molybdenum, ferro-boron, alloyed or refined ferro-silicon, silicon metal and ternary/quaternary alloys) which are produced in which are produced in varying quantities, with silicon metal and ferro-silicon increasingly produced in bulk.

Bulk ferro-alloys are primarily used in steelmaking and steel or iron foundries, with nickel and chromium also substantially used in the aerospace industry. The uses of special ferro-alloys are far more varied, and the proportion used in steelmaking has diminished over recent years in favour of those used in the aluminium and chemical industries, especially silicon products.

Main areas of usage

According to the Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries, the areas of usage for ferro-alloys depend upon the nature of the ferro-alloy:

- Ferro-chrome, along with nickel (ferro-nickel), is the major alloying element in the production of stainless steel. Stainless steel is used in a wide variety of areas, many related to consumer products and white goods, as well as applications requiring significant corrosion resistance;
- Ferro-silicon is primarily used to remove oxygen from molten steel. It can also be used as a reducing agent in steel, and adds electrical conductivity to certain specialised steel grades;
- Silicon metal is important as an alloying element in aluminium and for the production of silicones, electronic products and solar applications;
- Ferro-manganese and silico-manganese are mostly used to desulphurise steel, and to improve its strength, hardness and wear resistance;
- Ferro-vanadium increases the tensile strength and the high-temperature strength of carbon steel even if small amounts are added. Vanadium alloyed steel is therefore used for high-speed cutting tools;
- Tungsten increases the high-temperature strength and wear resistance of steel. Such steel (high-speed steel) is needed to produce high-speed cutting tools that can be used up to temperatures of about 600 ºC. Tungsten will also increase a number of other properties of the steel, such as the hardness, yield strength and the ultimate tensile strength;
- Ferro-titanium increases yield strength and reduces the cracking tendency;

- Ferro-boron increases the hardenability, creep resistance and hot workability of steel because boron-alloyed steel is oxidation-resistant up to 900 ºC;
- Ferro-niobium improves the corrosion resistance and weldability of steel and especially prevents the inter-crystalline corrosion of stainless chrome-nickel steel.

NACE codes

The manufacture of ferro-alloys is classified under the following NACE rev.2 code: 24.10 Manufacture of basic iron and steel and of ferro-alloys.

The manufacture of silicon is classified under NACE rev.2 code: 20.13 Manufacture of other inorganic basic chemicals

However, the NACE 4 -digit level cannot adequately picture the specificities of the ferro-alloys and silicon industry.

Stages in the production process

The processes to manufacture ferro-alloys all follow all the same pattern:

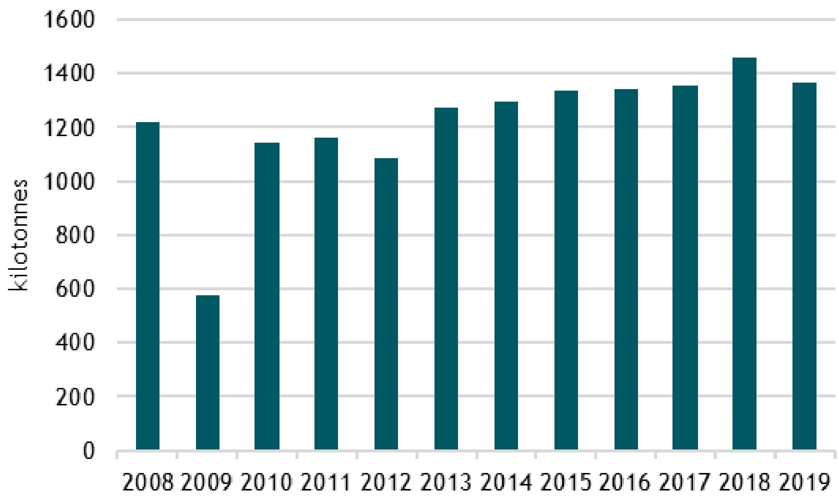
- The metallic ore, an oxide, is reduced into a ferrous alloy in an chemical reaction at high temperature performed in an electric arc furnace, by mixing it with iron and a “reducing agent”, generally carbon (in the form of pure metallurgic coke) for carbon-rich ferro-alloys, but sometimes silicon or aluminium for certain special alloys. This process, also called smelting is energy-intensive:
- The reduction of the oxide, because of the high temperatures needed to melt it with the electric arc, and because the “reduction” chemical reaction consumes large amounts of energy.

The energy consumption per tonne of metal differs greatly from one ferro-alloy to another. One reason is the difference in the chemical bonding strengths to oxygen for different elements in the ore (and hence the energy needed to break that bond during the chemical reaction) and the temperature required for the chemical reactions to proceed. Silicon, for instance, has both a higher bonding energy and requires higher process temperatures than manganese. Other reasons are variations in the metal content of the ore or concentrate and the final product, and the metal yield that it is possible to obtain for different ferro-alloys.

Economic situation of the sector

The summed production quantities of ferro-alloys (specifically, bulk ferroalloys not including minor alloys) and silicon are depicted in the figures below. Production of ferro-alloys sharply decreased in 2009 to its lowest production point of 576,000 tonnes. Production levels recovered in 2010 and modestly increased between 2018-2019, levelling out to 1.36 million tonnes in 2019. AlloyConsult reports that this increased production is wholly attributable to additional ferrochrome production, and that the production of other ferroalloys has slightly decreased in recent years.

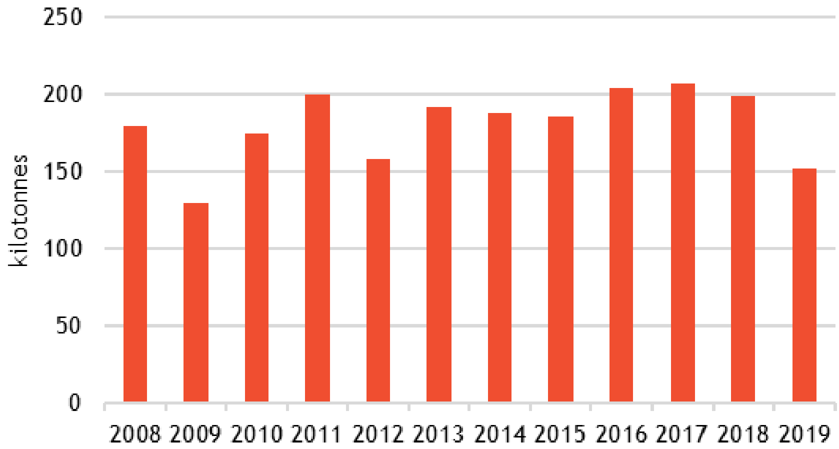
Figure D-36 Trends in production quantity of ferro-alloys in the EU27 Member States (tonnes).



Source: Data provided by Euroalliages and AlloyConsult (2020).

The production of silicon in the EU27 oscillated between 150,000-210,000 tonnes over the past decade, though dipped to 129,000 tonnes in 2009. Silicon production sharply dropped between 2018-2019 by 50,000 tonnes, 75% of its 2018 production levels.

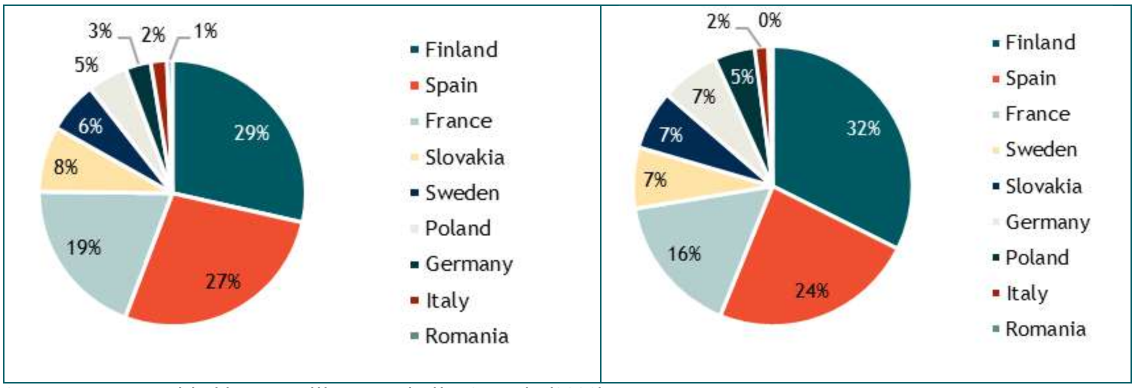
Figure D-37 Zoom-in on trends in production quantity of silicon in the EU27 Member States (tonnes) between 2009-2018.



Source: Data provided by Euroalliages and AlloyConsult (2020).

On average, 29% of the EU's ferro-alloy production was concentrated in Finland, with 27% concentrated in Spain, 19% in France, 8% in Slovakia, and 6% in Sweden. According to Euroalliages and AlloyConsult, silicon production in the EU is primarily concentrated in France (68.6%), with other substantial production volumes concentrated in Germany (16.4%) and in Spain (15.1%).

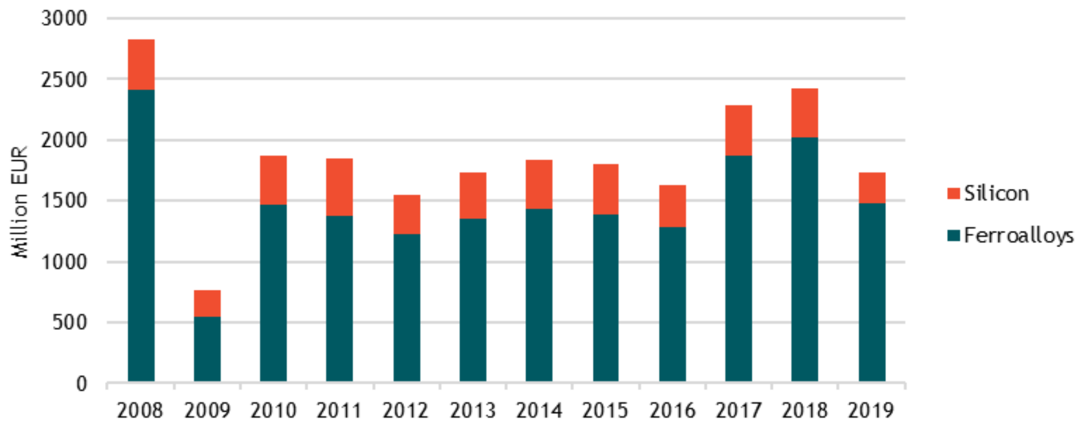
Figure D-38 Distribution of production quantity (left) and production value (right) of ferro-alloys in the EU27 Member States.



Source: Data provided by Euroalliages and AlloyConsult (2020).
Notes: Based on the average distribution of production quantity and production value in Member States between 2008-2018.

The production value of ferro-alloys dropped sharply in 2009 before recovering in 2010. Between 2010-2019, production values of ferro-alloys fell, oscillating between 1.5 billion and 2.5 billion Euros. Production value of silicon reached its lowest level of 223 million EUR in 2009, before oscillating levelling out to ~400 million EUR between 2010-2018. In 2019, it decreased to 259 million EUR.

Figure D-39 Trends in production value of ferro-alloys and silicon **in the EU27 (M€).**



Source: Data provided by Euroalliages and AlloyConsult (2020).

Production value for ferro-alloys is concentrated in Finland and Spain, which combined account for 56% of total EU ferro-alloys production value. France, Sweden, Slovakia, and Germany account for another 37% of the total production value.

Correspondingly, companies in the EU ferro-alloys and silicon sector are also concentrated in a limited number of Member States, with most active furnaces located in France, Germany, Slovakia and Spain. Outside of the EU, Norway is also highly active in the sector, with more furnaces than any other EU Member State.

Table D-33 Overview of companies and furnaces active in the EU ferro-alloys and silicon sector by Member State

Country	Active companies	Number of furnaces
Belgium	1	1
Finland	1	3
France	4	19
Germany	2	7
Poland	1	4
Slovakia	1	7
Spain	1	17
Sweden	1	4
Iceland*	2	3
Norway*	4	24

**Extra-EU countries*

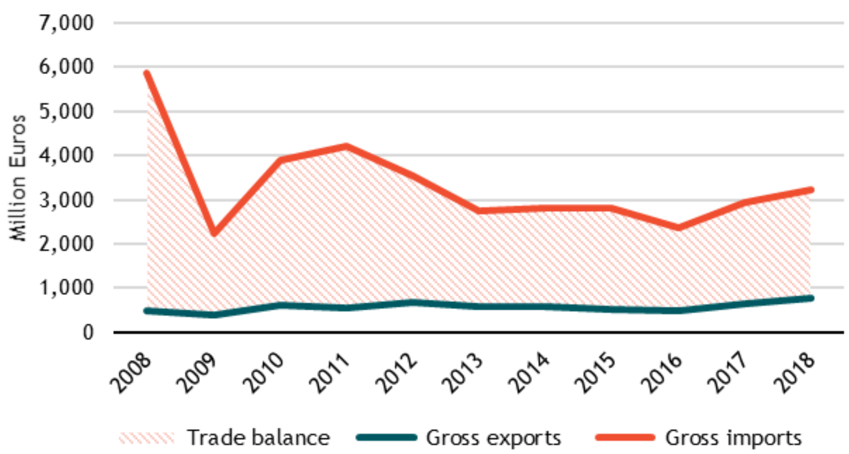
Trade situation of the sector

The EU27 is a net importer of both ferro-alloys and silicon and does not cover its needs with internal production. According to COMEXT data, trends in the imports and exports of ferro-alloys differed between 2008-2018; imports dropped sharply in 2009, climbing until 2011 before decreasing on average until 2016 to level out at 3.2 billion Euros in 2018. Exports of ferro-alloys remained steady between 2008-2018, gradually reaching their highest point of 762 million Euros in 2018.

According to COMEXT data, Silicon imports and exports both fell in 2009; imports grew steadily until 2015 before dropping in 2016 and 2017. Imports sharply rose again in 2018 to reach 640 million Euros. Silicon exports have oscillated since 2010, with relatively lower values (~37 million Euros) in 2013, 2014, and 2018, and relatively higher values (~53 million Euros) in 2015, 2016 and 2017.

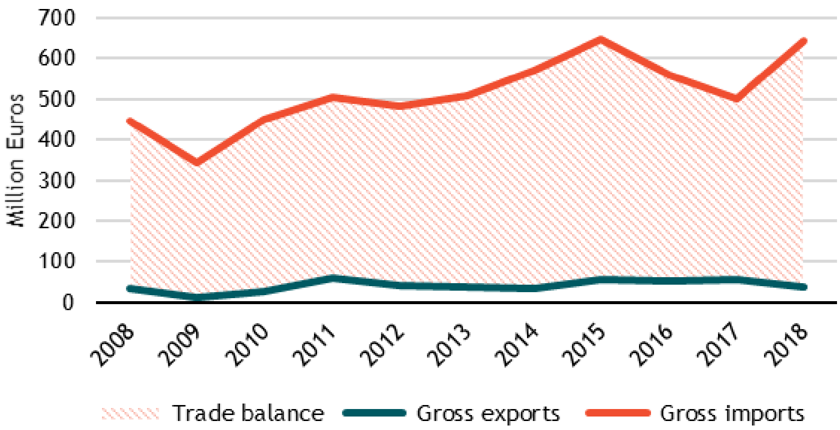
For both ferro-alloys and silicon, the international trade situation of the EU is that of external dependency: a very large fraction of the internal market needs are covered by extra-EU imports, whereas exports to extra-EU countries remain at a fraction of these extra-EU imports.

Figure D-40 Trends in trade balance of ferro-**alloys in the EU27 Member States (M€).**



Source: COMEXT (2020).

Figure D-41 Trends in trade balance of silicon **in the EU27 Member States (M€).**



Source: COMEXT (2020).

Data provided by Euroalliages and AlloyConsult provides a more exact representation of the ferro-alloy sector's exposure to international trade. Trends in gross exports and gross imports largely correspond to the trends represented by the COMEXT figures above, but values differ as Euroalliages data is more precise.

The EU ferro-alloys sector is very exposed to international trade. The share of internal consumption in the EU market served by extra-EU imports on average remains around 75%. Additionally, the share of the EU production dedicated to extra-EU exports rose from 15% to 53% between 2008-2009 before levelling out to ~30% between 2010-2017.

Table D-34 Exposure of ferro-alloys in the EU27 to international trade.

Indicator	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gross exports (M€)	350	288	498	439	465	423	406	373	367	528
Gross imports (M€)	5165	1971	3169	3369	3055	2605	2510	2423	1919	2790
Production value (M€)	2411	546	1463	1380	1224	1351	1435	1389	1286	1871
Internal consumption (M€)	7226	2229	4134	4310	3814	3533	3539	3439	2838	4133
Share of internal consumption served by extra-EU imports	71%	88%	77%	78%	80%	74%	71%	70%	68%	68%
Share of production dedicated to extra-EU exports	15%	53%	34%	32%	38%	31%	28%	27%	29%	28%

Source: Data provided by Euroalliages and AlloyConsult (2020).

The EU silicon sector is likewise highly exposed to international trade, with the share of internal consumption served by exports oscillating between 60%-69% over the past decade. On average, 11.2% of EU-produced silicon has been dedicated to exports.

Table D-35 Exposure of silicon in the EU27 to international trade.

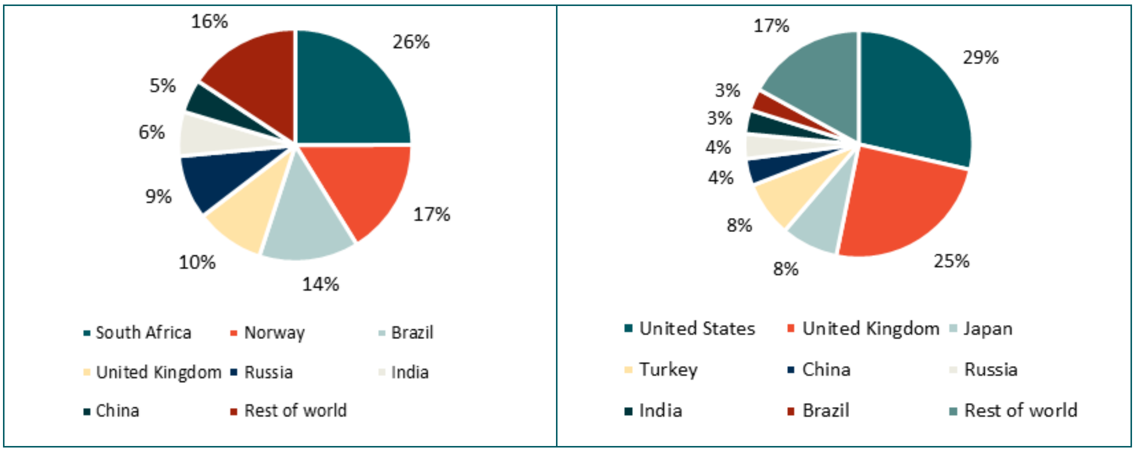
Indicator	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gross exports (M€)	36	12	31	70	45	38	37	55	52	56
Gross imports (M€)	568	410	578	670	611	613	652	733	633	577
Production value (M€)	421	223	404	472	320	377	405	408	343	412
Internal consumption (M€)	953	621	951	1072	886	952	1020	1086	924	933

Indicator	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Share of internal consumption served by extra-EU imports	60%	66%	61%	62%	69%	64%	64%	68%	69%	62%
Share of production dedicated to extra-EU exports	9%	5%	8%	15%	14%	10%	9%	13%	15%	14%

Source: Data provided by Euroalliages and AlloyConsult (2020).

The main extra-EU sources of ferro-alloy imports are South Africa, Norway, and Brazil, which together account for around 57% of imports; the main extra-EU export destinations for ferro-alloys are the United States and the United Kingdom, which account for 54% of exports.

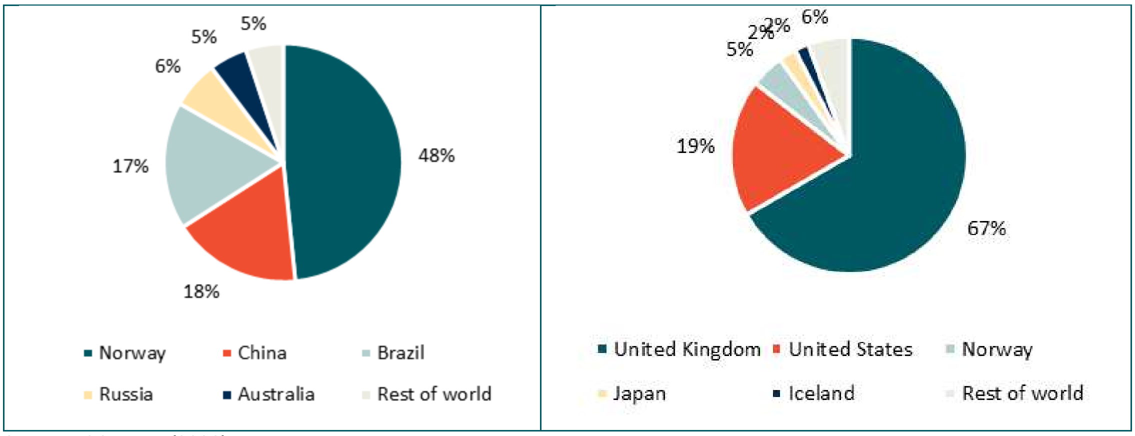
Figure D-42 Distribution of imports (left) and exports (right) of ferro-alloys in the EU27 Member States.



Source: COMEXT (2020).
Notes: based on average import/export levels between 2008-2018.

The main providers of silicon imports are Norway, China, and Brazil, which account for 84% of all imports to the EU. The main destinations for exports are the United Kingdom and the United States, which receive 86% of EU silicon exports.

Figure D-43 Distribution of imports (left) and exports (right) of silicon in the EU27 Member States.



Source: COMEXT (2020).
Notes: based on average import/export levels between 2008-2018.

Sample statistics

The sample consists of seven installations in Europe (EU27) out of the 21 installations in the EU. The sample is spread across six Member States with installations in the EU. Due to confidentiality reasons, the countries included in the sample cannot be delineated. The product spread of the surveyed plants was as follows: three plants producing Ferro-alloys (FeSi, FeCr), two plants producing silicon metal and two producing Manganese alloys (FeMn and SiMn) (see Table D-36). [189]

Table D-36 Ferro-alloys and silicon plants participating in the survey

Geographical regions	Questionnaires collected
Ferro-alloys	3
Silicon metal	2
Manganese alloys	2
Total	7

Table D-37 describes the ranges of installed capacity from the 7 plants that provided information on annual production capacity of ferro-alloys and silicon. For confidentiality reasons it is not possible to present production capacities for individual plants in the sample.

Table D-37 Plant capacity range of the sample. Source: Own elaboration with data from ferro alloys companies.

Capacity range (thousand tonnes/year)	Share of plants in sample
<200	71%
200-400	14%
>400	14%

Energy prices

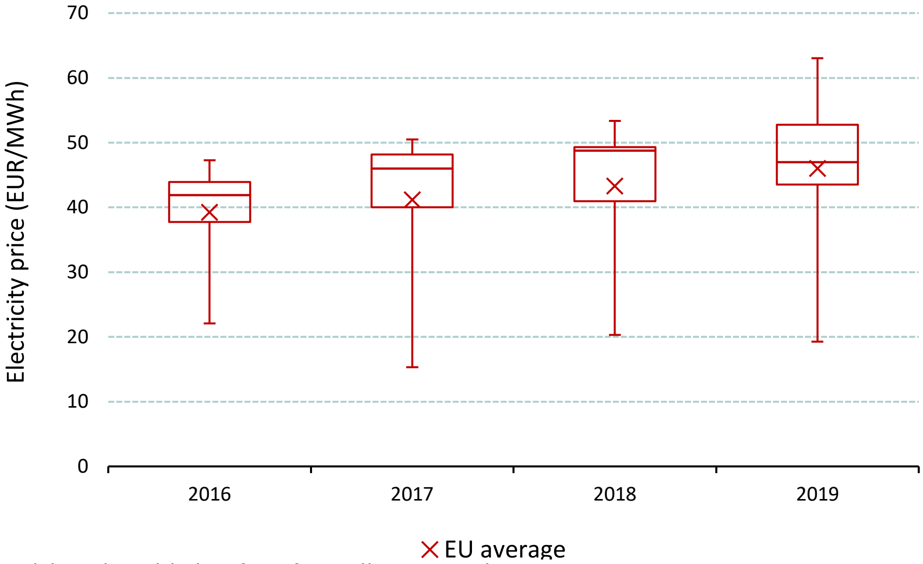
Electricity price

Electricity prices in €/MWh paid by EU ferro-alloys producers on average increased between 2016-2019, peaking in 2019 at €46.0/MWh (Table D-38,Figure D-44). These electricity price include the following price components: network costs - Transmission System Operator (TSO) and Distribution System Operator (DSO) - if applicable, levies, taxes, interruptability discounts and CO2 retributions but excluding VAT. As it can be observed Figure D-7, a large share of the sampled plants experienced higher electricity prices than the sample average calculated from 2016 to 2019, these varied from 57% to 71% of the sampled plants during the observed period, but these went no higher than €65/MWh

Six out of seven plants reportedly purchasing electricity in the wholesale market in at least one year of the observed period.

[189] There was also 1 questionnaire received for plants in the non-EU NWE region, however this was excluded from the analysis as at least three plants from three different companies are required in order to provide an average for the region.

Figure D-44 **Electricity prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration with data from ferro-alloys companies.
Note: based on the answers from 7 plants.

Table D-38 Descriptive statistics for electricity prices paid by sampled EU ferro-alloys and silicon producers **(€/MWh) -** simple averages.

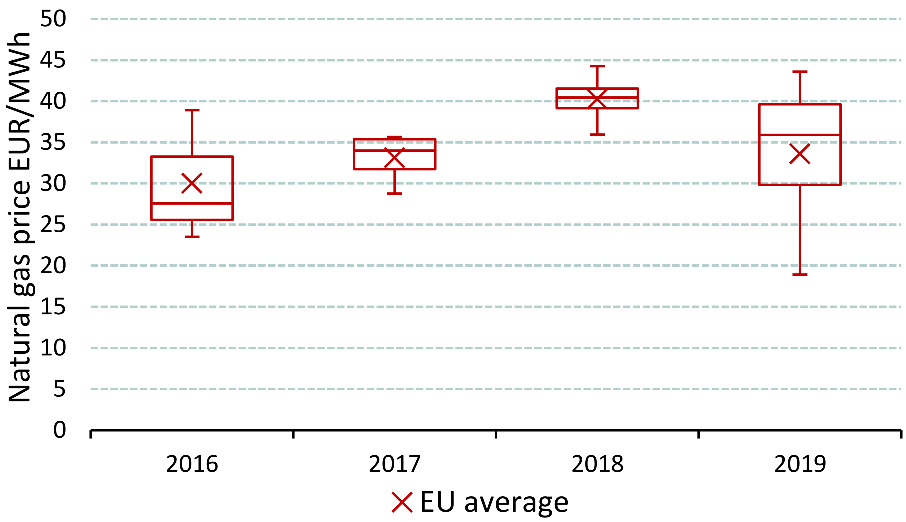
Electricity prices (€/MWh)	2016	2017	2018	2019
EU average	39.2	41.2	43.3	46.0
Share of plants above sample average	57%	71%	71%	57%

Source: Own elaboration with data from ferro-alloys and silicon companies.

Natural gas trends

From 2016 to 2018, the average price paid by producers of ferro-alloys and silicon for natural gas prices increased from €30/MWh in 2016 to €40/MWh in 2018. Particularly during 2017 and 2018 the natural gas prices reported were very concentrated. By 2019, the reported lowest and highest prices paid for natural gas by producers deviated widely, and half of the producers paid similar prices or lower than the simple EU average price.

Figure D-45 **Natural gas prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration with data from ferro-alloys and silicon companies.
Note: based on the answers from 3 plants in 2016, and 4 plants for years 2017 to 2019.

Table D-39 Natural gas prices paid by sampled EU ferro-alloys and silicon produc**ers (€/MWh)** - simple averages.

Natural gas price (€/MWh)	2016	2017	2018	2019
EU average	30.02	33.11	40.28	33.59
Share of plants above sample average	33%	50%	50%	50%

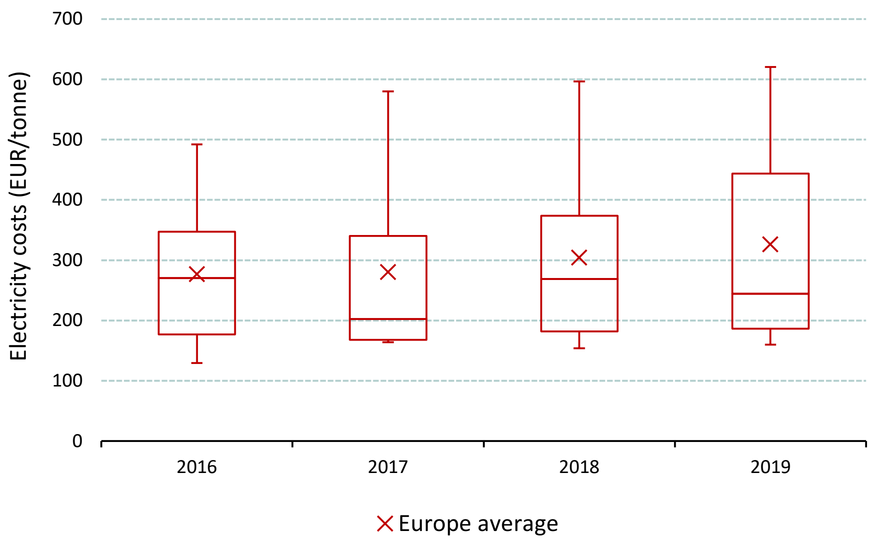
Source: Own elaboration with data from ferro-alloys and silicon companies.

Evolution of energy costs

Electricity costs

On average, EU producers of ferro-alloys and silicon faced an increase in electricity costs over the period under observation, going from €277 per tonne of production output in 2016 to €326.4 per tonne in 2019 (cf. Figure D-46 and Table D-40). The range of electricity costs paid by different ferro-alloys and silicon producers varied widely during this time, but the EU simple average was consistently above the median value each year. In 2016 43% of the sample had higher electricity costs per tonne than the calculated average, while for the following years this share went down to 29%. Electricity costs per tonne for Mn alloys producers were on the lower range, together with plants producing FeCr. Silicon and FeSi producers were amongst those in the higher electricity cost range. Only one EU plant reported self-producing electricity.

Figure D-46 Electricity costs - Box plots and simple averages.



Source: Own elaboration with data from ferro-alloys and silicon companies.
Note: based on the answers from 7 plants.

Table D-40 **Electricity costs (€/tonne)** - Simple averages.

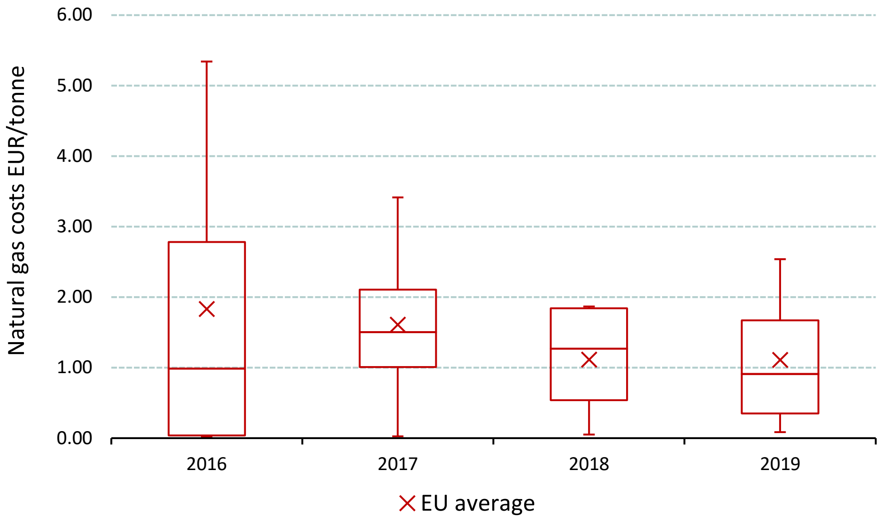
Electricity costs (EUR/tonne)	2016	2017	2018	2019
Europe average	277.0	280.4	304.3	326.4
Share of plants above sample average	43%	29%	29%	29%

Source: Own elaboration with data from ferro-alloys and silicon companies.

Natural gas costs

Figure D-47 and Table D-41 show natural gas costs borne by producers of ferro-alloys and silicon in the EU in €/tonne. Overall, there is a decreasing trend in natural gas in €/MWh and €/tonne between 2016-2018 before stabilising in 2019. Two out of the four plant with reported natural gas consumption have natural gas costs that are higher than the EU average. The decrease in natural gas costs on these plants can be explained by a decrease in natural gas intensity per tonne of output, as exposed in the following section.

Figure D-47 Natural gas - Box plots and simple averages.



Source: Own elaboration with data from ferro-alloys and silicon companies.
Note: based on the answers from 4 plants.

Table D-41 **Natural gas (€/tonne)** - Simple averages.

Natural gas costs (EUR/tonnes)	2016	2017	2018	2019
Europe average	1.8	1.6	1.1	1.1
Share of plants above sample average	50%	50%	50%	50%

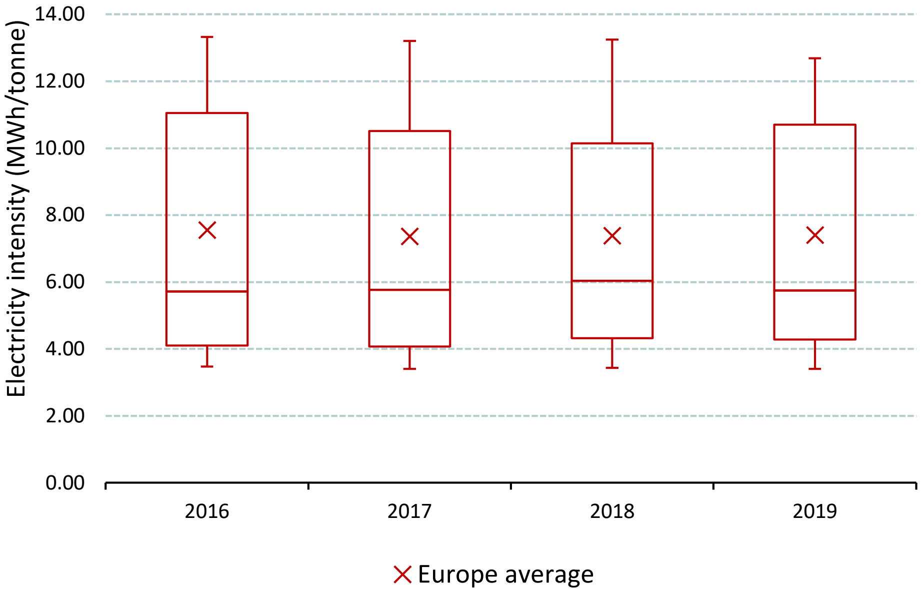
Source: Own elaboration with data from ferro-alloys and silicon companies.

Energy intensity

Electricity intensity

The electricity intensity (MWh/tonne) of EU ferro-alloys and silicon metal production did not significantly vary between 2016-2019. Electricity intensity slightly decreased from 7.55 MWh/tonne in 2016 to 7.40 MWh/tonne in 2019 (simple averages). The values for electricity intensity reported by companies are remarkably spread, suggesting that the electricity intensity of plants in the sample highly depend on the type of product manufactured. Aligned to electricity costs describe above, electricity intensity of FeSi and silicon metal producers are amongst the plants with higher values than the EU average. FeCr and Mn alloys producers tend to have lower electricity intensities, ranging between 3.4 and 6 MWh/tonne. This is in line with the chemical properties of the ferro-alloys mentioned above (section 0).

Figure D-48 Electricity intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration with data from ferro-alloys and silicon companies.
Note: based on the answers from 7 plants.

Table D-42 Electricity intensity (MWh/tonne) - Simple averages.

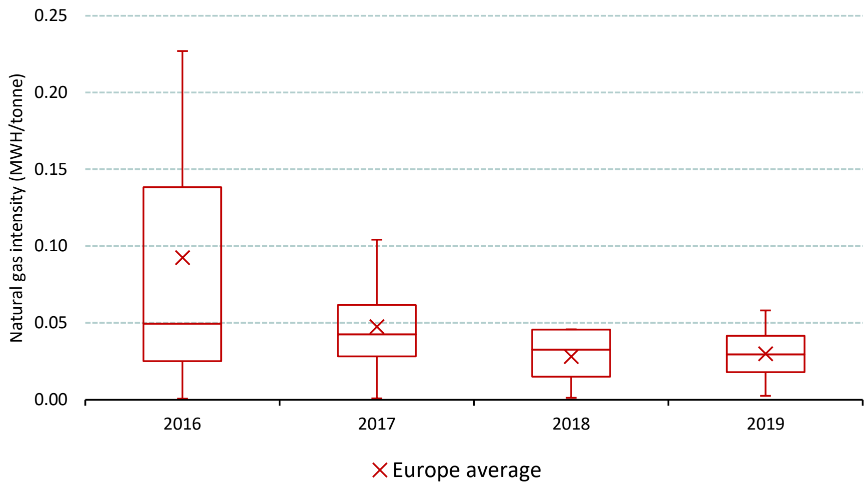
Electricity intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	7.55	7.36	7.38	7.40
Share of plants above sample average	43%	43%	43%	43%

Source: Own elaboration with data from ferro-alloys and silicon companies.

Natural gas intensity

The natural gas intensity of ferro-alloys and silicon production in the EU was much lower than the electricity intensity presented above.Figure D-49 and Table D-43 indicate that natural gas intensity at an EU level decreased steadily from 0.09 MWh/tonne of output in 2016 to 0.03 MWh/tonne in 2019.

Figure D-49 Natural gas intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration with data from ferro-alloys and silicon companies.
Note: based on the answers from 3 plants in 2016 and 4 plants for years 2017-2019.

Table D-43 Natural gas intensity (MWh/tonne) - Simple averages.

Electricity intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	0.09	0.05	0.03	0.03
Share of plants above sample average	33.3%	25.0%	50.0%	50.0%

Source: Own elaboration with data from ferro-alloys and silicon companies.

Competitiveness

Table D-44 presents an overview of the indicators used in this section to analyse the competitiveness of the ferro-alloys and silicon sector.

Table D-44 Overview of energy costs as a share of production costs, and energy costs as a share of turnover **(€/tonne, EU)** - Simple averages.

Indicator	2016	2017	2018	2019
Electricity cost €/tonne	277.01	280.40	304.31	326.43
Natural gas cost €/tonne	1.83	1.61	1.11	1.11
Personnel costs €/tonne	115.01	104.93	126.94	125.69
Other production costs €/tonne	709.98	789.94	790.92	766.07
Gross operating surplus €/tonne	302.45	481.06	470.41	205.55
Turnover €/tonne	1291.28	1553.02	1566.75	1299.15
Electricity costs as a share of production costs	29.5%	27.8%	28.2%	29.1%
Natural gas costs as a share of production costs	0.1%	0.1%	0.1%	0.1%
Energy costs as a share of production costs	29.7%	28.0%	28.3%	29.2%
Energy costs as a share of turnover	25.6%	21.1%	21.3%	28.2%

Source: Own elaboration based on data from ferro-alloys and silicon companies.
Notes: The figures in this table presents the EU simple average, considering the information shared by 6 plants on their electricity and natural gas costs, as well as the total operational production costs and turnover, weighted by their production output. It should be noted that 50% of the sampled plants go beyond the presented figure.

Profitability and market trends

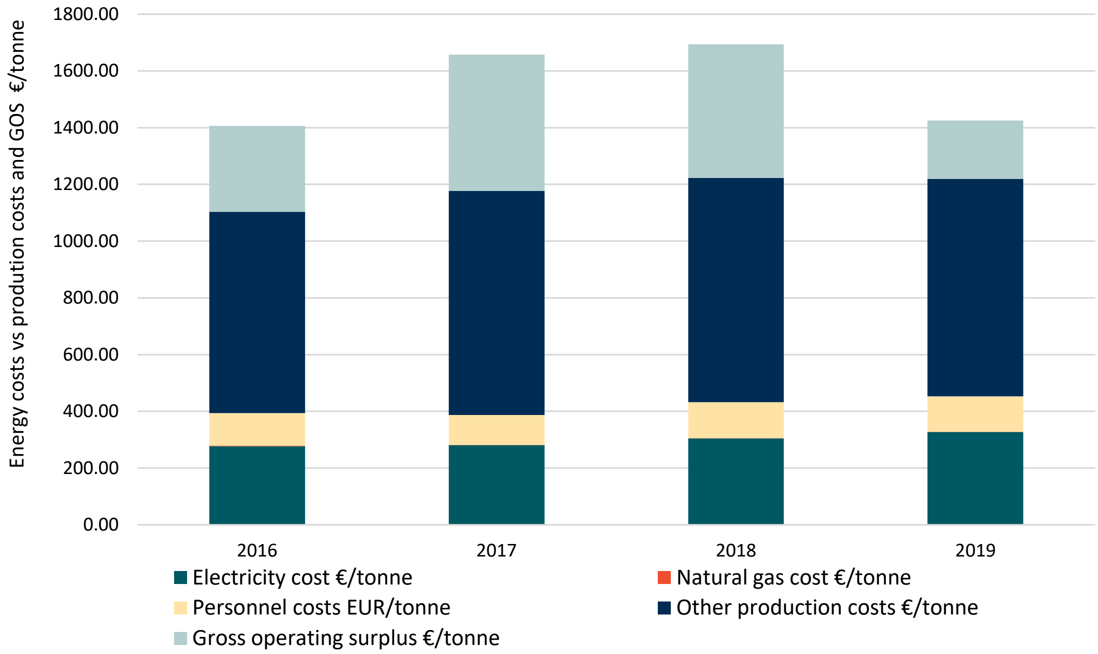
The Gross Operating Surplus of the plants surveyed in the questionnaire has been increasing between 2016 and 2018 and decreased again in 2019 but remaining at that date at a modest level of 17% of production costs. The improvement in the profitability of the ferro-alloys and silicon plants being surveyed between 2016 and 2018 is essentially due to a rise in the selling price (turnover per tonne). The profitability of the EU ferro-alloys industry reached a low point in 2016, largely due to a struggling EU steel sector, which in 2015 lost such a substantial share of its market that the EU became a net importer of steel for the first time. Gross operating surplus for the ferro-alloys sector rose to more normal values in 2017 after two sustained years of abnormal difficulty.

The market for ferro-alloys (and steel) receded again in 2019, when profitability of the sector shrank to its lowest value in recent years (see Figure D-50). EU steel production - and tangentially, EU ferro-alloys production - has consistently fallen since the third quarter of 2018, and prices have fluctuated in line with changing market conditions. Costs of raw materials for the ferro-alloys sector have substantially increased between 2016 and 2018, while electricity prices grew more volatile. So profitability of the sector - not only in the EU, but internationally - has dipped, recovered, and dipped again as the industry struggles to adapt to evolving markets for ferro-alloys and for their raw materials.

Adapting to market changes is particularly difficult for EU producers of ferro-alloys, which have faced steadily falling demand for their products since the 2008 financial crisis. At the same time, producers are threatened by substantial overcapacity outside of the EU and especially in China. In the case of silicon, the over-capacity recorded in China is more than double the world consumption; Chinese production capacity is ~7 million tons, while world consumption of silicon was ~2.9 million tons (in 2019). China also has chronic overcapacity in ferro-alloys production, with a capacity utilisation often below 50%. Overproduction of ferro-alloys in China leads to product dumping that could seriously harm EU manufacturers if protective trade measures were not enforced.

The EU ferro-alloys sector manufactures a larger share of specialty grade product than most of their international competitors, so part of their market is less threatened by changes in international pricing dynamics as some of their consumers require higher grade or niche goods. Still, the majority of EU-produced ferro-alloys can be easily replaced with imports, so the exposure of EU manufacturers remains high.

Figure D-50 Energy costs, other production costs and Gross Operating Surplus of the ferro-alloys and silicon **industry (€/tonne, EU), simple averages.**



Source: Own elaboration with data from ferro-alloys and silicon companies.

Impact of energy costs on competitiveness of the sector

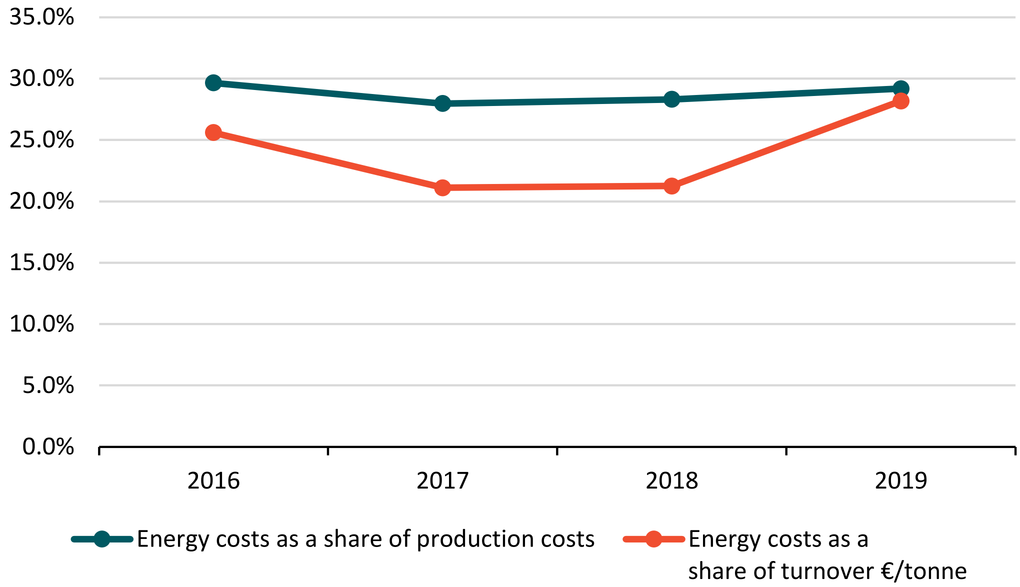
Electricity costs essentially account for the energy costs of the ferro-alloys and silicon sector. Natural gas costs are negligible (~0.1% of production costs). Electricity costs of the surveyed facilities rose between 2016-2019, from 277 €/tonne in 2016 to 326 €/tonne in 2019, an increase of 49 €/tonne. This increase in the electricity price contributed to the reduced profitability of the sector, despite a simultaneous rise in selling prices (from 1,073 €/tonne in 2016 to 1,200 €/tonne in 2019, or of 123 €/tonne).

The EU ferro-alloys sector has managed to maintain a steady trade balance since 2016, but the sector remains threatened by overcapacities outside of Europe and especially in China, which dominates the international ferro-alloys market and is the main ferro-alloys and silicon supplier in Europe. Alloys with the highest energy intensities (i.e., Ferro-silicon and Silicon) are currently protected by anti-dumping protective measures which have levelled the playing field and enabled EU producers to remain competitive with Chinese producers. Still, some Chinese producers have attempted to circumvent these measures which has to a certain degree undermined their efficacy.

But as price points are determined by production costs in the sector, ferro-alloys manufacturers view energy costs as key determinants of product competitiveness. They believe that even minimal increases in energy costs would threaten the competitiveness of EU plants which are already struggling to keep their costs as low as possible. The share of energy costs compared to production costs for the sector has remained steady since 2016, which has enabled the industry to maintain a relatively steady trade balance in recent years (see the figure below). EU producers might not have been able to recover from the 2015 recession in the steel sector and to compete with international plants if energy prices had not remained so steady.

The ferro-alloys sector believes that increasing CO_2 prices (likely to materialise following the implementation of recent Green Deal policies) will impact electricity costs for industry and potentially threaten the competitiveness of the sector. Stakeholders emphasise that the adequate compensation of indirect carbon costs will play a significant role in keeping electricity costs sustainable for operations in the entire ferro-alloys industry.

Figure D-51 Energy costs as a share of production costs and as a share of turnover for the ferro-alloys and silicon industry, simple averages.



Source: Own elaboration with data from ferro-alloys and silicon companies .
Notes: This figure presents the EU simple average, considering the information shared by 6 plants on their electricity and natural gas costs, as well as the total operational production costs and turnover, weighted by their production output.

Consequences of COVID-19 crisis for the ferro-alloys and silicon sector

According to Euroalliages, COVID-19 has already had a substantial impact on ferro-alloys and silicon manufacturers. Demand for the products has decreased in nearly all markets. Companies in the sector are unable to work with some transport companies who are refusing to move commodities to several EU countries because of COVID-19 safety measures and travel restrictions that increase waiting times at border crossings. Companies closures and production cutbacks have already started in the sector, and all EU customers have reduced their consumption levels.

In the immediate term, EU ferro-alloys manufacturers face several challenges including:

- Shortages along their supply chains;
- Negative effects on product sales;

- Reduced demand and loss of revenue;
- Disruptions in logistics and transport;
- Postponement and cancellation of orders due to closures or shutdowns of plants in customers' industries;
- Shortages of workers; and
- Huge uncertainties linked to a lack of harmonized Member State responses adopted under unprecedented conditions.

In the medium- to long-term, the sector will be significantly impacted by international policies implemented in response to COVID-19. The industry expects that a surge of international imports will follow the immediate crisis; they are wary that non-EU countries will adopt aggressive policies to revitalise their own economies. As global steel production has dropped, ferro-alloys stocks will increase and utilisation rates in Europe will substantially decrease due to reduced demand from the steel industry. It is possible that other countries producing ferro-alloys might allow for product dumping into Europe, in order to reduce excess stocks. For example, China - a major manufacturer of ferroalloys and metals - is reportedly planning to revoke export taxes for ferro-alloys as an incentive for manufacturers to resume production, boosting their economy. Given their overcapacities, this reported measure is worrying to EU ferro-alloys manufacturers who might not be able to compete with reduced prices of their Chinese counterparts.

The ferro-alloys sector has proposed several measures that could help mitigate the negative impacts of Covid-19 on the EU market. They favour measures that ensure imports are limited, as there will no longer be a level playing field with main global competitors. Measures might include increased import duties, imposing quotas, or even closing borders to select products originating in countries which are not subject to the same competition rules.

Fertilisers

Introduction

The information on products and processes is primarily based on input from the industry association Fertilizers Europe[190].

Characteristics of the product

Fertilisers provide agricultural crops with the nutrients that are not naturally available in the soil where these crops grow. These nutrients are essentially three chemical elements:

- Potassium (K in the standard international nomenclature);
- Phosphorus (P);
- Nitrogen (N).

The addition of fertilisers to a soil increases the yield of agricultural crops growing on it, and hence the overall production volume.

Approximately 80% of the value of fertilisers used in Europe is made of mineral fertilisers, i.e. of fertilisers made from mineral resources. The rest of this paragraph refers to mineral fertilisers only.

[190] https://www.fertilizerseurope.com/

Main areas of usage

Fertilisers are primarily used in agriculture. Specific products like ammonium nitrate, urea or ammonium phosphate, though predominantly for agricultural purposes, have some industrial applications.

NACE codes

The manufacture of fertilisers is the purpose of NACE rev.2 code 20.15 "Manufacture of fertilisers and nitrogen compounds".

Stages in the production process

The consumption in the EU in 2018 of mineral-based fertilisers is distributed as follows between chemical elements:

- 11.3 Mtonnes of nitrogen-based fertilisers (expressed in tonnes of incorporated nutrients and excluding nitrogen-based products for non-fertiliser use);
- 3.1 Mtonnes of potassium-based fertilisers;
- 2.9 Mtonnes of phosphorus-based fertilisers.

For nitrogen-based fertilizers, the largest product group, the process starts by mixing nitrogen from the air with hydrogen from natural gas at high temperature and pressure to create ammonia, in a process called the Haber-Bosch process. Approximately 65% of the natural gas is used as raw material, with the remainder is employed to power the "steam methane reforming" process transforming natural gas into hydrogen, and the process of of hydrogen and nitrogen synthesis.

The ammonia is used to make nitric acid, with which it is then mixed to produce nitrate fertilizers such as ammonium nitrate (AN). Ammonia may also be mixed with liquid carbon dioxide to create urea. Both these products can be further mixed together with water to form UAN (urea ammonium nitrate) solution.

Phosphorus (P)-based fertilizers are produced from mined ores. Phosphate rock is primarily treated with sulphuric acid to produce phosphoric acid, which is either concentrated or mixed with ammonia to make a range of phosphate (P_2O_5) fertilizers. Sulphuric acid itself is the result of the combustion of sulphur and of the combination of the resulting sulphur dioxide with water, which all are reactions that generate (rather than absorb) energy. As a result, none of the stages of the production of phosphorus-based fertilisers can be considered as energy-intensive.

Potassium (K)-based fertilizers are also produced from mined ores. Several chemical processes can be used to convert the potash rock into plant food, including potassium chloride, sulphate and nitrate. Potassium chloride is the compound naturally present in the mineral ore and requires no other treatment than purification. Potassium sulphate results from the reaction with sulphuric acid, which is not energy-intensive. Potassium nitrate results from the reaction with nitric acid, which is part of the process used to manufacture nitrogen-based fertilisers described above, so that the energy-intensive part of the process is already included there.

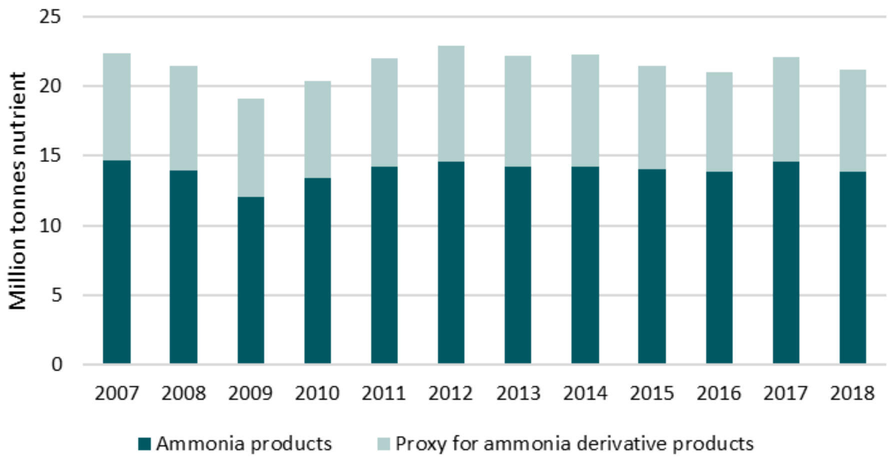
As a conclusion, the only energy-intensive segment of the production of fertilisers lies in the manufacturing of ammonia, and more specifically in the "steam reforming" of natural gas to obtain hydrogen, where the natural gas is both the feedstock (for 65%) and the energy carrier (for 35%).

Economic situation of the sector

The production quantity of fertilisers is difficult to estimate, as volume units in the sector vary between tonnes of product and tonnes of nutrient. The figure below depicts production levels for ammonia and for ammonia derivative products over the past decade. The production levels depicted do not account for other kinds of fertilisers produced and represent about 50-60% of total fertiliser production levels in the EU.

Between 2007-2018, ammonia production levels remained relatively constant, declining in 2009 but recovering in 2010 and 2011 to remain just below 15 million tonnes of nutrient. Production levels for ammonia derivative products - i.e., urea and ammonium nitrate - fluctuated between 7 and 8.4 million tonnes of nutrient between 2007-2018. Overall, production levels for ammonia and for ammonia derivative fertilisers combined remained above 20 million tonnes of nutrient except in 2009, when production of all fertilisers fell.

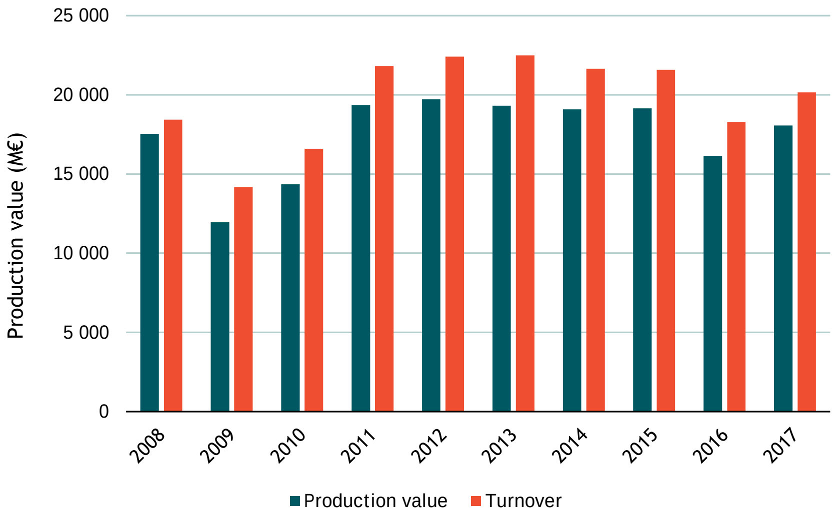
Figure D-52 Trends in production quantity of ammonia and key ammonia derivative fertilisers in the EU28.



Source: Data provided by Fertilizers Europe from the International Fertilizers Association (2020).

Production value of fertilisers has increased from 12 billion EUR to over 19 billion EUR between 2009 and 2011. Between 2011 and 2015, it stagnated at around 19 billion EUR, while it slightly decreased between 2015 and 2017. Turnover trends follow the same trends as production value, but at slightly lower rates.

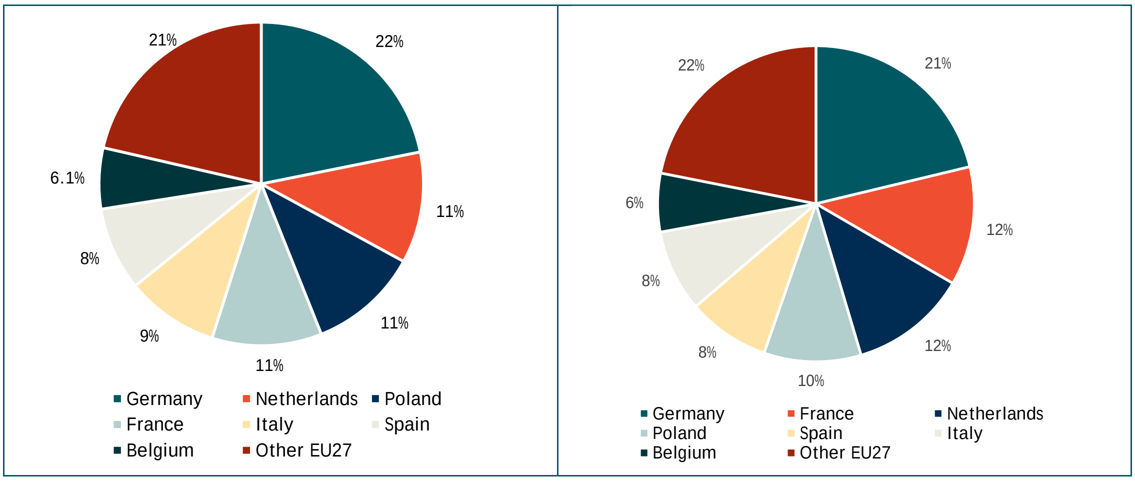
Figure D-53 **Trends in production value and turnover of fertilisers in the EU27 (M€).**



Source: Eurostat SBS (2020).

The distribution of production value shows that the fertiliser sector is quite concentrated. Seven Member States account for 71% of production value. Germany is the largest producer in terms of value, followed by the Netherlands, Poland, France Italy, Spain, and Belgium. The same seven Member States account for 78% of the sector's turnover, but in a slightly different order.

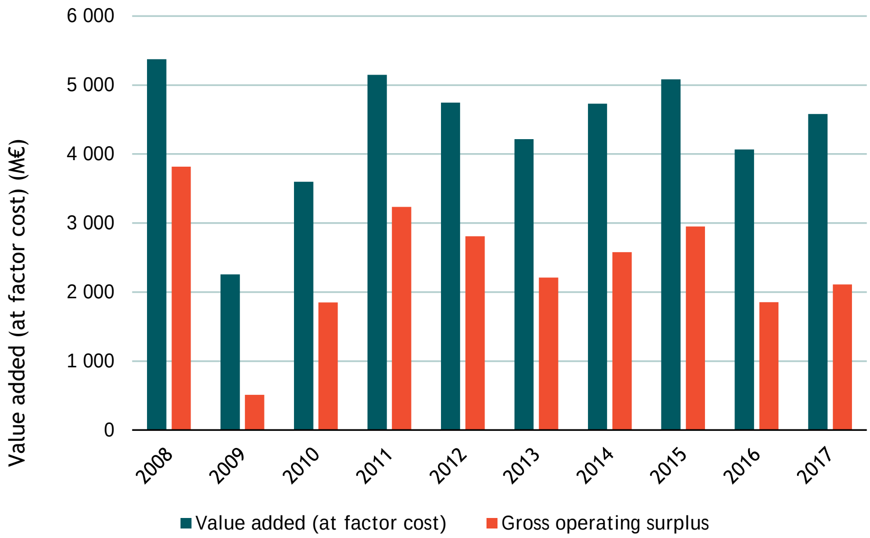
Figure D-54 Distribution of EU production value (left) and turnover (right) of fertilisers in the EU27 Member States.



Source: Eurostat SBS (2020).
Notes: based on average values between 2008-2017.

Value added levels of the fertiliser sector were highest in 2008, when they reached nearly 5.6 billion EUR. Value added dropped sharply to 2.3 billion EUR in 2009. Between 2010 and 2017, levels of value added oscillated between 3.5 and just over 5 billion EUR. Gross operating surplus levels of the sector followed a similar pattern, peaking in 2008 at more than 3.8 billion Euros, dropping in 2009 to around 510 million EUR before recovering in 2010 and oscillating between 1.9-2.1 billion EUR until 2017.

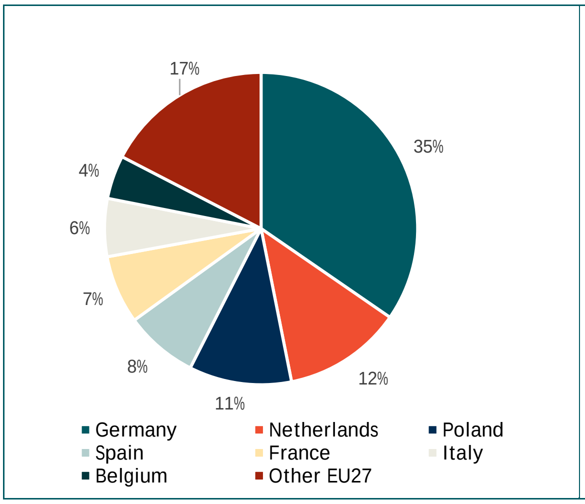
Figure D-55 **Trends in value added (at factor cost) and gross operating surplus of fertilisers in the EU27 (M€).**

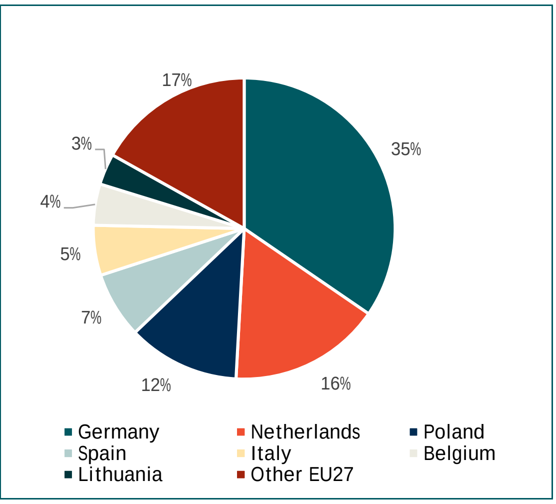


Source: Eurostat SBS (2020).

83% of value added and gross operating surplus values in the EU fertilisers sector are concentrated in seven Member States, with Germany again accounting for the highest share of both (35%).

Figure D-56 Distribution of value added at factor cost (left) and gross operating surplus (right) of fertilisers in the EU27 Member States.



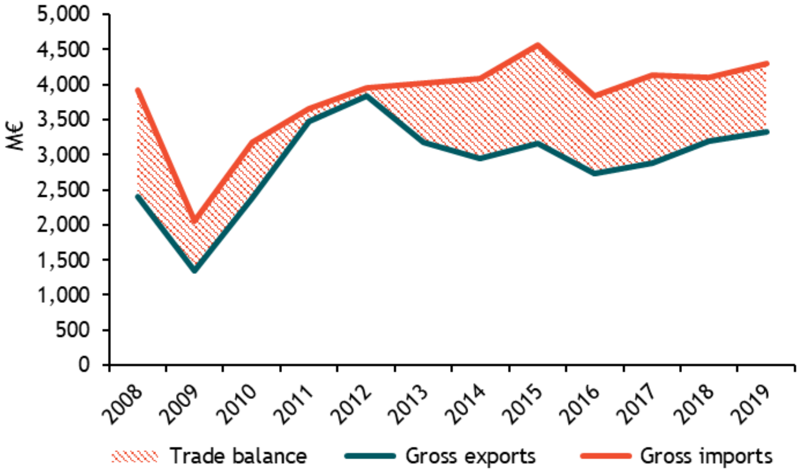


Source: Eurostat SBS (2020).
Notes: based on average values between 2008-2017.

Trade situation of the sector

The EU27 has been a net importer of fertilisers since 2008, though export levels approached import levels in 2012 before falling again between 2012-2019. Fertiliser imports fell sharply in 2009 but recovered quickly, peaking in 2015 at 4.6 billion Euros. Though they decreased slightly in 2016, imports remained around 4.2 billion Euros between 2017-2019. Fertiliser exports likewise dropped sharply in 2009 before rising to peak in 2012 at 3.8 billion Euros. Exports then fell between 2013-2016 before slowly increasing to ~3.3 billion Euros in 2019. The figure below displays data pertaining to mineral or chemical nitrogenous fertilisers, mineral or chemical phosphatic fertilisers, and mineral or chemical potassic fertilisers combined.[191]

Figure D-57 Trends **in trade balance of fertilisers in the EU27 (M€).**



Source: COMEXT (2020).
Notes: COMEXT codes 3012-3105

The trade situation of the most energy-intensive part of the EU fertilisers industry, pertains specifically to quantities (in kilotonnes) of nitrogen fertilisers. The fertilisers sector is considerably exposed to

[191] Import and export figures were collected for COMEXT for the Codes 3102, 3103, 3104 and 3105.

international trade; on average between fertiliser years[192] 2011-2018, 26.8% of internal nitrogen fertilisers consumption in the EU was served by extra-EU imports. These figures only represent part of the entire sector; for other types of fertilisers, internal consumption is served by even higher shares of extra-EU imports. An 2018 EC assessment calculated that the trade intensity of the broader fertilisers sector was 31.8%.[193]

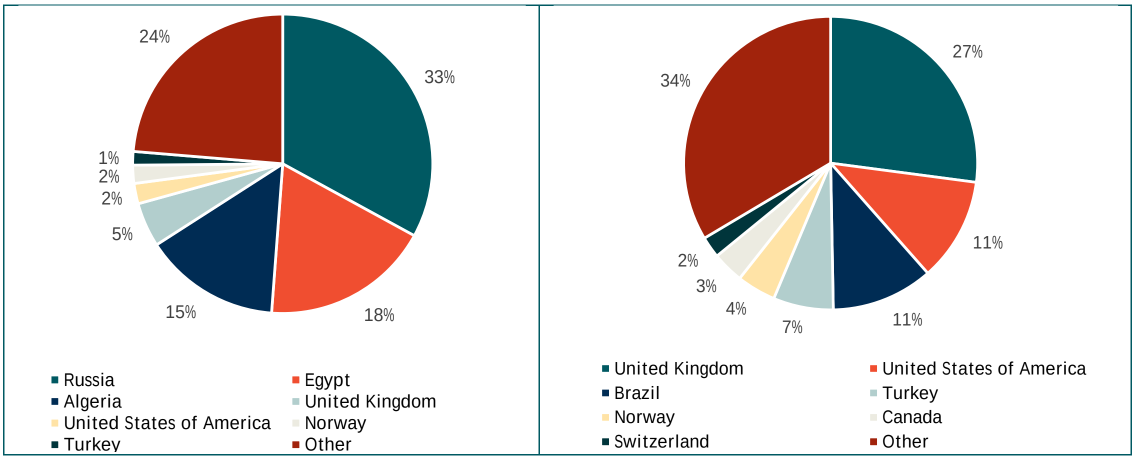
Table D-45 Exposure of fertilisers in the EU27 to international trade.

Indicator	2011*	2012	2013	2014	2015	2016	2017	2018
Gross imports (kilotonnes of nitrogen)	2430	2923	3482	3575	4242	4006	4107	4098
Internal consumption (kilotonnes of nitrogen)	12058	12636	13219	13521	13807	13996	14150	13778
Share of internal consumption served by extra-EU imports	20.2%	23.1%	26.3%	26.4%	30.7%	28.6%	29.0%	29.7%

Source: COMEXT and data provided by Fertilizers Europe (2020).

The main three extra-EU import sources for the fertilisers industry are Russia, Egypt and Algeria, which together account for 66% of imports; while the main three extra-EU export destinations are the UK, the USA and Brazil account for 49% of exports.

Figure D-58 Distribution of imports (left) and exports (right) of fertilisers in the EU27.



Source: COMEXT (2020).

Sample statistics

The sample consists of thirteen installations in Europe (EU27), spread across eight Member States and accounting for nearly 65% of fertiliser production in the EU. Due to confidentiality reasons, the countries included in the sample cannot be delineated.

Table D-46 Fertiliser plants participating in the survey

Geographical regions	Questionnaires collected
North Western Europe	3
Central Eastern Europe	7
Southern Europe	3
Total	13

[192] Note that import quantities are recorded per fertilizer year; i.e., the quantities reported for the year 2011 were imported and consumed between July 2010-June 2011.
[193] This was concluded while assessing the risk of carbon leakage in the EU fertilizer sector for Phase 4 of the ETS.

Table D-47 describes the ranges of installed capacity for the 13 plants that provided information on annual production capacity of fertilisers (in million tonnes per year). For confidentiality reasons it is not possible to present production capacities for individual plants in the sample.

Table D-47 Plant capacity ranges of the sample.

Capacity range (million tonnes/year)	Share of plants in sample
<1	38%
1-2	31%
>2	31%

Source: Own elaboration based on data from fertiliser companies.

The product spread of the surveyed plants included Ammonia, ammonium nitrate, calcium ammonium nitrate, urea, nitrogen-phosphorus-potassium (NPK) fertilisers, urea ammonia nitrate solutions (UAN), phosphoric acid (PAWET), and other straight nitrogen (OSTRN). Subsequent analysis on energy prices and costs presents results according to the types of products produced at plants, to differentiate between trends for ammonia producers and producers of other fertiliser products. Surveyed plants fall into the categories outlined in Table D-48. Calculated results cannot be displayed for producers of derivative fertilisers, but their influence is reflected in overall averages.

Table D-48 Fertiliser plants participating in the survey according to product types

Type of plant	Questionnaires collected
Producer of ammonia	2
Producer of ammonia and other derivative fertilisers	10
Producer of derivative fertiliser	1

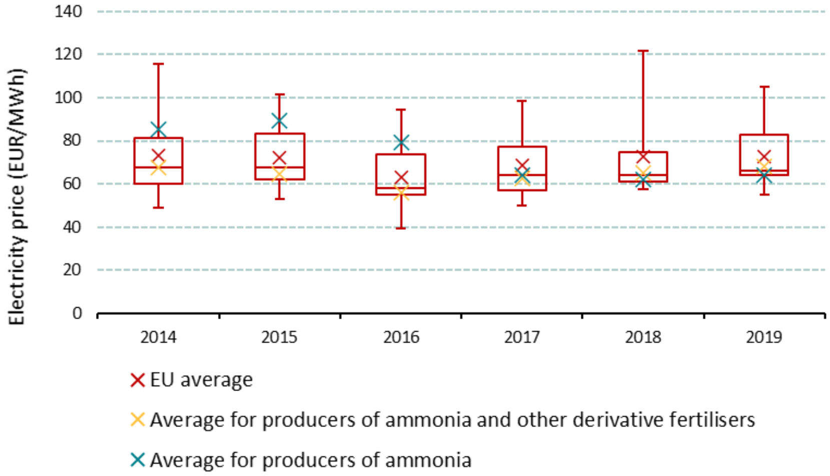
Energy prices

Electricity price

Electricity prices in €/MWh paid by EU fertiliser producers on average remained relatively steady between 2014-2019, with a slight decrease from 2014 to 2019 from 73.2 to 72.5 €/MWh (Table D-49, Figure D-59Figure D-7). These electricity prices account for all price components including network costs (i.e., Transmission System Operator (TSO) and Distribution System Operator (DSO) fees) and if applicable, levies, taxes, interruptability discounts and CO2 retributions. They exclude VAT charges. As depicted in Figure D-7, producers of ammonia paid higher electricity prices on average than producers of ammonia and derivative fertilisers until 2018, when average prices for ammonia producers dropped. Volatility in prices for producers remained high over the period.

Ten out of thirteen plants reported purchasing all electricity in the wholesale market in every year of the observed period. The remaining three, all producers of ammonia and derivative products, did not purchase any electricity in the wholesale market.

Figure D-59 **Electricity prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

Table D-49 Descriptive statistics for electricity prices paid by sampled EU fertiliser **producers (€/MWh) -** simple averages.

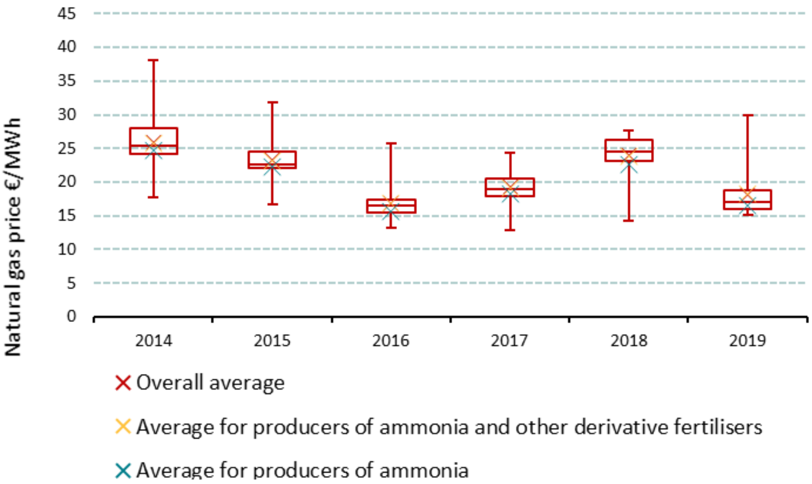
Electricity prices (€/MWh)	2014	2015	2016	2017	2018	2019
Overall average	73.2	72.2	63.1	68.4	72.8	72.5
Average for producers of ammonia and other derivative fertilisers	67.9	64.5	56.2	62.4	65.3	68.3
Average for producers of ammonia	85.4	89.2	79.3	64.3	61.9	64.3

Source: Own elaboration based on data from fertiliser companies.

Natural gas trends

Figure D-60 and Table D-50 show the average price paid by producers of fertilisers for natural gas fluctuated significantly between 2014-2019. The natural gas price reached its lowest average value of 16.9 €/MWh in 2016, before increasing in 2018 to an "unusually high" (according to producers[194]) value of 24.1 €/MWh. The natural gas price decreased substantially again in 2019 to 18.1 €/MWh. Producers of ammonia pay slightly higher prices for natural gas than producers of ammonia and other derivative fertilisers, though the range of gas prices paid by different producers is much narrower than the range of electricity prices paid.

Figure D-60 **Natural gas prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

[194] Fertilizers Europe (2019), 2018/2019 Overview - accessible via https://www.fertilizerseurope.com/wp-content/uploads/2019/08/Fertilizers_Europe_Annual_Overview_2018-2019_web.pdf

Table D-50 Natural gas prices paid by sampled EU fertiliser **producers (€/MWh) -** simple averages.

Natural gas price (€/MWh)	2014	2015	2016	2017	2018	2019
Overall average	25.9	23.3	16.9	19.3	24.1	18.1
Average for producers of ammonia and other derivative fertilisers	25.7	23.2	16.9	19.1	23.9	18.2
Average for producers of ammonia	24.7	22.3	15.6	18.3	22.6	16.5

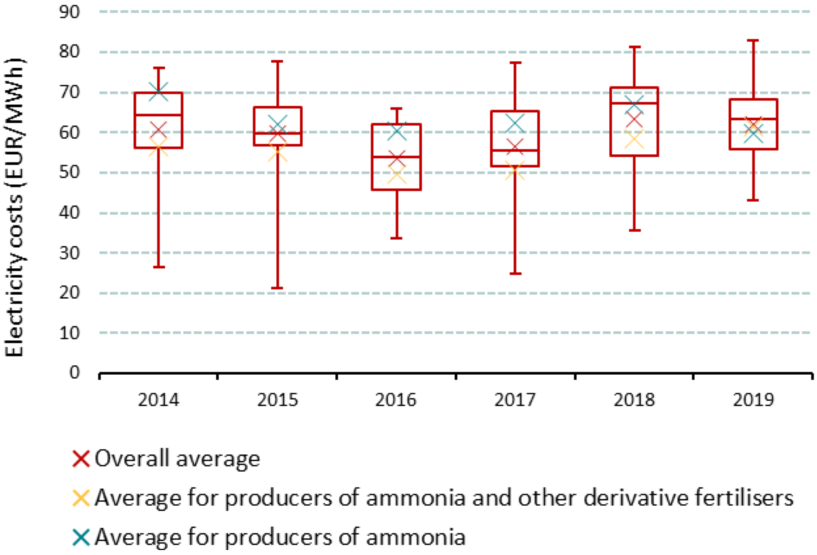
Source: Own elaboration based on data from fertiliser companies.

Energy costs

Electricity costs

Trends in electricity costs for EU producers of fertilisers differ when comparing Euros/MWh versus Euros/Tonne of product. As depicted inFigure 0-61, average costs in Euros/MWh fell between 2014-2016, then gradually rose until 2018 before falling again in 2019. A wide range of prices was paid by fertiliser plants; producers of ammonia paid more per MWh than producers of ammonia and derivative fertilisers until 2019, when the costs range narrowed and average costs for all producers converged.

Figure 0-61 Electricity costs in **€**/MWh **-** Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

Table D-51 **Electricity costs (€/**MWh) - Simple averages.

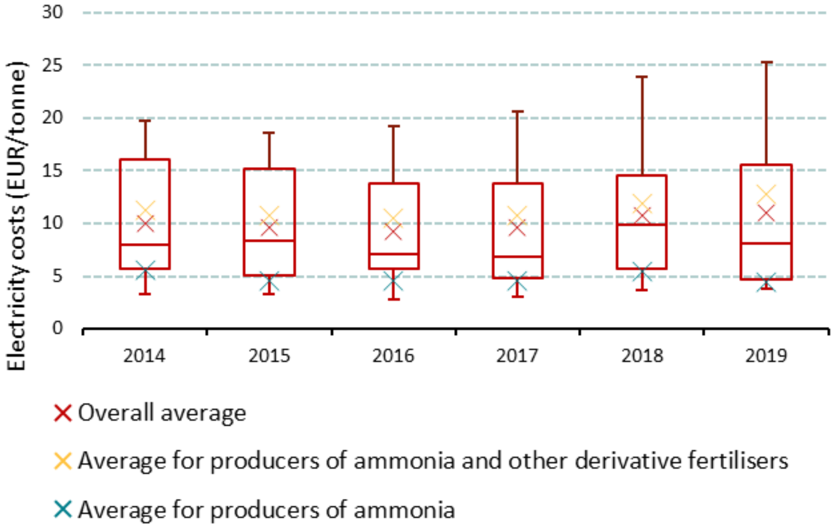
Electricity costs (EUR/MWh)	2014	2015	2016	2017	2018	2019
Overall average	60.9	59.7	53.5	56.4	63.3	62.2
Average for producers of ammonia and other derivative fertilisers	56.4	55.3	49.7	50.6	58.6	61.3
Average for producers of ammonia	70.1	62.0	60.3	62.2	67.0	59.8

Source: Own elaboration based on data from fertiliser companies.

Contrastingly, electricity costs in Euros/Tonne for EU producers of fertilisers remained relatively steady between 2014-2019, staying between 9.3 and 10.9 €/tonne of production. Consistently, producers of ammonia incurred the lowest costs per tonnes of product, while producers of ammonia and derivative fertilisers incurred higher than average costs per tonnes of product. While average figures for producers of derivative fertilisers cannot be depicted to protect confidentiality, this cost trend indicates that producers of derivative fertilisers would incur highest electricity costs per tonnes of product, sitting at the top of the range.

Eight of thirteen plants reported self-producing electricity, several at levels comparable to or greater than their purchased electricity.

Figure D-62 Electricity costs in EUR/tonne - Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

Table D-52 **Electricity costs (€/tonne) -** Simple averages.

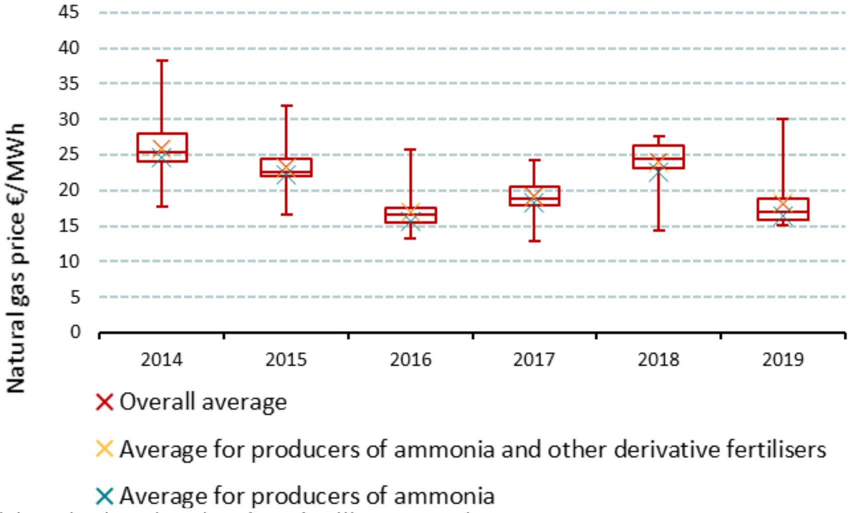
Electricity costs (EUR/tonne)	2014	2015	2016	2017	2018	2019
Overall average	10.0	9.7	9.3	9.6	10.7	10.9
Average for producers of ammonia and other derivative fertilisers	11.2	10.8	10.5	10.7	11.9	12.8
Average for producers of ammonia	5.5	4.5	4.5	4.5	5.4	4.4

Source: Own elaboration based on data from fertiliser companies.

Natural gas costs

Figure D-63 shows natural gas costs incurred by producers of fertilisers in Euros/MWh, while Figure D-64 shows costs incurred in Euros/tonne. As with electricity costs, natural gas costs are correlated to fertiliser product type and trends differ when considering costs in different bases. When considering Euros/MWh, the range of costs incurred by most fertiliser producers was narrow; costs for all types of producers fell between 2014-2016, rose again until 2018, and fell sharply in 2019. Producers of ammonia incurred slightly lower natural gas costs on average than producers of ammonia and derivative fertilisers. In line with this trend, producers of derivative products incurred higher costs than both groups, though average cost figures for this group cannot be explicitly presented.

Figure D-63 Natural gas - Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

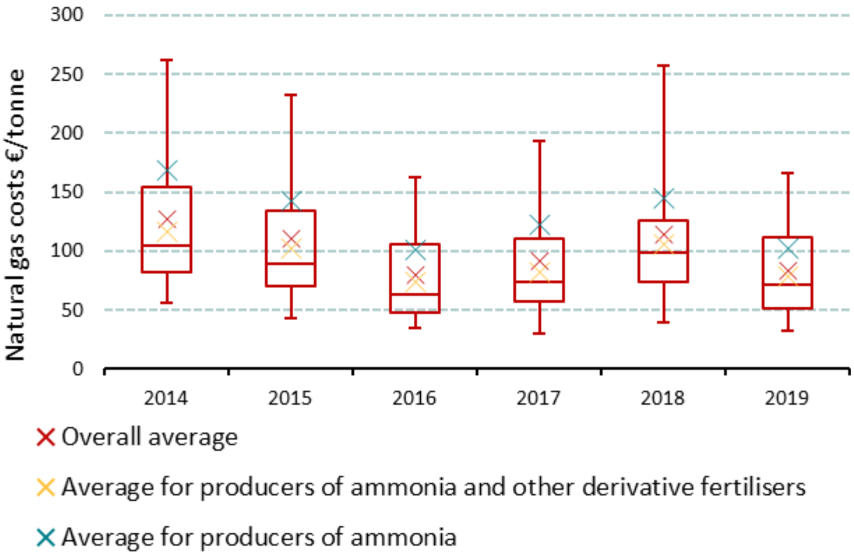
Table D-53 **Natural gas (€/MWh)** - Simple averages.

Natural gas costs (EUR/MWh)	2014	2015	2016	2017	2018	2019
Overall average	25.9	23.3	16.9	19.3	24.1	18.1
Average for producers of ammonia and other derivative fertilisers	25.7	23.2	16.9	19.1	23.9	18.2
Average for producers of ammonia	24.7	22.3	15.6	18.3	22.6	16.5

Source: Own elaboration with data from fertiliser companies.

As with electricity costs, the trend reverses when considering natural gas costs in Euros/tonne. Average natural gas costs per production quantity decreased between 2014-2016, then increased in 2017 and 2018 before decreasing again in 2019. But when considering Euros/tonne, producers of ammonia incurred higher costs on average than producers of ammonia and derivative products. The range of cost/product is quite wide, partly due to the wide-ranging production capacities of the plants surveyed.

Figure D-64 Natural gas - Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

Table D-54 **Natural gas (€/tonne)** - Simple averages.

Natural gas costs (EUR/tonnes)	2014	2015	2016	2017	2018	2019
Overall average	127.1	110.1	79.9	91.9	113.7	83.7
Average for producers of ammonia and other derivative fertilisers	116.1	101.7	74.3	82.5	105.4	78.6
Average for producers of ammonia	168.8	142.0	100.7	122.7	144.9	102.4

Source: Own elaboration with data from fertiliser companies.

Other fuel costs

It should be noted that four plants reported the use of self-produced steam as part of their energy use; however, averages of the costs of self-produced steam as an energy fuel for the production process cannot be presented due to confidentiality issues.

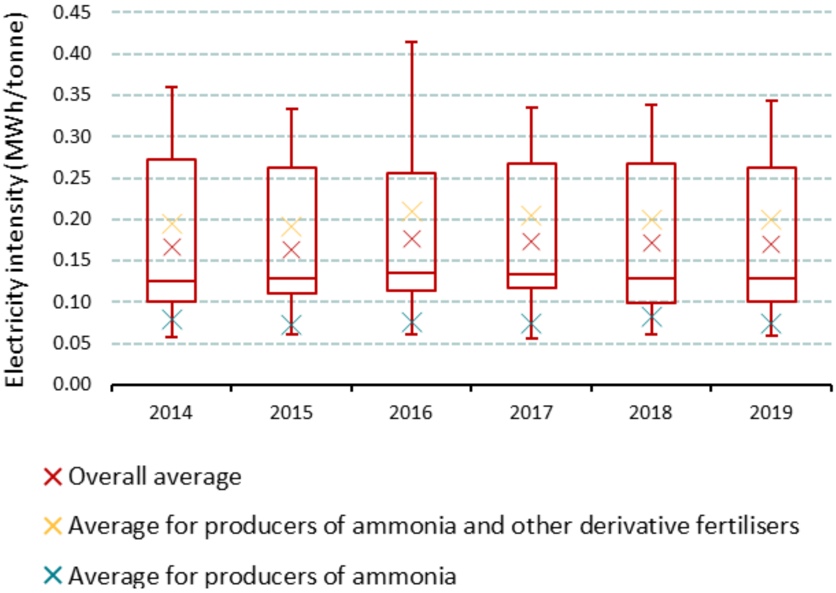
Energy intensity

Electricity intensity

The average electricity intensity (MWh/tonne) of EU fertiliser production remained steady between 2014-2019 (Figure D-65 and Table D-55Table D-17). The wide range of electricity intensities reported is attributable to the range of fertiliser types produced at different plants. The average electricity intensity for producers of ammonia is much lower than electricity intensity for producers of ammonia and derivative fertilisers, which is in turn lower than average electricity intensity for producers of derivative fertilisers (for which explicit averages cannot be shown). Production quantities of ammonia are considerably higher than quantities of derivative fertilisers (for which ammonia serves as feedstock), such that even if electricity consumption levels are comparable across different types of plants, intensity levels in MWh/tonne are lower for plants that produce only ammonia.

Interestingly, electricity intensity levels for 11 fertiliser plants are driven by significant levels of self-produced electricity consumption. On average across the sample surveyed, 42% of all electricity consumed by plants between 2014-2019 was self-produced.

Figure D-65 Electricity intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

Table D-55 Electricity intensity (MWh/tonne) - Simple averages.

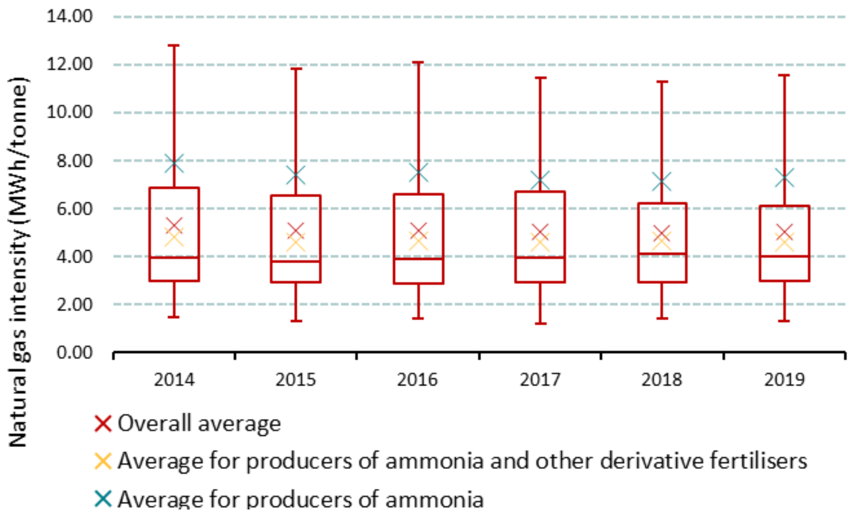
Electricity intensity (MWh/tonne)	2014	2015	2016	2017	2018	2019
Overall average	0.17	0.16	0.18	0.17	0.17	0.17
Average for producers of ammonia and other derivative fertilisers	0.2	0.2	0.2	0.2	0.2	0.2
Average for producers of ammonia	0.1	0.1	0.1	0.1	0.1	0.1

Source: Own elaboration with data from fertiliser companies.

Natural gas intensity

The natural gas intensity of fertiliser production in the EU was substantially higher than the electricity intensity presented above. Again, the wide range of intensities can be attributed to different product ranges at fertiliser plants.Figure D-66 and Table D-56 indicate that natural gas intensity at an EU level remained steady between 2014-2019, with average values approaching 5 MWh/tonne over the period. In contrast to average electricity intensity, average natural gas intensity for producers of ammonia is much higher than natural gas intensity for producers of ammonia and derivative fertilisers, partly because natural gas is used as a feedstock for ammonia production. Producers of derivative fertilisers only have lower intensities than other fertiliser plants which require higher levels of natural gas to produce ammonia.

Figure D-66 Natural gas intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration based on data from fertiliser companies.

Table D-56 Natural gas intensity (MWh/tonne) - Simple averages.

Electricity intensity (MWh/tonne)	2014	2015	2016	2017	2018	2019
Overall average	5.31	5.07	5.12	5.03	5.01	5.02
Average for producers of ammonia and other derivative fertilisers	4.8	4.6	4.7	4.6	4.6	4.6
Average for producers of ammonia	7.9	7.4	7.5	7.2	7.1	7.3

Source: Own elaboration based on data from fertiliser companies.

Competitiveness of the sector

Table D-57 presents an overview of the indicators used in this section to analyse the competitiveness of the fertilizers sector.

Table D-57 Overview of energy costs as a share of production costs, and energy costs as a share of turnover **(€/tonne, EU) -** Simple averages.

Indicator	2014	2015	2016	2017	2018	2019
Electricity cost €/tonne	10	10	9	10	11	11
Natural gas cost €/tonne	127	110	80	92	114	84
Personnel costs €/tonne	18	18	18	19	20	20
Other production costs €/tonne	33	42	44	33	49	62
Gross operating surplus €/tonne	68	81	63	60	45	66
Turnover €/tonne	238	243	197	195	218	222
Electricity costs as a share of production costs	6.9%	7.4%	8.3%	8.2%	6.7%	7.7%
Natural gas costs as a share of production costs	64.7%	59.9%	52.8%	57.7%	64.2%	55.0%
Energy costs as a share of production costs	72%	67%	61%	66%	71%	63%
Energy costs as a share of turnover	53%	47%	44%	50%	64%	48%

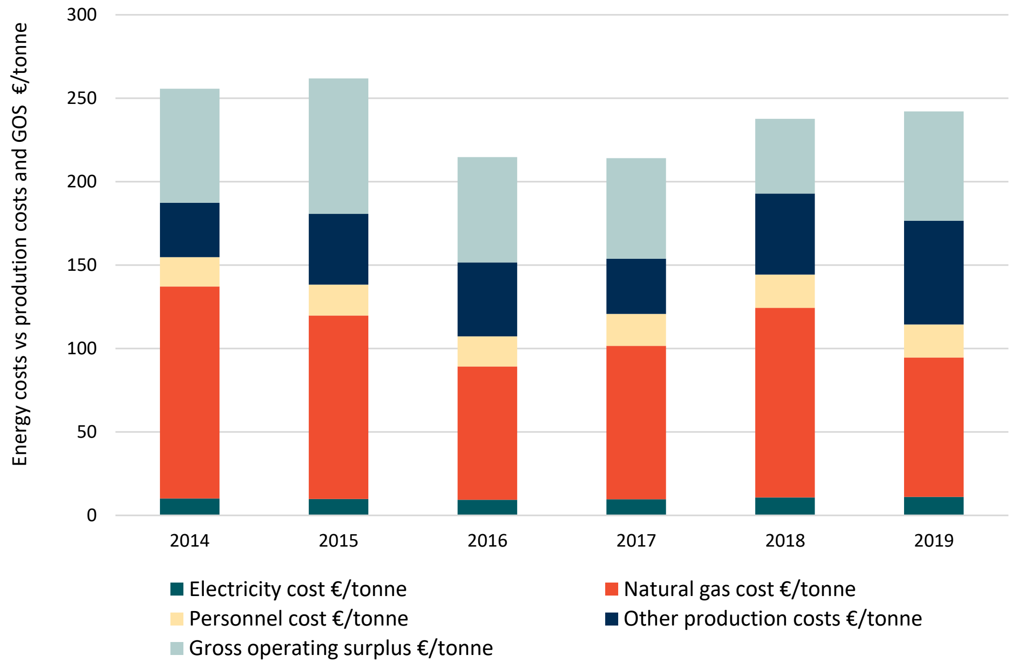
Source: Own elaboration based on data from fertilizer companies.
Notes: based on responses from 9 plants for the years 2014-2017 and from 11 plants for the years 2018-2019.

Profitability

Energy costs represent a substantial fraction of production costs and of turnover of the plants in the sample: between 61% and 72% of production costs, and between 44% and 64% of turnover. Among the energy costs, the costs of natural gas predominate and represent ca. 90% of all energy costs. This very high value is understandable if we consider that the plants in the sample manufacture nitrogen-based compounds. In such plants natural gas is an input in the “steam reforming” process in which it is transformed into hydrogen (this role represents ca. 65% of the consumption), in addition to being an energy carrier. The figures being reported do not distinguish between these two roles of natural gas, and conflate these costs into one figure.

Profitability of the plants in the sample remained reasonable over the reporting period (2014 - 2019), with gross operating surplus representing between 20.6% and 33.3% of turnover. The lowest level of profitability appeared in 2018, when the costs of natural gas rose from 92 €/tonne in 2017 to 114 €/tonne in 2018 (an increase of 22 €/tonne), simultaneously to “other costs” rising by 16 €/tonne (from 33 €/tonne to 49 €/tonne), whereas the turnover per tonne only rose by 23 €/tonne (from 195 to 218 €/tonne), resulting in a decline of gross operating surplus of 15 €/tonne (from 60 to 45 €/tonne). Profitability was restored in 2019 due to a sharp decline of 30 €/tonne in the cost of natural gas (down to 84 €/tonne), in a context of stable turnover per tonne and of rising “other costs”.
It can thus be seen on this case that, despite its prominence in the cost structure, the cost of natural gas is not the only determinant of the profitability of the sector of nitrogen-based fertilisers of our sample.

Figure D-67 Energy costs, other production costs and Gross Operating Surplus of the fertilizer **industry (€/tonne, EU)**, simple averages.



Source: Own elaboration with data from fertilizer companies.

Impact of energy costs on competitiveness of the sector

The European fertilisers sector views energy costs - and specifically, gas costs - as the most important determinant of industry competitiveness.[195] And international energy cost dynamics are just as influential as domestic cost dynamics; even if EU fertilisers are produced more cheaply due to lower gas costs over time, they cannot be marketed competitively if international fertilisers can be produced even more cheaply due to even lower gas costs.

Fluctuations in energy cost dynamics re-shaped the EU fertiliser market in recent years. Between 2012 to 2018, the European market for nitrogen fertilisers (including non-fertiliser applications, e.g. urea-based diesel exhaust fluids such as AdBlue) continuously grew as the EU recovered from the 2009 financial crisis. During this period (between 2013-2016), gas costs for EU producers fell (see Section 0). Counterintuitively, this did not result in an increased EU production to meet additional EU demand. Rather, the production of ammonia and of nitrogen fertilisers declined. International imports rather than domestic products increased to meet the demand growth in the EU market.

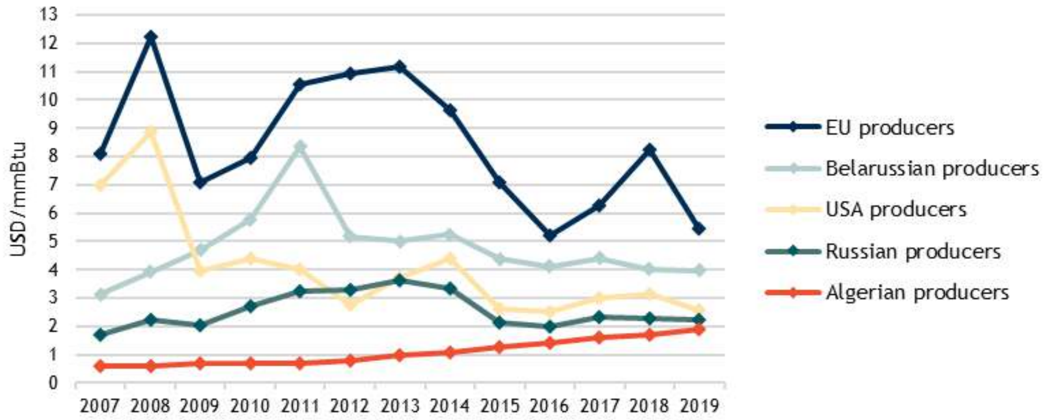
Reduced production of nitrogen fertilisers in the EU can be partly attributed to the closure of several Romanian plants, shut down because economic difficulties prevented a major company from manufacturing its fertiliser products at internationally competitive prices. Export volumes of EU fertilisers declined as products were re-directed to meet domestic demand from users formerly served by Romanian plants. Simultaneously, European fertilizer exporters could not compete with an increasing international supply from producers with lower costs.

Several countries increased their export-oriented production capacity for fertilisers after 2012; Russia, Belarus, Algeria, and the United States became the largest exporters - and lowest-cost producers - of nitrogen fertilizers. While the gap in the cost of gas between the EU and its competitors (Russia,

[195] Consultation with Fertilizers Europe, 4 September 2020.

Belarus, Algeria and the US) declined in the EU between 2014-2016, it increased between 2016 to 2018 gas prices, but it declined again after 2018.

Figure D-68 Gas prices for international fertiliser producers.



Source: Fertilizers Europe, International Business News (Belarus), U.S. Energy Information Administration, Fertecon, Russian Federal Antimonopoly Service.

In 2016, when gas prices in the EU reached their lowest point, EU fertiliser producers were still paying twice as much for gas as their competitors in the US, Russia, and Algeria. The contrast is even more stark in years with higher EU gas prices: in 2018, for example, EU producers paid twice as much as their Belarussian competitors, and four times as much as competitors in the US, Russia and Algeria.

Gas price differentials translate sharply into fertiliser production cost differentials, as gas costs can account for 50-65% of fertiliser production costs (see Table D-57). Market share losses for EU producers can thus be directly attributed to competition from Russian, American and North African fertiliser producers with vastly lower production costs.

Some of this competition is ascribed to unfair trade practices; i.e., DG Trade has recognised that Russian state-fixing of domestic gas prices for local fertiliser producers leads to market dumping that unfairly harms the EU industry. Consequently, an anti-dumping duty was imposed on some Russian nitrogen fertilizers. Still, EU fertiliser producers will continue to face threats from Russian, Belarussian, American, and Algerian competitors as long as their gas prices remain substantially lower than the EU gas prices.

Consequences of COVID for the fertilizers sector

The EU fertiliser industry has been able to maintain its production operations during the COVID-19 crisis. Fertilizer products were recognised by the EU and Members States as an indispensable part of the food-chain. The introduction of "Green Lanes" in border-crossing regulations and the inclusion of "agricultural inputs" among essential goods resolved many of the logistical issues fertiliser producers were facing when supplying products to farmers across the EU. According to industry's preliminary data, the impact of the COVID-19 crisis on fertiliser demand in the EU has been limited.

Refineries

Introduction

The information on the products and processes is essentially based on the input by the Members of the European Petroleum Refining association represented by FuelsEurope and Concawe[196].

Characteristics of the product

Refineries represent the first stage of the processing of crude oil. Crude oil is the generic term to describe a mixture of naturally-present deposits of liquid mineral hydrocarbons. These liquid hydrocarbons present three important characteristics:

- They are liquid, making them easy to transport and to store (unlike gas);
- They burn with very high energy to mass and energy to volume ratios, making them very well suited to fuel mobile vehicles (which need to carry their energy stock with them and cannot - with the exception of rail vehicles and trolleybuses - connect to a fixed power supply grid);
- They contain the atoms of carbon and hydrogen that are the base of organic chemistry.

Main areas of usage

Refineries deliver the following directly usable products:

- A broad range of gaseous and liquid fuels:
  - Liquid Petroleum Gas (LPG), i.e. propane and butane, essentially for heating purposes;
  - Gasoline for light road vehicles;
  - Kerosene for aviation;
  - Automotive diesel, for light and heavy road vehicles, as well as non-road vehicles (e.g. construction machinery);
  - Agricultural diesel, for heavy farming vehicles;
  - Bunker fuels, essentially for maritime transport.
- Lubricants;
- Bitumen, a high-viscosity liquid stored at high temperature, used directly on rooftops and blended together with granulates to form the asphalt on roads.

Refineries also produce intermediate products to be used further down the manufacturing value chain:

- Ethane, LPG and Naphtha, a fraction of crude oil, to be further processed by steam crackers to produce the basic organic chemicals feeding the chemical industry (see below); and
- Coke, a solid fuel essentially made of carbon, to be used in metallurgy;
- A by-product of the refining of crude oil is sulphur, to be used by the chemical industry, for which refineries now represent the largest source.

NACE codes

The NACE rev.2 code 19.2 Manufacture of refined petroleum products covers this sector. It should be noted that EUROSTAT data under this NACE code covers both:

- Mainstream refineries, which are refineries with production capacities over 2.5 Million tonnes per year;
- Smaller installations producing highly specialised petroleum-based products (e.g. lubricants, greases, solvents, coatings, etc.) that are not considered as mainstream refineries, and that generally manufacture product with greater value added and generate less Green House Gas (GHG) emissions to GVA ratio is on average lower than mainstream refineries.[197]

[196] https://www.fuelseurope.eu/ and https://www.concawe.eu/
[197] https://www.fuelseurope.eu/wp-content/uploads/2017/05/fe_ets_def_pages.pdf

Stages in the production process

Crude oil is a mixture of liquid mineral hydrocarbons, blended with impurities, such as sulphur and nitrogen. The relative proportions of each component naturally present in crude oil do not match the proportions required by the market. The functions performed by a refinery are thus:

- The distillation, where crude oil is physically separated into a number of fractions of different boiling ranges. This is done by heating up in a distillation column at atmospheric pressure. For the heavier fractions, vacuum distillation is used in order to lower the temperature at which the heavier fractions can be separated without thermal decomposition. The desired fractions are collected separately and sent for further processing. They cover the whole crude oil boiling range from light gases through LPG, naphtha (virgin gasoline), middle distillates (kerosene and gasoil) and heavy oils;
- Hydrotreating, the process whereby elements such as sulphur and nitrogen are removed from a range of streams, chiefly naphtha and middle distillates, on a solid state catalyst and in the presence of hydrogen. This may be applied, in various forms, to both virgin streams and to those produced by conversion processes. Hydrotreating is required to meet final product specifications and also to make certain intermediate streams suitable for further processing. Process conditions are generally more severe for heavier fractions for which the term "hydrodesulphurisation" is often used;
- Catalytic reforming is universally applied to mostly virgin naphtha to "re-form" low octane saturated hydrocarbons into branched paraffin's and high octane aromatics. The reactions take place on a platinum-containing catalyst at high temperature and low pressure. The catalyst bed is essentially fixed, although modern reformers include a slowly moving catalyst, continuously withdrawn from the reactor section, regenerated and returned. There is a net production of hydrogen that is used in the hydrotreating plants;
- Isomerisation is another process that increases the octane of light naphtha by converting straight-chain paraffins into branched ones. It is often installed in addition to the catalytic reformer when Naphtha stream cannot be exported as petrochemical feedstock;
- Fluid catalytic cracking, in which the feedstock (the portion of the crude oil that has an initial boiling point of 340 °C or higher) is heated to a high temperature (typically 535°C) and moderate pressure (typically 1.7 bar), and brought into contact with a hot, powdered solid acid catalyst. The catalyst breaks the long-chain molecules of the high-boiling hydrocarbon liquids into much shorter molecules, which are collected as a vapor;
- Hydrocracking is a catalytic cracking process assisted by the presence of added hydrogen gas, under very high pressures (70 to 200 bar) and high temperatures (350 to 500°C);
- Visbreaking, a mild conversion thermal cracking process applied to residual streams. Yields of light products are modest but the main benefit is a reduction of the viscosity of the residue which reduces the need for middle distillates as blending components in order to produce marketable heavy fuel oils. If a coker is installed the Visbreaker normally becomes redundant;
- Coking, a severe version of thermal cracking where the residual feedstock is turned into light products and a large proportion of coke;
- Blending is a complex balancing act between product quality, off-take commitments, loading capacities, process plants rundowns and storage capacity. This activity, managed jointly with crude and feedstocks supply, has received increasing attention in recent years, especially in a context of more severe and multifaceted product quality requirements.

The fundamental issue facing the modern refiner is that the market product mix is structurally lighter than the available feedstock (crude oil). In chemistry terms this means that many of the molecules found in crude oil are too large and that their average hydrogen to carbon ratio is too low. Refineries must therefore reduce the size of molecules by “cracking” but also increase that ratio. This can be done by either removing carbon or adding hydrogen. The most common conversion processes are Catalytic cracking, Hydrocracking, Visbreaking and Coking.

“Heavy” hydrocarbons have a lesser energy content per kg than “light” hydrocarbons, so that transforming “heavy” hydrocarbons into “light” ones, i.e. the “cracking” of the long molecules, requires energy (the chemical reaction is described as “endothermic”). This energy being fed to the chemical reaction is incorporated in chemical form in the smaller molecules (for one part - the rest of the energy input constitutes the energy loss of the process). The energy-intensive stages of the process thus include:

- The distillation, because the crude oil needs to be brought to high temperatures to evaporate its successive components: ca. 150°C for naphtha, 150 to 250°C for kerosene, 250 to 360°C for diesel fuel, and up to 400°C (under partial vacuum) for heavier fractions of the crude;
- The cracking, because of the high temperatures involved, but also often (hydrocracking) high pressures, and because these chemical reactions capture energy (they are endothermic).

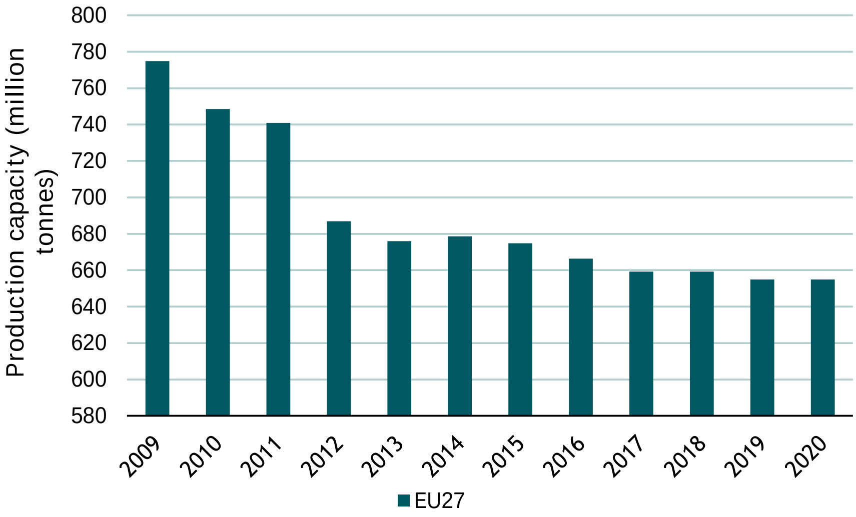
Since refineries are highly integrated installations, these specifically energy-intensive stages cannot be analytically separated from the other ones in the data provided by the refineries. The energy sources being used by refineries are:

- A fraction of the crude oil (typically in the range of 10%) used by the refinery - the rest (typically 90%) constitutes the feedstock out of which the final products are manufactured;
- Natural gas, which produces hydrogen in a process called “steam reforming”, when the hydrogen needed by the hydrocracking process exceeds the production capacity of the installations of the refinery itself. Another important use of natural gas in refineries is as an energy carrier, burnt in process heaters and kettles.

5.3.11 Economic situation of the sector

The primary production capacity of refineries in EU27 has seen a sharp decrease of 15.5% from 2009 and 2020, decreasing from 775 million tonnes to 655 million tonnes. In 2012, the primary refining capacity in EU27 experienced the sharpest decrease of over 7%, from 741 million tonnes in 2011 to 687 million tonnes in 2012.

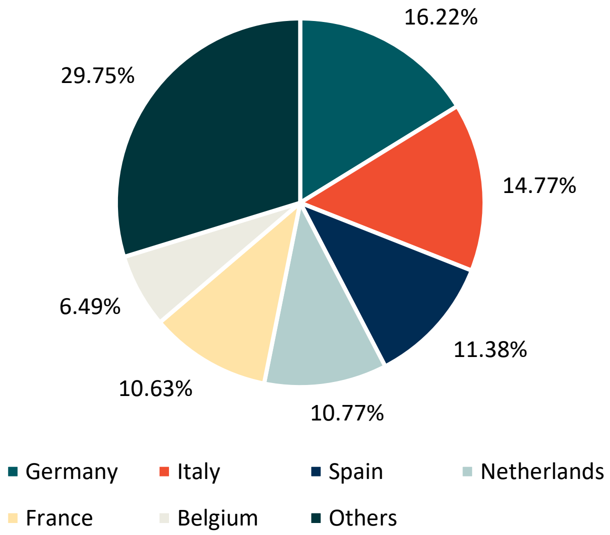
Figure D-69 Trends in production capacity of refineries in the EU27 Member States (in million tonnes per year).



Source: Concawe.

In 2020, the countries with the highest refining capacities were in Germany (16.2%), Italy (14.8%) and Spain (11.4%) accounting for 42% of the total production capacity of refineries within EU27. This is followed by the Netherlands, France and Belgium, accounting for almost 28% of the total refining capacity within EU27. These are so-called mainstream refineries, which exclude refineries with capacities under 1.5 Million tonnes per year.

Figure D-70 Distribution of production capacity of refineries in the EU27 Member States in 2020.



Source: Concawe (n.d.).

The distribution of refineries corresponds to the share of production capacity of refineries within EU27. The highest number of refineries are recorded in Germany (11), Italy (10) and Spain (8), followed by France (7) and the Netherlands (5).

Table D-58 Number of refineries in the EU by Member State. Source: CONCAWE.

Member State	2020
Austria	1
Belgium	3
Bulgaria	1

Member State	2020
Croatia	2
Czech Republic	2
Denmark	2

Member State	2020
Finland	2
France	7
Germany	11
Greece	4
Hungary	1
Ireland	1
Italy	10
Lithuania	1

Member State	2020
Netherlands	5
Poland	2
Portugal	2
Romania	3
Slovakia	1
Spain	8
Sweden	3

Production value of refineries saw an increasing trend since 2009, reaching a peak in 2012 at 250 billion Euros. Since then, production dropped to 86 billion Euros in 2015 and has seen a slight increase since then to 124 billion Euros in 2017. Turnover follows the same trends as production value, with a peak in 2012 and a dip in 2015, followed by a mild increase to 148 billion Euros turnover in 2017. Both production value and turnover seem to follow the trends of international crude oil prices (see Figure D-72).

Figure D-71 Production value and turnover of refineries **in the EU27 (M€). Source: Eurostat SBS (2020).**

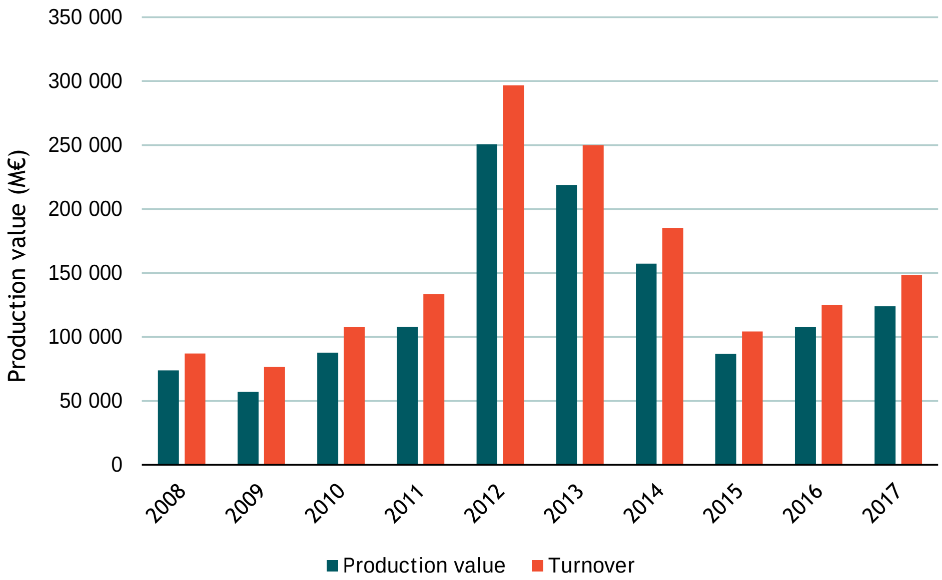
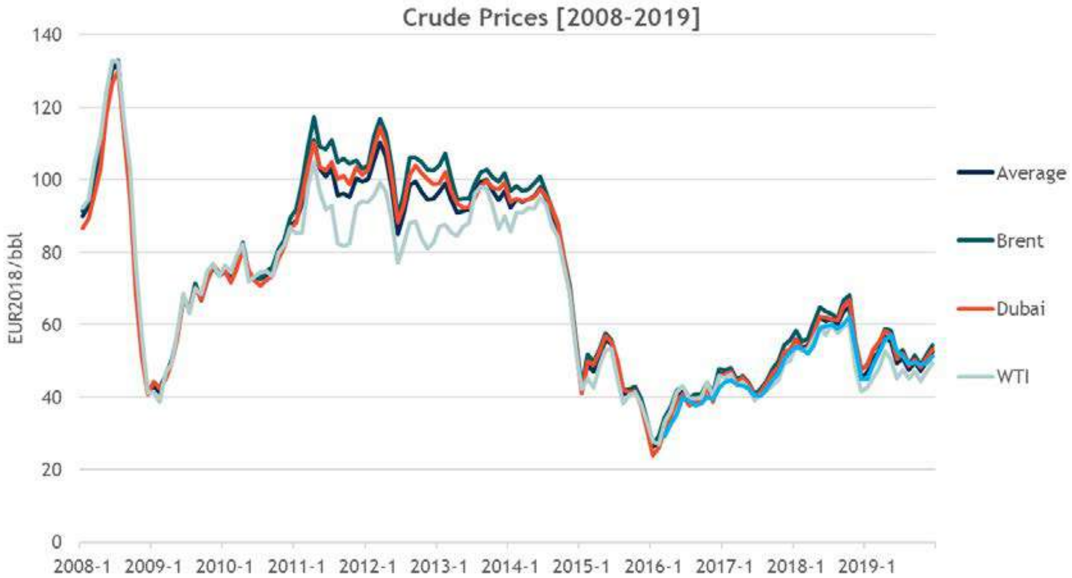


Figure D-72 Crude oil prices, main benchmarks, 2008-2019, EUR_{2018}/barrel (bbl).

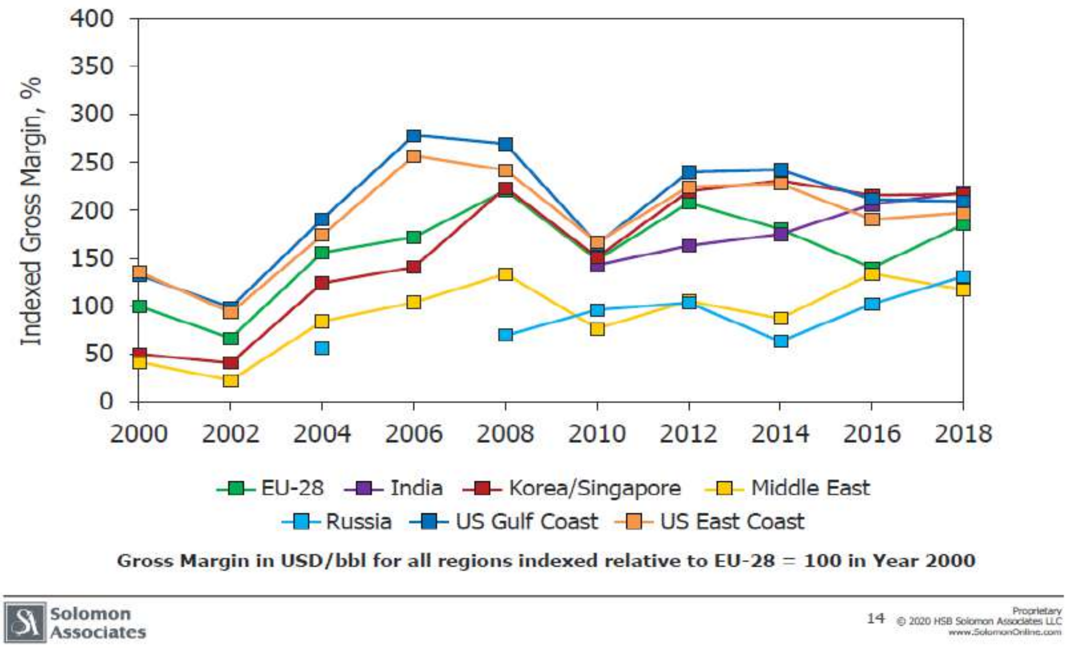


Notes: Average corresponds to World average as provided by the World Bank - Global Economic Monitor Commodities.
Source: Own calculations based on data from World Bank, IEA

The Gross Margin[198] of refineries also provides an indicator of their competitiveness, measuring the product value after the raw materials costs, as a share of the raw material inputs. In the EU28[199] Gross Margin has been oscillating since 2008 (in comparison to 2000, which is the reference year at 100%): in 2008 it was at its peak at over 200%, but it rapidly decreased down to 150% in 2010. In 2012 it recovered to close to 200% but again decreased to around 150% in 2016, and slightly increased in 2018 (see Figure D-73 below). Compared to non-European countries, the EU28 had consistently lower gross margins than the United States (both Gulf and East coasts), while in 2010 it was overtaken by Korea/Singapore, and in 2014 by India. On the other hand, EU28 Gross Margins are larger than those of refineries in Russia and the Middle East.

[198] Gross Margin refers to Gross Product Value minus Raw material costs, divided by Net Raw Material Input.
Gross Product Value: Sum of net product quantity multiplying product price, plus net value of lube refinery and chemical plant transfers, and refinery-produced fuel, minus third-party product terminalling.
Raw Materials Costs: Sum of crude quantity multiplying crude price, plus costsfor other net raw materials, plus third party raw material terminalling
[199] Gross Margin statistics not available by EU27, therefore this number includes the UK.

Figure D-73 Trends in Gross Margin of refineries in the EU28(USD/bbl).

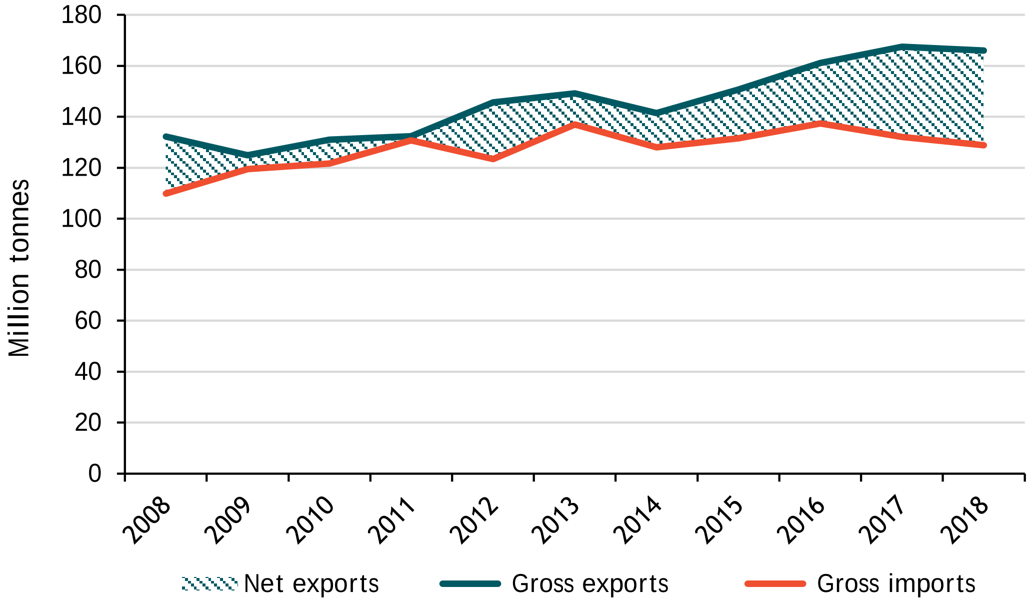


Source: Solomon Associates (2019) via Concawe.

Trade situation of the sector

In terms of production quantity, the EU27 is a net exporter of products from the refining sector. Gross imports oscillated over the years but with an overall increasing trend between 2008 and 2018: it increased from almost 110 million tonnes in 2008 to 137 million tonnes in 2011. On the other hand, gross exports of the refining sector started at 130 million tonnes on average during years 2008-2011, and then started to rapidly increase up to 167.5 million tonnes in 2017 to slightly decrease in 2018 down to 166 million tonnes. As a result, net exports of refined petroleum products between 2008 and 2018 increased 66%.

Figure D-74 Trade balance of refineries in the EU27 Member States (Million tonnes).



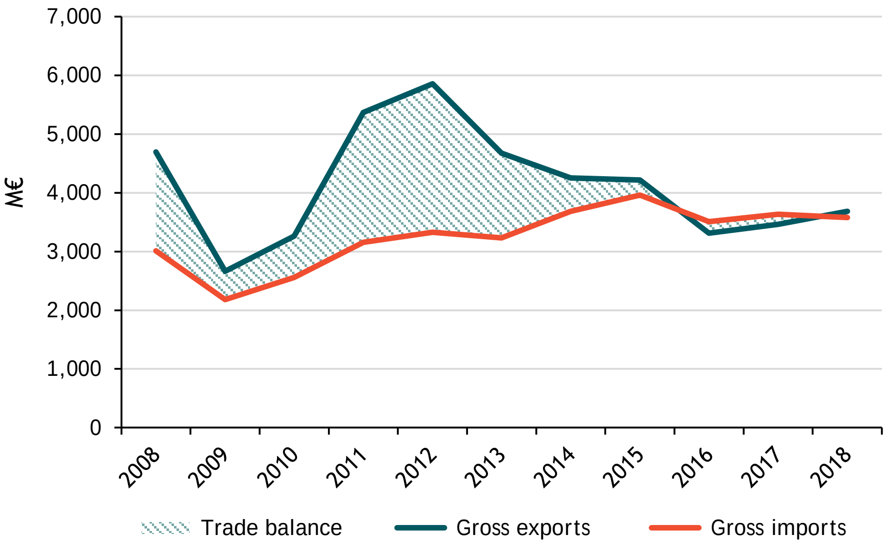
Source: COMEXT (2020).
Note: based on COMEXT code 2710 - Petroleum oils and oils obtained from bituminous minerals (excl. Crude); preparations containing >= 70% by weight of petroleum oil or oils from bituminous minerals; these being the basic constituents of the preparations; waste oils

When zooming in per type of petroleum product (excluding bio-components), different trends are noted for EU trade[200]:

- Gasoline: the EU is a net exporter of gasoline, with increasing overproduction of gasoline in the EU over the years caused by a decrease in domestic consumption. Starting from 2013 this trend stabilized, probably driven by a change in consumer preferences towards gasoline and refinery shut down in the previous year's 2011-2012. In 2018 net exports accounted for over 40% of domestic gasoline production. Traditionally, the EU exported its gasoline surplus to the USA, however since the 2000s the USA increased their local supply due to cheap shale oil and cheap energy. In 2018, EU refiners exported their gasoline surplus mainly to North America, West Africa and Asia;
- Kerosene: the EU is a net importer of kerosene, with around 30% of internal demand supplied by net imports (mainly from Russia and Asia/Middle East);
- Diesel/gasoil: most of the internal demand in the EU is supplied by domestic production, with only 10% of final consumption supplied by net imports;
- Heavy Fuel Oil (HFO): the EU exports a significant amount of HFO, on the range of 10 to 15 Million tonnes per year.[201]

EU27 imports and exports in terms of value are highly dependent on the crude oil prices, this was made evident in the case of gross exports, following the same trends as those observed in Figure D-72 : increasing from 2009 to 2012, decreasing until 2016 and then showing a slight increasing trend again in 2017 and 2018. This evolution is in line with that of the price of oil being imported by the EU.[202] In the case of gross imports value, these followed an increasing trend after 2009, until 2015 when they peaked at almost 4 billion Euros. During 2016 and 2017, gross imports slightly surpassed gross exports, but this was reversed in 2018.

Figure D-75 **Trends in trade balance of refineries in the EU27 Member States (M€).**



Source: COMEXT (2020).
Note: based on COMEXT code 2710 - Petroleum oils and oils obtained from bituminous minerals (excl. Crude); preparations containing >= 70% by weight of petroleum oil

[200] Refers to EU28. Source: FuelsEurope (2020). https://www.fuelseurope.eu/wp-content/uploads/SR_FuelsEurope-_2020-1.pdf
[201] Direct comunication with Concawe
[202] https://data.oecd.org/energy/crude-oil-import-prices.htm

The EU refining sector is strongly exposed to international trade. The share of internal consumption in the EU market served by extra-EU imports has consistently remained above 35%. In 2008 and 2009, more than 80% of EU's consumption was served by extra-EU imports. Subsequently, it decreased progressively to 37.5% in 2012, before increasing again. Similarly, the share of production from EU's refineries dedicated to extra-EU exports has consistently exceeded 40%, and above 55% since 2014.

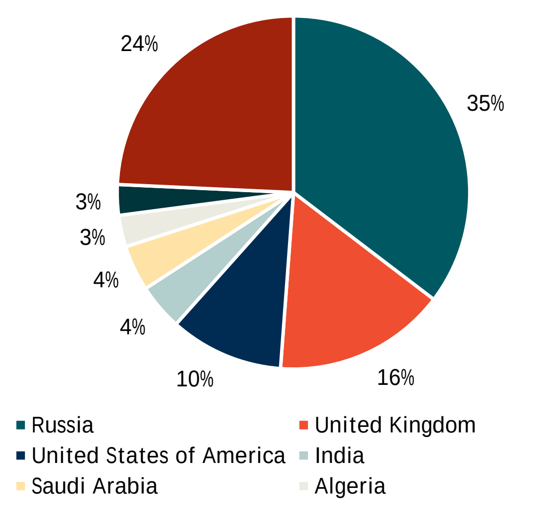
Table D-59 Exposure of refineries in the EU27 to international trade.

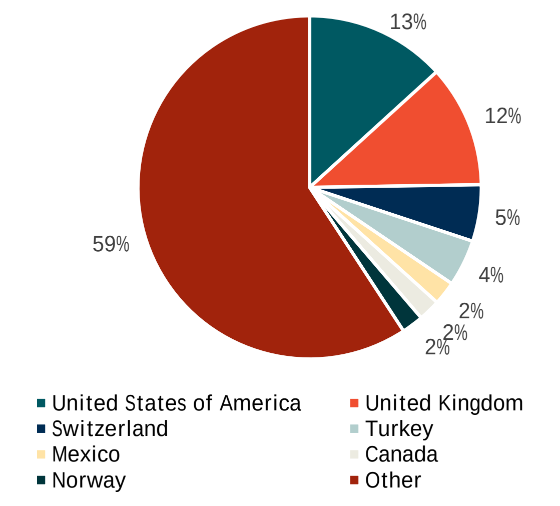
Indicator	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gross exports (M€)	71,063	46,664	64,330	85,181	104,137	99,066	87,702	68,746	58,735	74,051
Gross imports (M€)	60,352	43,196	59,242	83,546	87,763	89,901	77,979	55,858	47,959	57,087
Production value (M€)	73,903	57,093	87,684	107,836	250,641	218,761	157,238	86,888	107,574	123,947
Internal consumption (M€)	63,193	53,625	82,596	106,201	234,267	209,595	147,515	74,000	96,798	106,983
Share of internal consumption served by extra-EU imports	95.5%	80.6%	71.7%	78.7%	37.5%	42.9%	52.9%	75.5%	49.5%	53.4%
Share of production dedicated to extra-EU exports	96.2%	81.7%	73.4%	79.0%	41.5%	45.3%	55.8%	79.1%	54.6%	59.7%

Source: Own elaboration based on COMEXT and SBS (2020)

The main three extra-EU import sources in terms of import value (EUR) are Russia, the UK and Saudi Arabia which together account for 46% of imports; while the main three extra-EU export destinations are the USA, the UK and Switzerland accounting for 28% of exports.

Figure D-76 Distribution of imports (left) and exports (right) of refineries in the EU27 Member States.





Source: COMEXT (2020).
Notes: based in the sum of years 2008-2018.

Sample statistics

The sample consists of 23 installations in Europe (EU27, UK, Switzerland and Norway), out of a total number of 81 mainstream refineries[203] in Europe. The sample is spread in 15 out of the 21 Member States with installations. Due to confidentiality reasons, the countries included in the sample cannot be exposed. The regional spread of the surveyed plants was as follows: 8 plants in the North Western

[203] CONCAWE, 2020. https://www.concawe.eu/refineries-map/

Europe (NWE)[204] region, 4 plants in the Central Eastern Europe (CEE)[205] region and 8 in the Southern Europe (SE)[206] region (see Table D-6). There were also 3 questionnaires received for plants in the non-EU NWE[207] region, however, these could not be included in the analysis due to confidentiality reasons.

Table D-60 Refineries participating in the survey

Geographical regions	Questionnaires collected
North Western Europe (NWE)	8
Central Eastern Europe (CEE)	4
Southern Europe (SE)	8
Non-EU NWE	3
Total	23

Between 2014 and 2019 the turnover by sampled plants represented from 16 to 22% of the overall sectoral production capacity at the EU27 level (Table D-61). From the 20 EU27 plants that provided information on annual production capacity, 17 were mainstream refineries (capacity above 1.5 Million tonnes per year). For confidentiality reasons it is not possible to present production capacities for individual plants in the sample.

Table D-61 Production capacity of sampled plants out of capacity from EU27 refineries (%).

Refineries	2016	2017	2018	2019
Production capacity%	16%	22%	22%	22%
Plants disclosing their capacity	16	20	20	20

Source: Own elaboration with data collected at the plant level and from CONCAWE website.

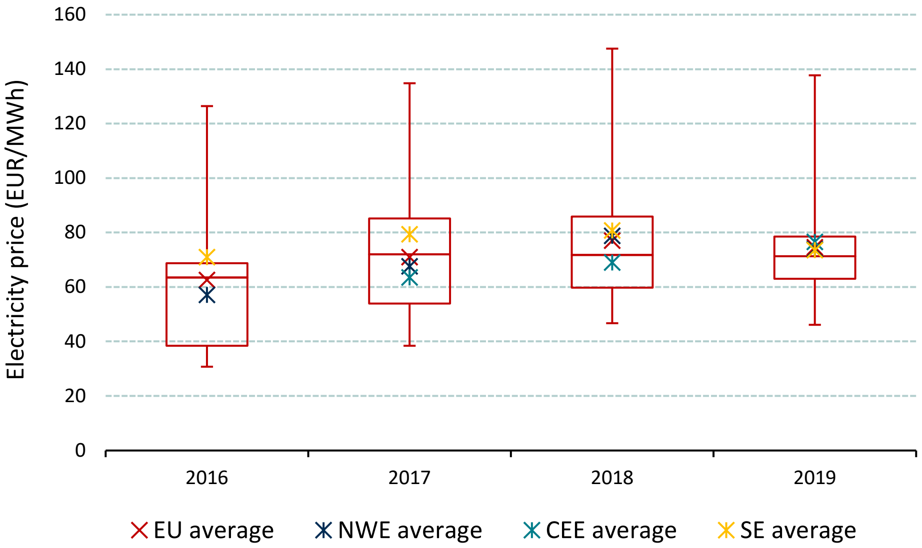
Evolution of energy prices

Electricity prices

The refining sector in the EU experienced an increase in electricity prices, going from €62.6/MWh in 2016 to €77/MWh in 2018, with a slight decreased in 2019 to €74.5/MWh. Electricity prices increased in all regions, but the rise was more pronounced for refineries in the NWE region, going from €57/MWh in 2016 to €78.7/MWh in 2018. In general, electricity prices in SE were the highest during the period, except for 2019 when electricity prices in the CEE region reached €76.6/MWh.

[204] North Western Europe (NWE): Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden.
[205] Central Eastern Europe (CEE): Lithuania, Romania, Bulgaria, Czech Republic, Hungary, Estonia, Latvia, Slovakia and Poland.
[206] Southern Europe (SE): Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, and Spain.
[207] Non-EU NWE region: The United Kingdom (UK), Norway and Switzerland.

Figure D-77 **Electricity prices (€/MWh) -** Box plots and simple averages.



Source: Own elaboration with data from refineries.
Notes: based in answers from 10 plants in 2016, 17 plants in 2017 and 2018, and from 15 plants in 2019.

Table D-62 Descriptive statistics for electricity prices paid by sampled EU refineries **(€/MWh) -** simple averages.

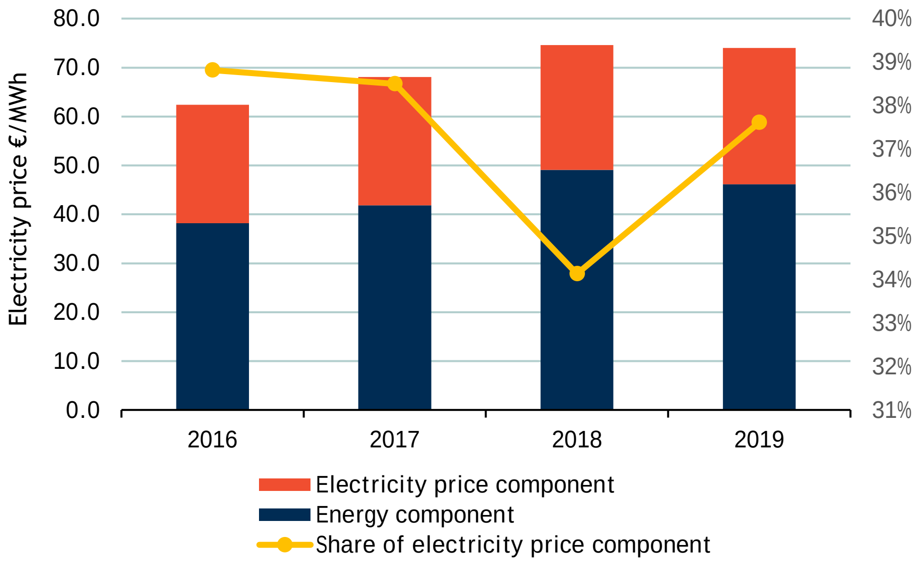
Electricity prices (€/MWh)	2016	2017	2018	2019
EU	62.6	71.0	77.0	74.5
NWE	57.0	67.5	78.7	73.9
CEE	n.a.	63.5	69.0	76.6
SE	70.9	79.4	80.7	73.5

Source: Own elaboration with data from refineries.

Components of electricity prices

Figure D-78 shows the evolution of some components of electricity price paid by refineries in the EU between years 2016 to 2019—simple averages. These are split between energy component and electricity price components. Electricity price components refer to: network costs - Transmission System Operator (TSO) and Distribution System Operator (DSO) - if applicable, levies, taxes, interruptability discounts and CO_2 retributions but excluding VAT. The average energy component of the electricity price in the EU has slightly increased since 2016, reaching 49.1€/MWh in 2018 and decreasing slightly to €46.2/MWh in 2019. Finally, only four plants reported purchasing electricity in the wholesale market during the 2016-2019 period.

Figure D-78 Components of the electricity price (€/MWh, EU) - Simple averages.



Source: Own elaboration with data from refineries.
Notes: based on answers from 6 plants in 2016, 10 plants in 2017 and 2018, and from 8 plants in 2019 that displayed both their electricity prices, including and excluding price components.

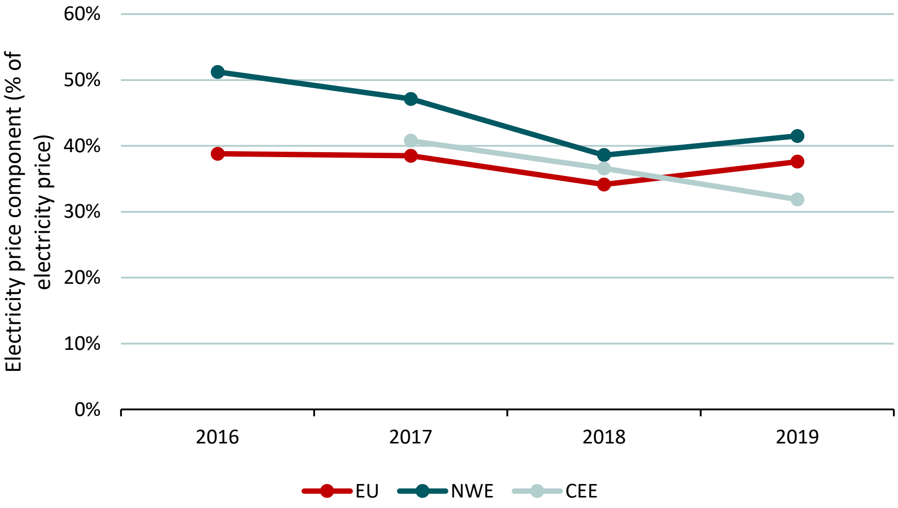
Table D-63 **Components of electricity price: energy component (€/MWh)** and electricity price component **(€/MWh)**- Simple averages.

EU simple averages	2016	2017	2018	2019
Energy component (€/MWh)	38.2	41.9	49.1	46.2
Electricity price component (€/MWh)	24.2	26.2	25.5	27.8
Share of energy component (%)	61%	59%	64%	62%
Share of electricity component (%)	39%	39%	34%	38%

Source: Own elaboration with data from refineries.

Figure D-79 below shows the electricity price components as a percentage of the total electricity price in the EU and in the NWE and CEE regions. In general, refineries in the NWE region have a higher percentage of electricity price component in the total electricity price than in the CEE region. Refineries in NWE and CEE regions both experienced a decrease in the share of electricity price components as a percentage of the total electricity price between 2017 and 2018. However, the trends of the two regions diverged between the years of 2018 and 2019. Refineries in the NWE regions saw a slight increase of about 2% in the share of electricity price components, while refineries in the CEE regions continued to decline further, of about 5%. As a result, the EU experienced an overall decrease of about 1% in the electricity price components as a share of the total electricity price. Details for the SE region could not be presented due to the low number of respondents.

Figure D-79 Evolution of the electricity price components as a share of the total electricity price - Simple averages.



Source: Own elaboration with data from refineries.

Table D-64 **Components of electricity price: energy component (€/MWh) -** Simple averages.

Energy component (€/MWh)	2016	2017	2018	2019
EU	38.2	41.9	49.1	46.2
NWE	27.8	33.5	46.1	41.2
CEE	n.a.	39.3	44.7	54.5
SE	n.a.	n.a.	n.a.	n.a.

Source: Own elaboration with data from refineries.

Table D-65 **Components of electricity price: electricity price component (€/MWh) -** Simple averages.

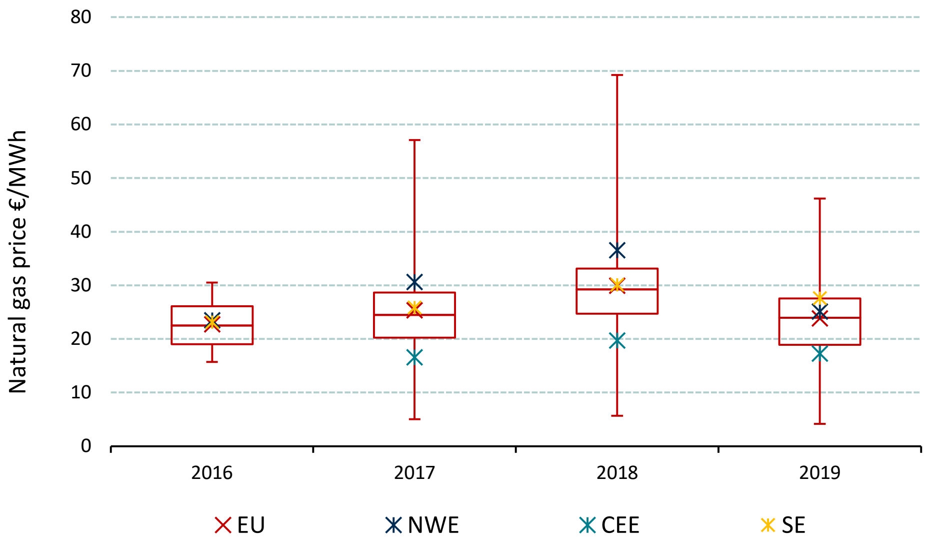
Electricity price component (€/MWh)	2016	2017	2018	2019
EU	24.2	26.2	25.5	27.8
NWE	29.2	29.8	29.0	29.2
CEE	n.a.	27.1	25.8	25.5
SE	n.a.	n.a.	n.a.	n.a.

Source: Own elaboration based on data from refineries.

Natural gas prices

Figure D-80 and Table D-66 show an increasing trend in natural gas prices from €22.7/MWh in 2016 to almost €30/MWh in 2018. Afterwards, the average price paid by refineries decreased again to € 23.8/MWh in 2019. Refineries in the NWE region reported higher natural gas prices than the CEE and SE regions until 2018. By 2019, natural gas prices in the SE region surpassed other regions, with €27.6/MWh. Natural gas prices in the CEE region were reported to be consistently lower than the NWE and SE region during the observed period.

Figure D-80 Natural gas **prices (€/MWh)** - Box plots and simple averages.



Source: Own elaboration with data from refineries.
Notes: based in answers from 8 plants in 2016, 16 plants in 2017 and 2018, and from 15 plants in 2019.

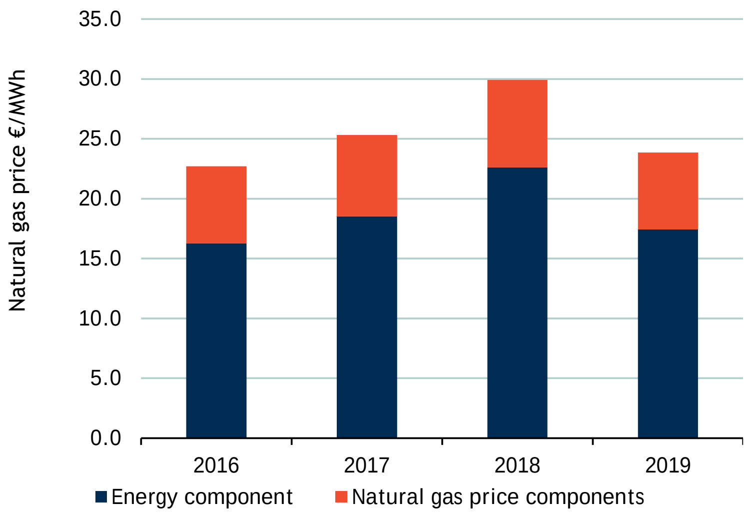
Table D-66 Natural gas prices paid by sampled EU refineries **(€/MWh)** - simple averages.

Natural gas price (€/MWh)	2016	2017	2018	2019
EU	22.7	25.3	29.9	23.8
NWE	23.5	30.6	36.6	25.1
CEE	n.a.	16.6	19.7	17.3
SE	23.1	25.8	30.1	27.6

Components of natural gas price

The energy component of the natural gas price registered its lowest point in 2016, with 16.3 €/MWh, after which they increased €22.6 €/MWh in 2018 (Figure D-81). In contrast, the price components of natural gas (network costs, levies and taxes, except for VAT). reached its highest point in 2018 at €7.3/MWh but decreased again to €6.4/MWh in 2019.

Figure D-81 **Components of the natural gas price (€/MWh, EU)** - Simple averages.

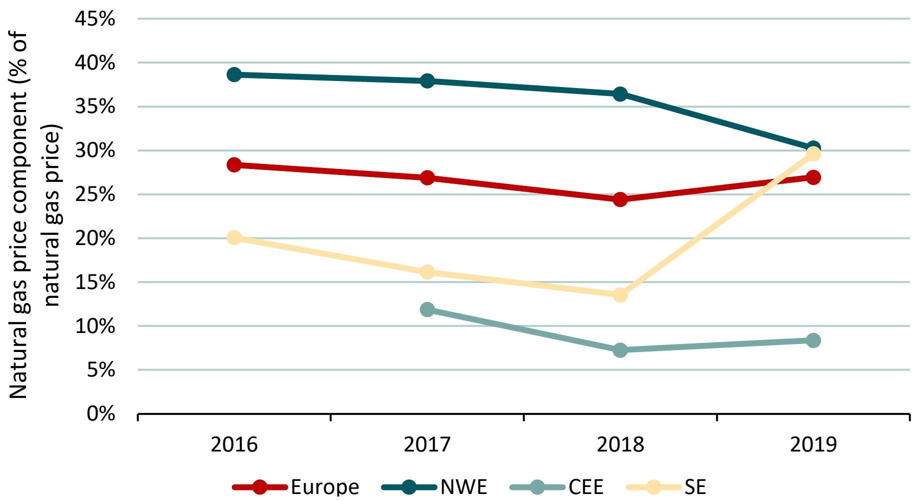


Source: Own elaboration with data from refineries.

The percentage of natural gas price component in the total price of natural gas within the EU decreased by about 3% between the period of 2016 and 2018, before increasing slightly by about 1% between 2018 and 2019. Overall, the percentage of natural gas price components in the total price of natural gas in the EU decreased by about 1% between the period of 2016 and 2019.

In general, the refineries in the NWE region experienced a higher percentage of the natural gas price component in the total price of natural gas, followed by the regions of SE and CEE. Between the period of 2017 and 2018, the refineries in the regions of NWE, SE and CEE experienced a general decrease in the share of natural gas price component in the total price of natural gas between 2017 to 2018. However, while this share decreased about 2% for refineries in both the NWE and SE regions, refineries in the CEE region experienced a sharper decrease of about 4%. Between 2018 and 2019, there were larger fluctuations across the three regions in the share of natural gas price component in the total natural gas price in the EU. This percentage fell by about 6% in the NWE region, while increasing by 16% in the SE region, and about 2% in the CEE region.

Figure D-82 Regional comparison of natural gas price component as a share of natural gas price.



Source: Own elaboration with data from refineries.

Table D-67 **Components of natural gas price: energy component (€/MWh) -** Simple averages.

Energy component €/MWh	2016	2017	2018	2019
Europe	16.3	18.5	22.6	17.4
NWE	14.4	19.0	23.2	17.5
CEE	n.a.	14.6	18.3	15.8
SE	n.a.	21.7	26.0	19.4

Source: Own elaboration with data from refineries.

Table D-68 **Components of natural gas price: price component (€/MWh) -** Simple averages.

Natural gas price component €/MWh	2016	2017	2018	2019
Europe	6.4	6.8	7.3	6.4
NWE	9.1	11.6	13.3	7.6
CEE	n.a.	2.0	1.4	1.4
SE	n.a.	4.2	4.1	8.2

Source: Own elaboration with data from refineries.

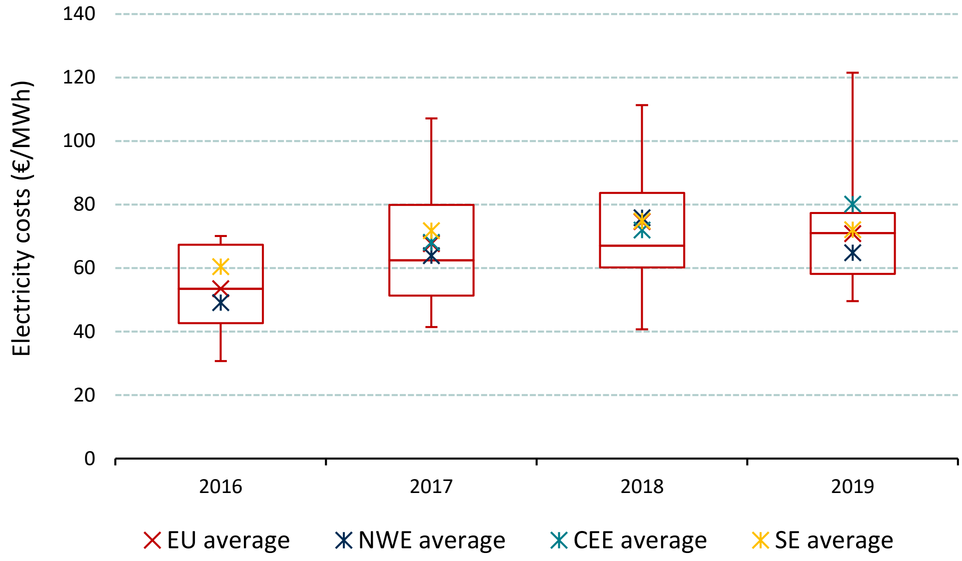
Evolution of energy costs

Electricity costs

Electricity costs of refineries include both purchased electricity (including electricity price components) and the costs of self-generated electricity. Average electricity costs in EUR/MWh at the EU level were on an increasing trend from €53.5/MWh in 2016 to €74.6/MWh in 2018, decreasing slightly to €70.8/MWh in 2019. During the 2016-2018 period the refineries in the NWE region experienced lower electricity costs than those in CEE and SE. In 2018 the electricity costs in converged for the NWE, SE and CEE regions between €72 to €76/MWh, however in 2019 they started diverging again: there was a significant decrease in the NWE region, where the electricity cost went down to €65/MWh, the SE region experienced a modest decrease to €72/MWh, and in the CEE region it increased considerably to €80.1/MWh. The increase in electricity costs for the CEE region was driven both by an increase in electricity prices, and a decrease in production output.

Overall, electricity costs are lower than electricity prices, mainly due to self-generation of electricity reported by 6-9 plants during the 2016-2019 period.

Figure D-83 **Electricity costs (€/MWh) - Simple averages.**



Source: Own elaboration with data from refineries.
Notes: based in answers from 10 plants in 2016, 17 plants in 2017 and 2018, and from 15 plants in 2019.

Table D-69 **Electricity costs (€/MWh) - Simple averages.**

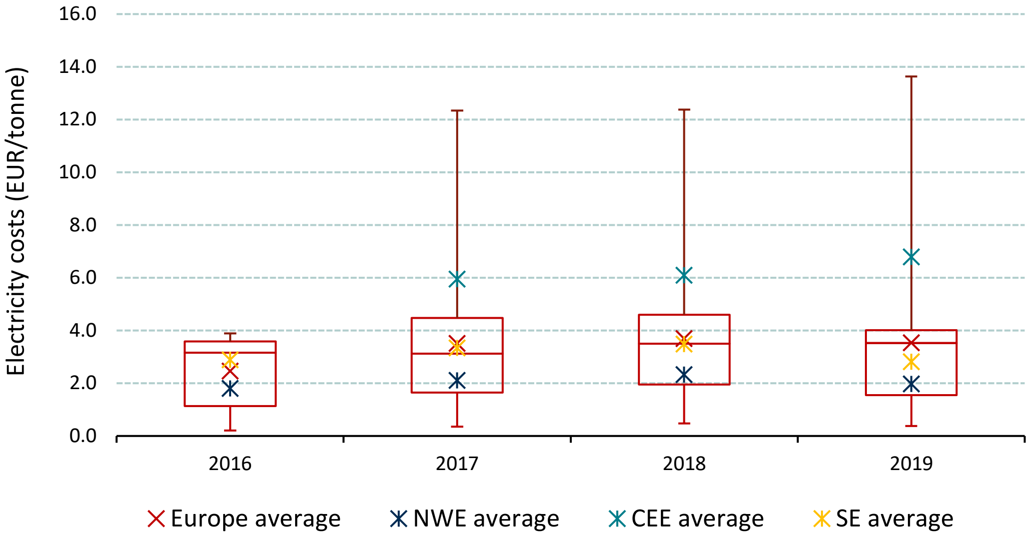
Electricity costs (EUR/MWh)	2016	2017	2018	2019
Europe average	53.5	67.7	74.6	70.8
NWE average	49.1	63.9	75.8	64.9
CEE average	n.a.	68.1	72.0	80.1
SE average	60.4	71.7	74.8	72.0

Source: Own elaboration with data from refineries.

Figure D-84 shows that the average electricity costs per tonne of output in EU refineries increased slightly from €2.5/tonne in 2016 to €3.7/tonne in 2018 and decreased again to €3.5/tonne in 2019. This is in line with the behaviour of electricity prices in €/MWh. The refineries in the NWE reported lower electricity cost per tonne than the CEE and SE regions, ranging between €1.8 to €2.3 per tonne (Figure

D-84 and Table D-70Table D-15). On the other hand, refineries in the CEE region reported the highest electricity costs of the EU, going from €5.9/MWh in 2017 to €6.8/MWh.

Figure D-84 Electricity costs - Box plots and simple averages.



Source: Own elaboration with data refineries.
Notes: based in answers from 8 plants in 2016, 16 plants in 2017 and 2018, and from 15 plants in 2019.

Table D-70 **Electricity costs (€/tonne)** - Simple averages.

Electricity costs (EUR/tonne)	2016	2017	2018	2019
Europe average	2.5	3.5	3.7	3.5
NWE average	1.8	2.1	2.3	2.0
CEE average	n.a.	5.9	6.1	6.8
SE average	2.9	3.3	3.5	2.8

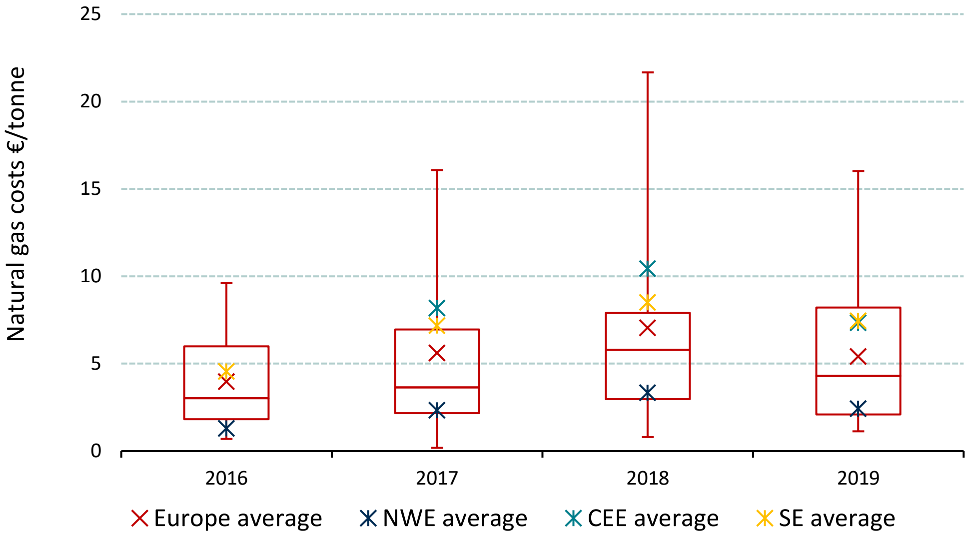
Source: Own elaboration with data refineries.

Natural gas costs

Figure D-85 and Table D-71 show an increase in the natural gas costs per tonne of output borne by refineries in the EU in €/tonne. On average, plants across the EU increased their natural gas costs per tonne of output from €4/tonne in 2016 to €7/tonne in 2018 and decreased slightly to €5.4/tonne in 2019. Given that the natural gas intensity remained stable during this period, this increase was likely due to increase in natural gas prices.

In general, CEE refineries bore higher natural gas cots per tonne produced, followed closely by the SE region, while the NWE region have maintained lower natural gas costs per tonne produced than refineries in other regions.

Figure D-85 Natural gas - Box plots and simple averages.



Source: Own elaboration with data refineries.
Notes: based in answers from 8 plants in 2016, 16 plants in 2017 and 2018, and from 15 plants in 2019.

Table D-71 **Natural gas (€/tonne)** - Simple averages.

Natural gas costs (EUR/tonnes)	2016	2017	2018	2019
Europe average	3.5	5.6	7.0	5.4
NWE average	1.0	2.3	3.3	2.4
CEE average	n.a.	8.2	10.4	7.3
SE average	4.6	7.2	8.5	7.5

Source: Own elaboration based on data from refineries.

Other fuels costs

This section includes analysis of the costs of other fuels, namely self-produced refinery fuels, that were reported by refineries. The main self-produced fuels reported by refineries are[208]:

- Refinery fuel gas: waste gas, coke gas;
- Refinery fuel oil: mainly heavy liquid fuel oil;
- Fluid Catalytic Cracking (FCCU) coke.

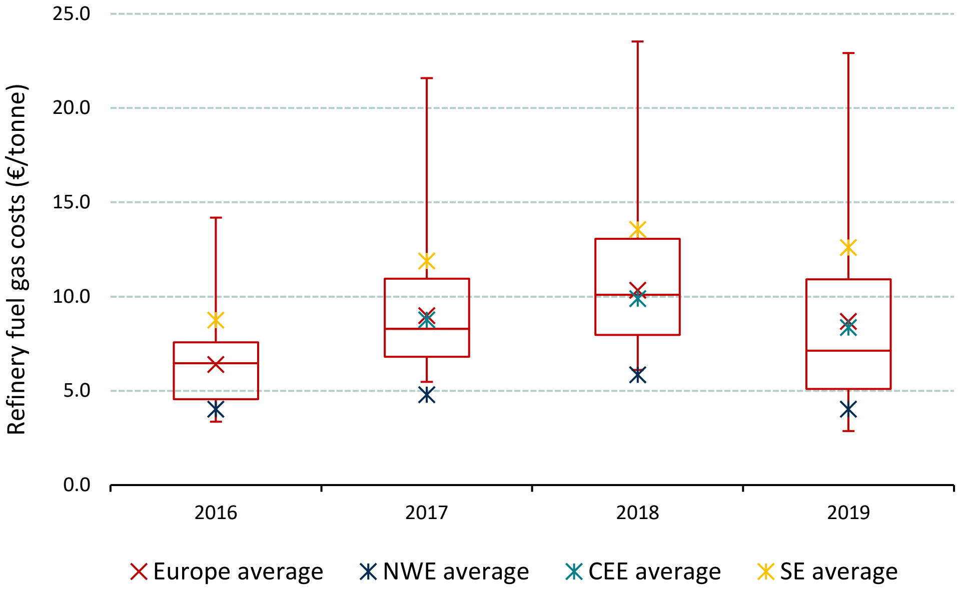
The costs of these fuels were reported by the plants, their estimates were either based on the natural gas or the oil prices and adjusted with the calorific values of the fuel. [209]

Refinery fuel gas

A large number of the sampled refineries reported consuming self-produced fuel gas. On average, the cost of refinery fuel gas in €/tonne of production output increased from €6.4/tonne in 2016 to €13.5 in 2018, to decrease down to €8.7/tonne in 2019. The costs of self-produced fuel gas were more pronounced in the SE region, which ranged between €8.7-12.6 per tonne of output during the observed period. CEE average costs varied between €8.4 - €10/tonne, while NWE costs were the lowest of the three regions, between €4-6/tonne (see Figure D-86 below).

[208] Fuels other than those listed below were also reported, but due to the small number of plants that reported them these were not included in the analysis. These fuels include: liquified petroleum gas (LPG), Diesel, Mixed petroleum residue, Steam, Hydrogen and purge gas.
[209] For two plants that reported the volume of fuel gas used, but without their estimated costs, we estimated these costs based on the wholesale prices of natural gas of the plants.

Figure D-86 Refinery fuel gas costs **(€/tonne)** - Box plots and simple averages.



Source: Own elaboration based on data from refineries.
Notes: based in answers from 9 plants in 2016, 13 plants in 2017 and 2018, and from 12 plants in 2019.

Table D-72 Refinery fuel gas costs **(€/tonne)** - Simple averages.

Natural gas costs (EUR/tonnes)	2016	2017	2018	2019
Europe average	6.4	9.0	10.3	8.7
NWE average	4.0	4.8	5.9	4.0
CEE average	n.a.	8.8	9.9	8.4
SE average	8.7	11.9	13.5	12.6

Source: Own elaboration based on data from refineries.

Refinery fuel oil

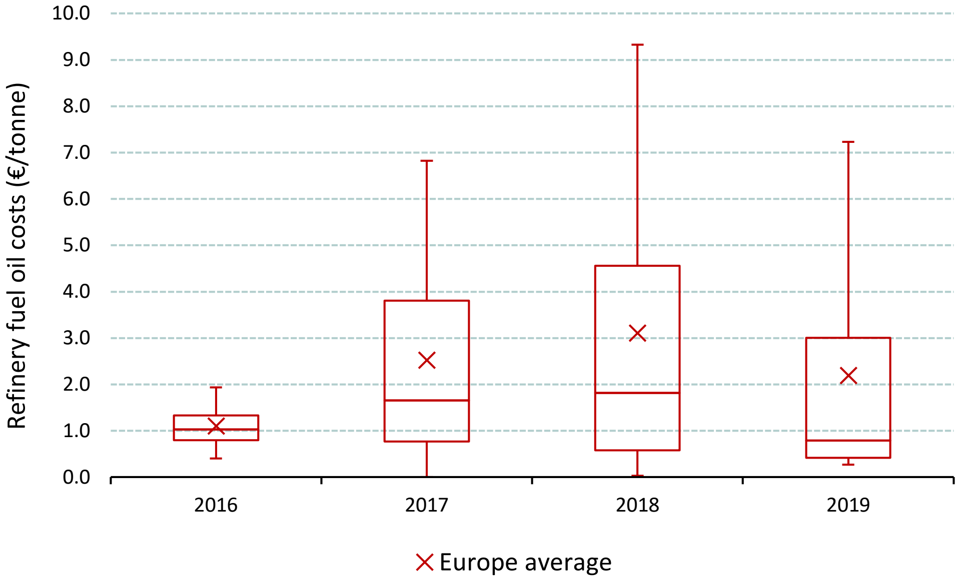
From 3 plants that provided their refinery fuel costs in 2016, and 5 plants in 2017 - 2019, an EU average refinery fuel oil is presented in Table D-73 and Figure D-87. The average refinery fuel oil costs in the EU increased from €1.1/tonne of output in 2016 up to €3.1/tonne in 2018, to later decrease down to €2.2/tonne in 2019. The sample for this indicator was scattered between values of close to zero, up to above €9/tonne. Regional averages could not be presented due to the low number of respondents.

Table D-73 Refinery fuel oil costs **(€/tonne)** - Simple averages.

Refinery fuel oil (EUR/tonnes)	2016	2017	2018	2019
Europe average	1.1	2.5	3.1	2.2

Source: Own elaboration based on data from refineries.

Figure D-87 Refinery fuel oil **costs (€/tonne)-** Box plots and simple averages.

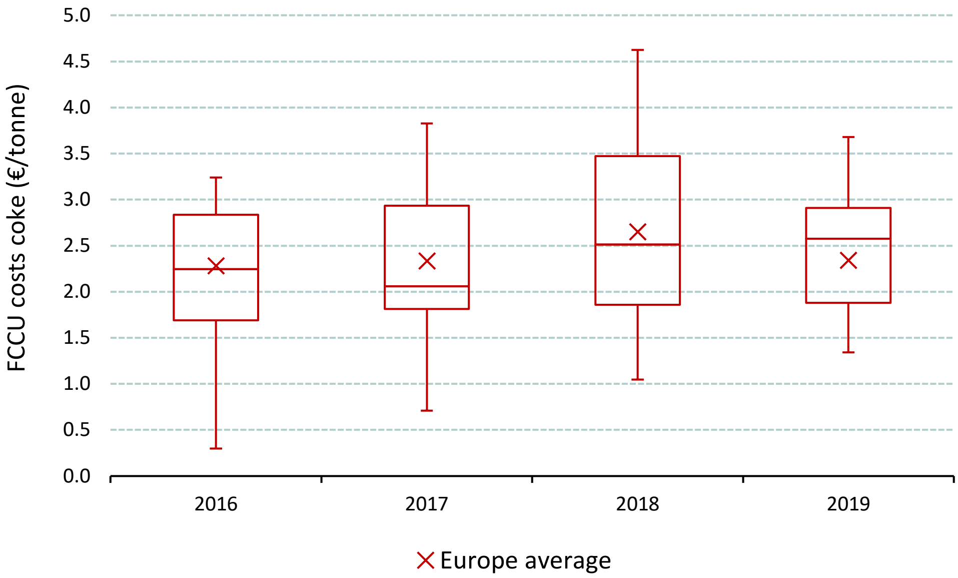


Source: Own elaboration based on data from refineries.
Notes: based in answers from 3 plants in 2016, and 5 plants from 2017 to 2019.

FCCU coke

In 2016, 4 refineries reported consumption of FCCU coke as part of their energy consumption, averaging €2.3/tonne (simple average). From 2017 to 2019 the sample increased to 6, along with the average of FCCU coke costs, peaking in 2018 at €2.6/tonne. By the end of 2019 the EU average decreased again to €2.3/tonne. Regional averages could not be presented due to the low number of respondents.

Figure D-88 FCCU coke **costs (€/tonne)-** Box plots and simple averages.



Source: Own elaboration based on data from refineries.
Notes: based in answers from 4 plants in 2016, and 6 plants from 2017 to 2019.

Table D-74 **FCCU coke costs (€/tonne)** - Simple averages.

FCUU coke (EUR/tonnes)	2016	2017	2018	2019
Europe average	2.3	2.3	2.6	2.3

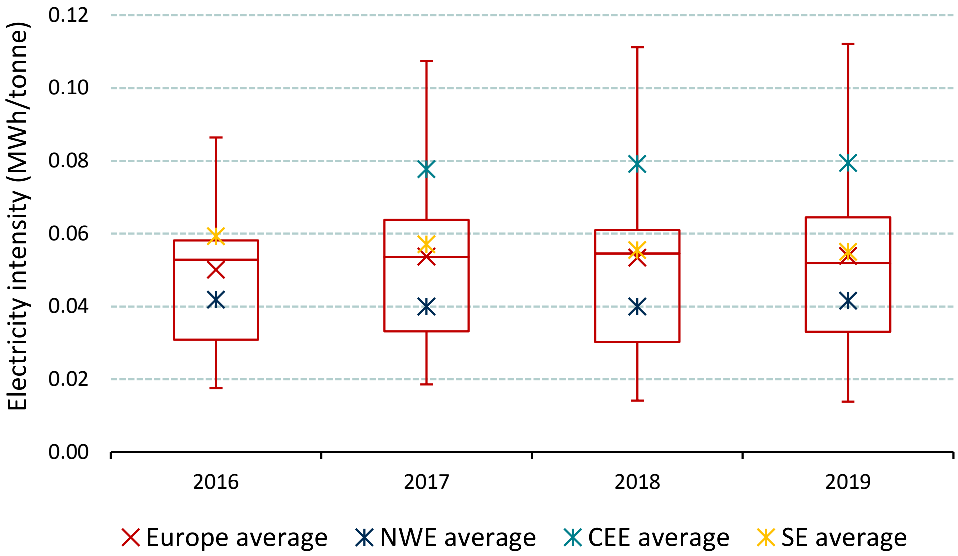
Source: Own elaboration based on data from refineries.

Energy intensity

Electricity intensity

Figure D-89 shows that there were relative no changes in electricity intensity averages for the EU, and its different regions in the observed period. From 2016 to 2019 the average electricity intensity in the EU refining sector remained at 0.05 MWh/tonne of production output, with lower intensity observed in the NWE region (0.04 MWh/tonne), and higher electricity intensities in the CEE and SE regions at 0.08 ant 0.06 MWh/tonne (respectively).

Figure D-89 Electricity intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration based on data from refineries.
Notes: based in answers from 15 plants in 2016, 20 plants in 2017 and 2018, and from 19 plants in 2019.

Table D-75 Electricity intensity (MWh/tonne) - Simple averages.

Electricity intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	0.05	0.05	0.05	0.05
NWE average	0.04	0.04	0.04	0.04
CEE average	n.a.	0.08	0.08	0.08
SE average	0.06	0.06	0.06	0.06

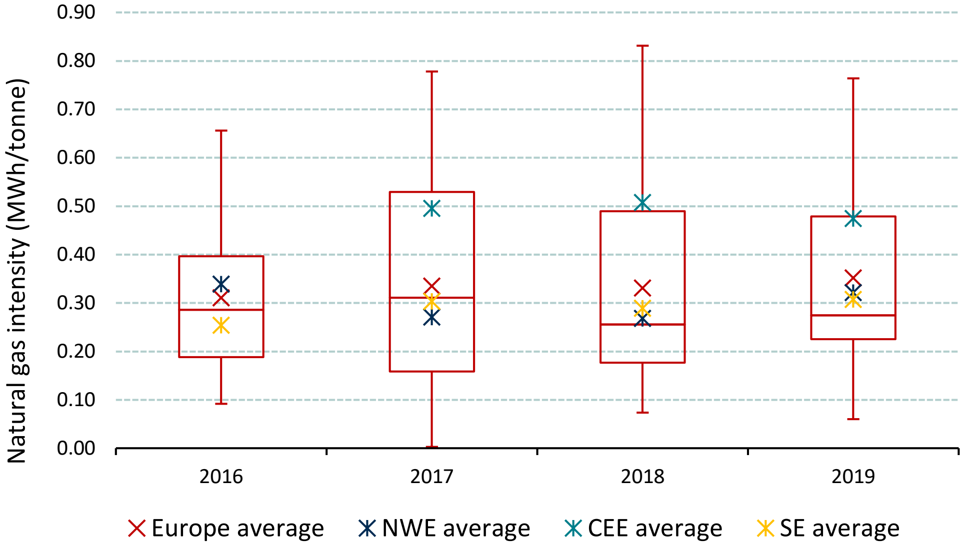
Source: Own elaboration based on data from refineries.

Natural gas intensity

The natural gas intensity of refineries in the EU is higher than the electricity intensity presented above. Figure D-90 and Table D-76 indicate natural gas intensity at the EU level was maintained fairly stable, ranging between 0.33 to 0.35 MWh/tonne between 2017 and 2019. The lowest natural gas intensity was observed in 2016, at 0.31MWh/tonne, but this could be due to the lower number of replies for that year from plants in the CEE region, which reported higher natural gas intensity (between 0.47-0.51 MWh/tonne) than other regions.

The NWE region initially decreased its natural gas intensity in years 2017 and 2018, but in 2019 it reported an increase up to 0.32 MWh/tonne. Similarly, the refineries in the SE region increased their natural gas intensity from 0.25 MWh/tonne to 0.31 MWh/tonne.

Figure D-90 Natural gas intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration based on data from refineries.
Notes: based in answers from 12 plants in 2016, 18 plants in 2017 and 2018, and from 17 plants in 2019.

Table D-76 Natural gas intensity (MWh/tonne) - Simple averages.

Natural gas intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	0.31	0.34	0.33	0.35
NWE average	0.34	0.27	0.27	0.32
CEE average	n.a.	0.50	0.51	0.47
SE average	0.25	0.30	0.29	0.31

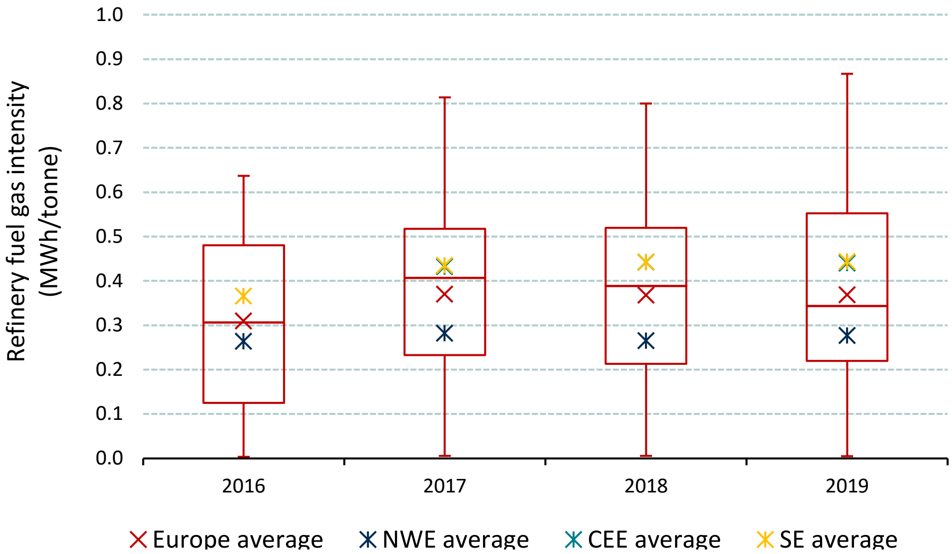
Source: Own elaboration based on data from refineries.

Other fuels intensity

Refinery fuel gas

EU refineries experienced a relative stable fuel gas intensity between 2016 to 2019, ranging from 0.31 MWh/tonne in 2016 to 0.37 MWh/tonne from 2017 to 2019. The CE and SEE regions had very similar fuel gas intensity, at around 0.44 MWh/tonne, while the NWE varied between 0.26-0.28 MWh/tonne.

Figure D-91 Refinery fuel gas intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration based on data from refineries.
Notes: based in answers from 14 plants in 2016, 19 plants in 2017 and 2018, and from 18 plants in 2019.

Table D-77 Refinery fuel gas intensity (MWh/tonne) - Simple averages.

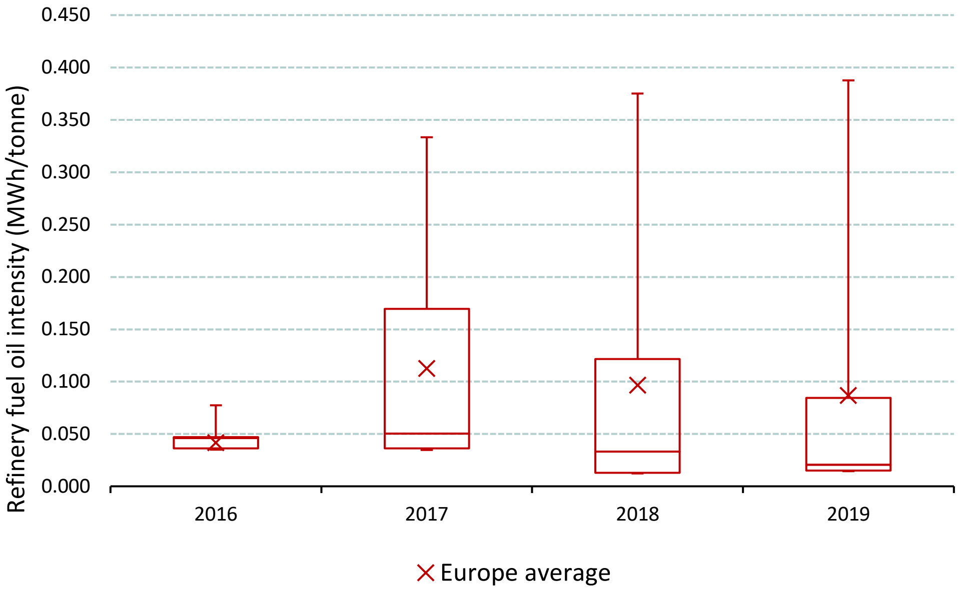
Fuel gas intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	0.31	0.37	0.37	0.37
NWE average	0.26	0.28	0.27	0.28
CEE average	n.a.	0.43	0.44	0.44
SE average	0.37	0.44	0.44	0.44

Source: Own elaboration based on data from refineries.

Refinery fuel oil

Refinery fuel oil intensity in the EU refineries increased sharply from 0.042 MWh/tonne in 2016 to 0.113 MWh/tonne in 2017 (simple averages). After peaking in 2017, the fuel oil intensity started a decreasing trend, down to 0.087 MWh/tonne in 2019.

Figure D-92 Refinery fuel oil intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration based on data from refineries.
Notes: based in answers from 5 plants in 2016, 6 plants in 2017 and 2018, and from 7 plants in 2019.

Table D-78 Refinery fuel oil intensity (MWh/tonne) - Simple averages.

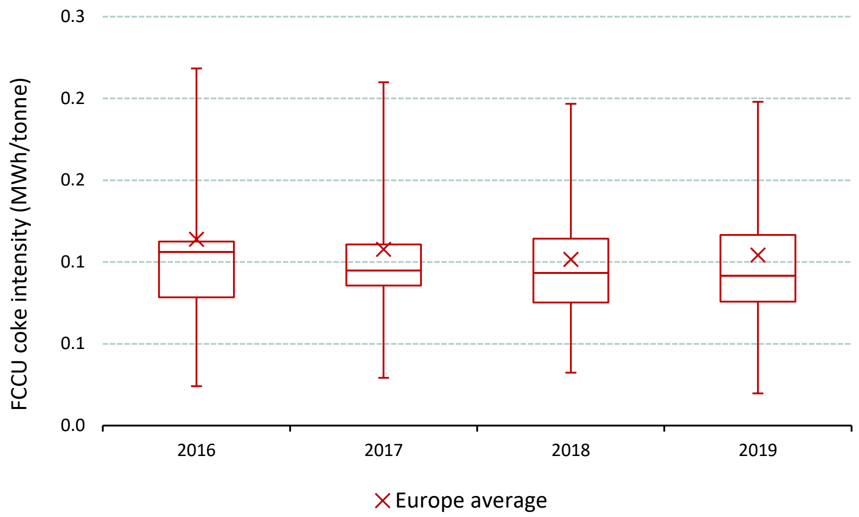
Fuel oil intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	0.042	0.113	0.097	0.087

Source: Own elaboration based on data from refineries.

FCCU coke

Energy intensity of FCCU coke was stable during the period studied. , the EU average was maintained at 0.11 MWh/tonne between 2016 and 2017, and decreased to 0.10 MWh/tonne in 2018 and 2019.

Figure D-93 FCCU coke intensity (MWh/tonne) - Box plots and simple averages.



Source: Own elaboration based on data from refineries.
Notes: based in answers from 5 plants in 2016, and 7 plants in 2017, 2018 and 2019.

Table D-79 FCCU coke intensity (MWh/tonne) - Simple averages.

FCCU coke intensity (MWh/tonne)	2016	2017	2018	2019
Europe average	0.11	0.11	0.10	0.10

Source: Own elaboration based on data from refineries.

Competitiveness of the sector

Table D-80 presents an overview of the indicators used in this section to analyse the competitiveness of the refineries sector.

Table D-80 Overview of energy costs as a share of production costs, and energy costs as a share of turnover **(€/tonne, EU)** - Simple averages.

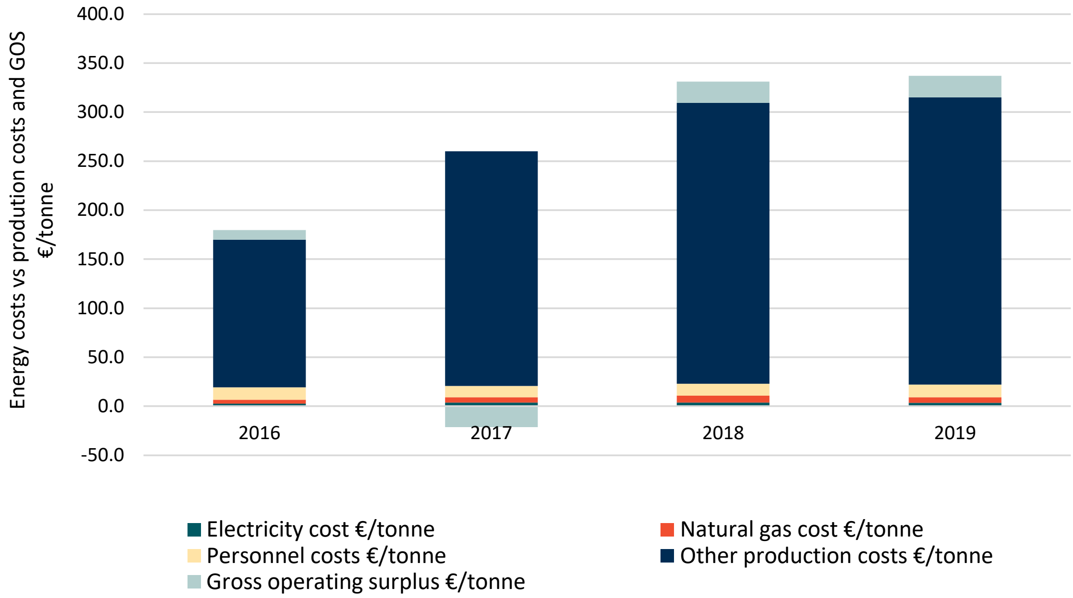
Indicator	2016	2017	2018	2019
Electricity cost €/tonne	2.6	3.6	3.8	3.6
Natural gas cost €/tonne	4.0	5.6	7.0	5.4
Other production costs €/tonne	150.4	239.3	286.3286.3	293.0
Personnel costs €/tonne	12.8	11.5	12.2	13.1
Gross operating surplus €/tonne	9.8	-21.4	21.9	22
Turnover €/tonne	179.6	238.6	331.3	337.1
Electricity costs as a share of production costs	4%	4%	5%	4%
Natural gas costs as a share of production costs	3%	5%	9%	5%
Energy costs as a share of production costs[210]	8%	10%	14%	9%
Energy costs as a share of turnover	5%	7%	10%	6%

Source: Own elaboration based on data from refineries.
Notes: Only a limited number of the surveyed plants provided their annual production costs and turnover per tonne of output (7 in 2016, and 13 from years 2017 to 2019).There were more questionnaire replies available for the ***calculation of electricity and natural gas costs*** *in €/tonne (up to16 answers per year). As a consequence, the presented indicators energy costs as a share of production costs, and energy costs as a share of turnover do not necessarily match the averages of the individual components of the production costs presented in this table.*

[210] For this project the definition of production costs included the costs of crude oil as feedstock. According to Concawe and Fuels Europe, the refining industry standard method to calculate production costs excludes the costs of crude oil. Therefore, the energy costs as a share of production costs presented in this table are lower than those calculated by the industry.

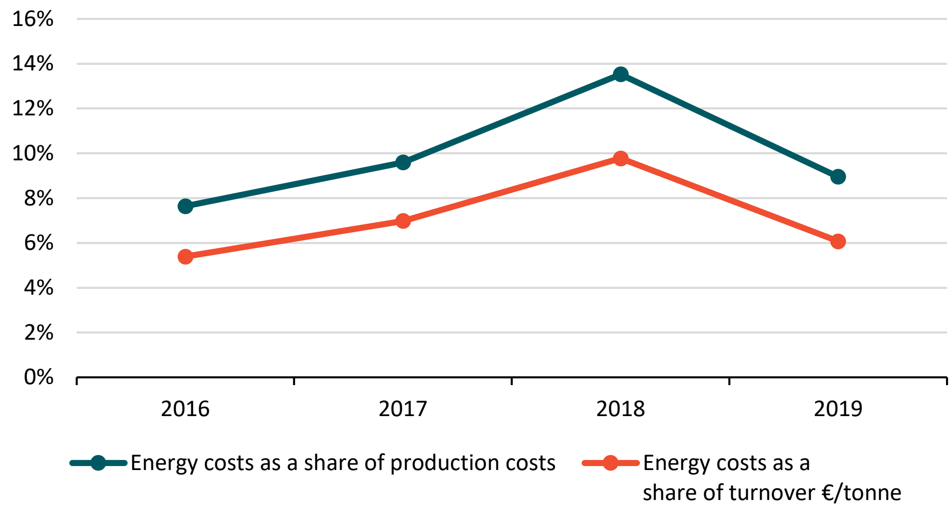
Source: Study on energy prices, costs and their impact on industry and households

Figure D-94 Energy costs, other production costs and Gross Operating Surplus of the refining **industry (€/tonne,** EU), simple averages.



Source: Own elaboration based on data from refineries.

Figure D-95 Energy costs as a share of production costs vs energy costs as a share of turnover for the refining industry **(€/tonne, EU), simple averages**.



Source: Own elaboration based on data from refineries.

Competitiveness of the sector - including other (self-produced) fuels

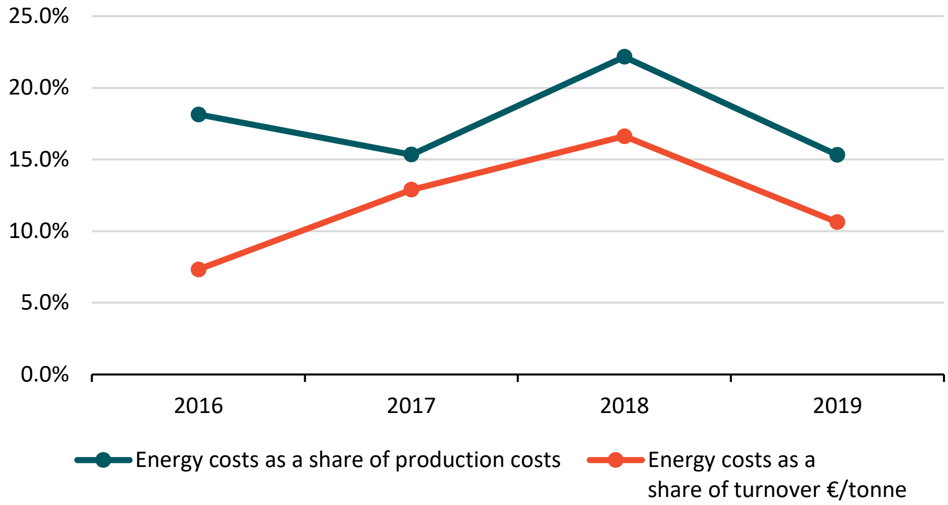
Figure D-96 Overview of energy costs as a share of production costs, and energy costs as a share of turnover including Other self-produced fuels **(€/tonne, EU) -** Simple averages.

Indicator	2016	2017	2018	2019
Electricity cost €/tonne	2.6	3.6	3.8	3.6
Natural gas cost €/tonne	4.0	5.6	7.0	5.4
Other fuels costs €/tonne	8.8	10.5	13.3	10.1
Other production costs €/tonne	141.6	228.8	273.0	282.9
Personnel costs €/tonne	12.8	11.5	12.2	13.1
Gross operating surplus €/tonne	9.8	-21.4	21.9	22.0
Turnover €/tonne	179.6	238.6	331.3	337.1
Electricity costs as a share of production costs	4%	4%	5%	4%

Indicator	2016	2017	2018	2019
Natural gas costs as a share of production costs	3%	5%	9%	5%
Other fuels costs as a share of production costs	13%	8%	12%	8%
Energy costs as a share of production costs[211]	18.1%	15.1%	22.0%	14.2%
Energy costs as a share of turnover	7.3%	12.9%	16.6%	9.9%

Source: Own elaboration based on data from refineries.
Notes: Only a limited number of the surveyed plants provided their annual production costs and turnover per tonne of output (7 in 2016, and 13 from years 2017 to 2019).There were more questionnaire replies available for the calculation of electricity, natural gas costs, in €/tonne (up to16 answers per year). For Other fuels (aggregating fuel gas, fuel oil and FCCU coke) there were less answers (up to 10 answers per year). As a consequence, the presented indicators energy costs as a share of production costs, and energy costs as a share of turnover do not necessarily match the averages of the individual components of the production costs presented in this table.

Figure D-97 Energy costs as a share of production costs vs energy costs as a share of turnover including Other self-produced fuels for the refining industry **(€/tonne, EU), simple averages.**



Source: Own elaboration based on data from refineries.

This discussion only considers the energy costs *stricto sensu* of refineries, i.e. the usage by refineries of energy source that are fed into the process: external sources (gas and electricity), and the internal sources (refinery gas, refinery fuel oil, FCCU coke) as reported by the surveyed refineries. According to Concawe[212], around 7.3% of the crude oil entering the refinery as feedstock is consumed to provide energy to the process from within (in the form of refinery fuel gas, FCCU coke and other liquids, called the "internal sources").

Based on this definition of energy costs, we can see that self-produced fuels play a significant role in the total production costs of refineries: between 8 and 13% [213] taking crude oil price into account as production costs, while if crude oil costs are excluded from production cost (industry standard method), energy costs are estimated to be between 49 and 55%[214]. The operating costs of refineries are therefore dominated by the "other costs" (essentially the supply of the raw material, namely crude oil). Consequently, the profitability of refineries is essentially determined by the international markets: the

[211] For this project the definition of production costs included the costs of crude oil as feedstock. According to Concawe and Fuels Europe, the refining industry standard method to calculate production costs excludes the costs of crude oil. Therefore, the energy costs as a share of production costs presented in this table are lower than those calculated by the industry.
[212] Not published, based on Concawe's LP modelling of the entire refining industry in the EU28.
[213] Based in the results of own analysis from collected questionnaires of EU27 refineries.
[214] Solomon Associates (2019) via Concawe. Shares are the result of dividing energy costs (USD/bbl) by Cash OpEx (USD/bbl) for the EU28 for years 2016 and 2018. Cash OpEx is the sum of personnel costs, energy costs and other costs.

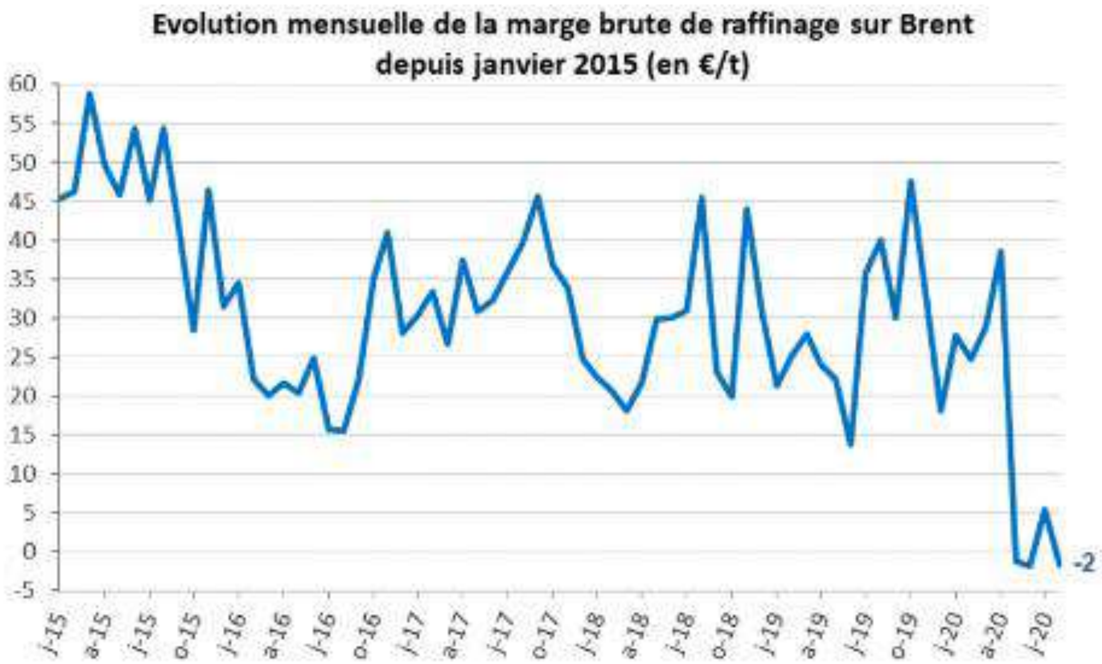
price of crude oil is determined by the international oil market (Brent quotation), while refined products are priced as well on an international market driven by supply/demand equilibrium. The products quality are relatively homogeneous between the world regions and therefore, it is relatively easy to substitute domestically produced petroleum products with imported products from outside the EU if domestic production becomes too expensive (depending on transport costs of refined products, local production costs and market). The limited ability to make more specialised products, and the resulting inability to fully pass on increased costs reduces the profit margin of some European refineries. As a result, exposure of some refineries to international competition is relatively high.

Consequences of COVID-19 crisis for the sector

The lock-down of the economy in March/April 2020 had a huge consequence on the petroleum product demand as the transport of people and goods were heavily restricted. In countries with a strict lock-down, such as France, Italy and Spain, the demand for Diesel and gasoline dropped between 60 and 80% in comparison with the previous year. Regarding Jet fuel, the impact was even worse with the Demand reduced by 80 to 95%, and recovery post lock down being much slower.

The majority of refineries being available for operation and the crude oil being supplied, the supply of liquid fuels was significantly higher than the Demand. The market of petroleum products being driven by supply/demand, the relative price went down significantly and refinery margin dropped. As a result, many refineries have reduced to minimum operating capacity as a response to negative net margin.

Figure D-98 **Monthly evolution of refinery margins after January 2015 (Brent, in €/tonne).**



Source: French Ministry[215]

[215] https://www.ecologie.gouv.fr/prix-des-produits-petroliers

Annex E -Task 2 country and sector fact sheets

Task 2 fact sheets summarise the results of data analysis on energy costs for manufacturing and non-manufacturing industries. Sector level fact sheets present analysis on all manufacturing sectors. Country level fact sheets will present analysis on the top manufacturing and non-manufacturing sectors in each EU MS. Sectors are selected for inclusion in country fact sheets based on their energy cost shares; the sectors with the highest cost shares (above 2% on average) in each country are included.

See the separate PowerPoint version of of Annex E for Sector and Country factsheets.

Study on energy prices, costs and their impact on industry and households

Final report
Annex E - Task 2 Country Factsheets

Trinomics

Cost dynamics of energy intensive industries in Austria (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C233 - Clay building materials
3. C241 - Iron and steel
4. C171 - Pulp and paper
5. C232 - Refractory products
6. C206 - Man-made fibres
7. C231 - Glass
8. C201 - Basic chemicals
9. C106 - Grain products
10. C245 - Casting of metal

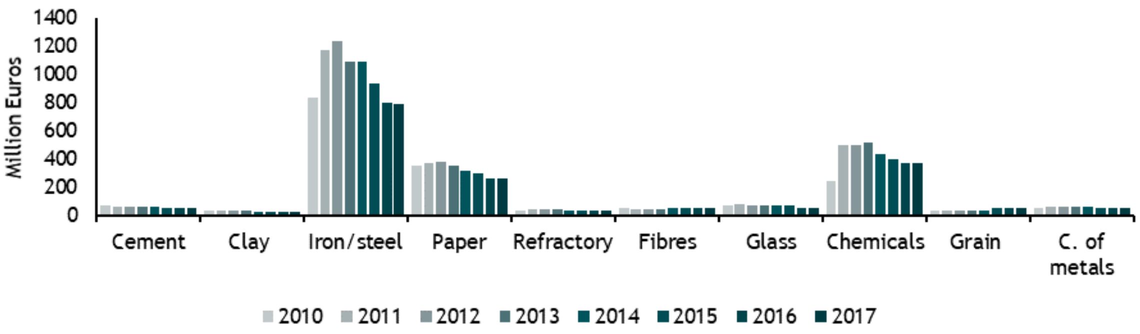
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

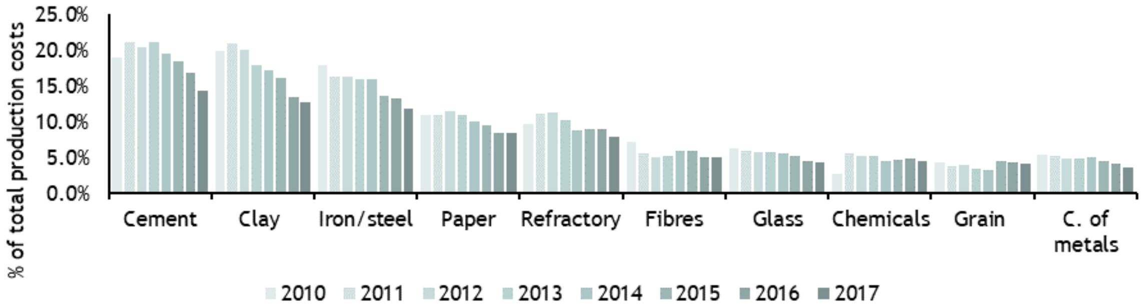
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

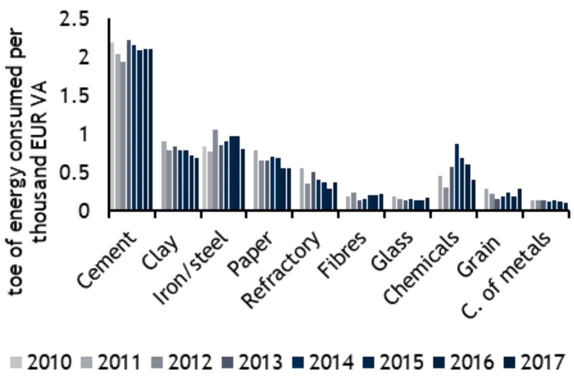


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

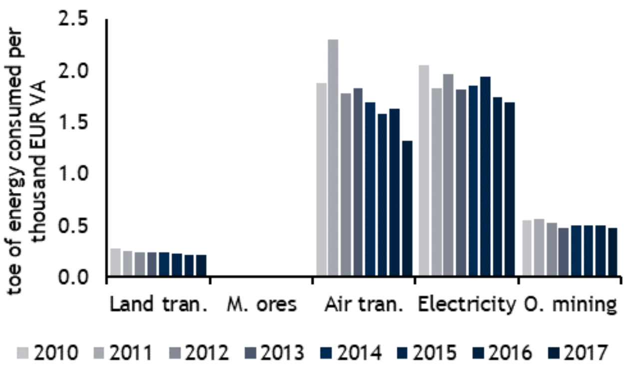
Energy intensity

Consumption of energy per value added

Manufacturing sectors



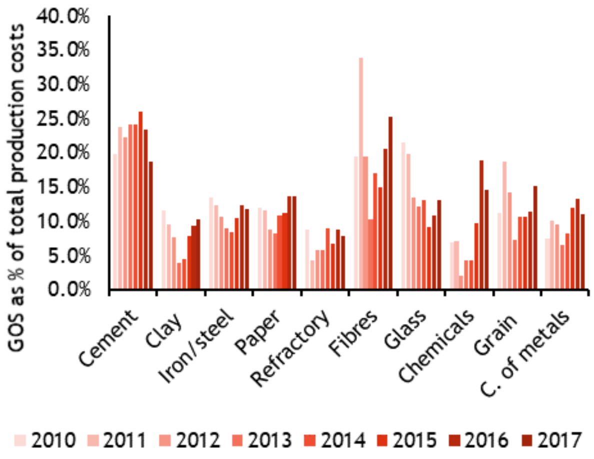
Non-manufacturing sectors



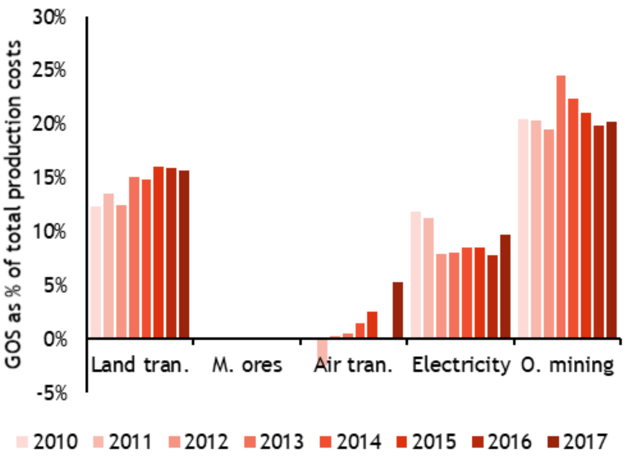
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Austria (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C192 - Refineries
3. C201 - Basic chemicals
4. C235 - Cement, lime and plaster
5. C25 - Fabricated metal products
6. C244 - Non-ferrous metals
7. C28 - Machinery and equipment
8. C161 - Sawmills

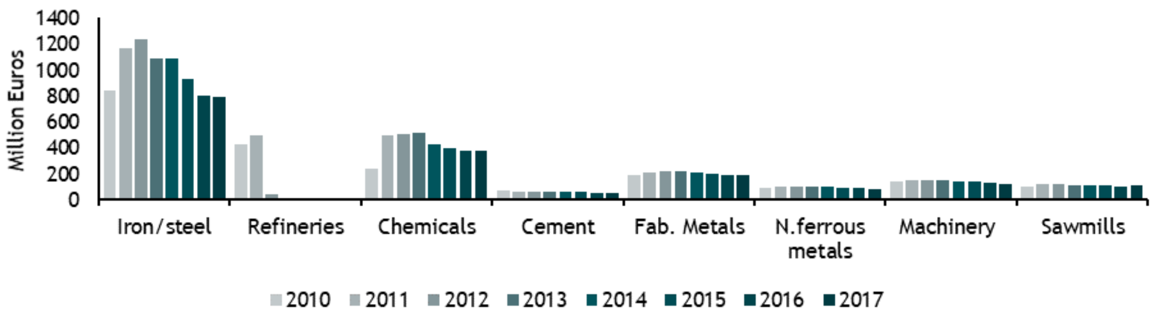
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. D35 - Electricity, gas and steam
2. H49 - Land transport
3. H51 - Air transport

Energy cost shares

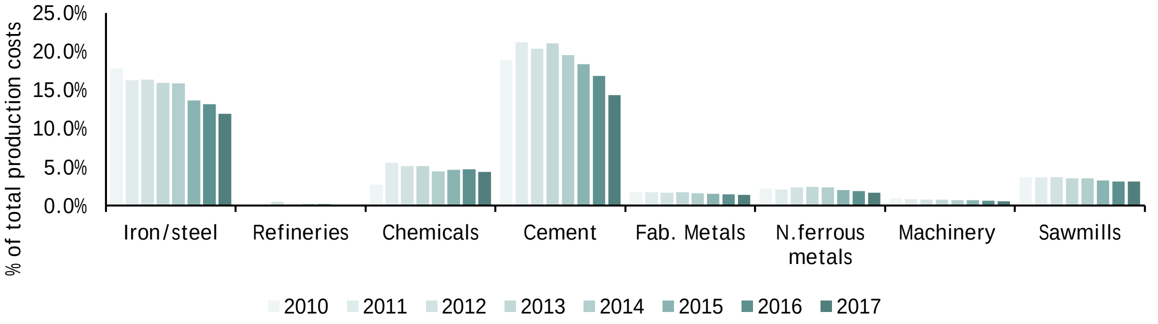
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

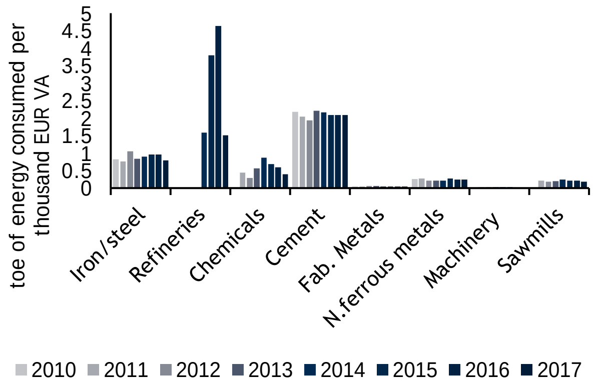


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

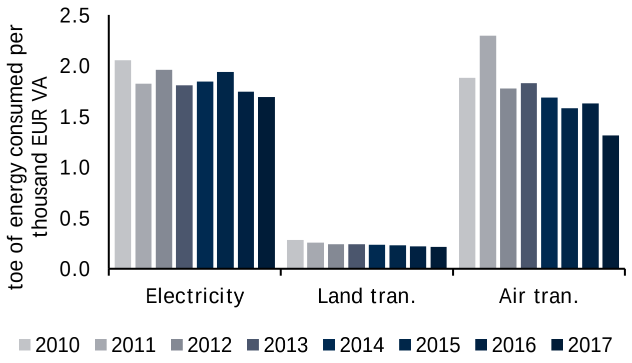
Energy intensity

Consumption of energy per value added

Manufacturing sectors



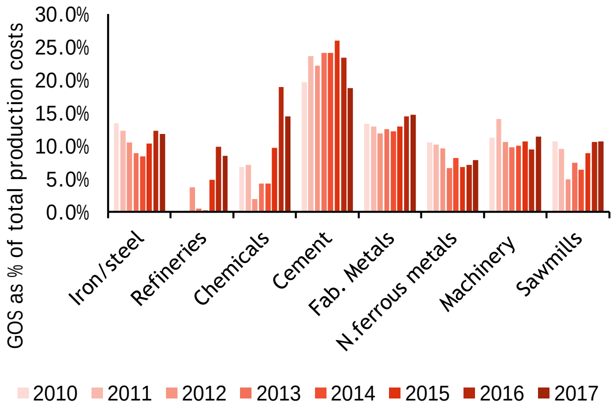
Non-manufacturing sectors



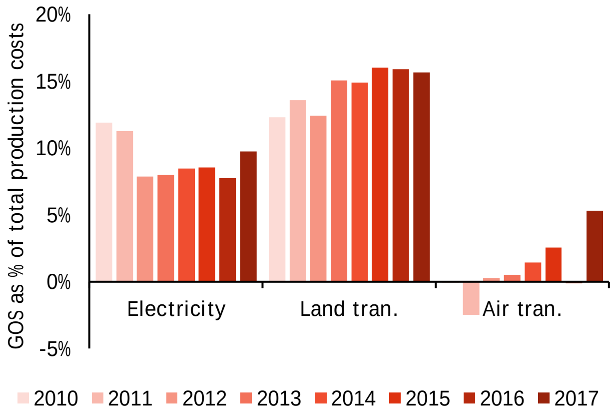
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Belgium (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C235 - Cement, lime and plaster
3. C171 - Pulp and paper
4. C232 - Refractory products
5. C201 - Basic chemicals
6. C231 - Glass
7. C241 - Iron and steel
8. C245 - Casting of metal
9. C234 - Porcelain and ceramics
10. C103 - Fruit and vegetables

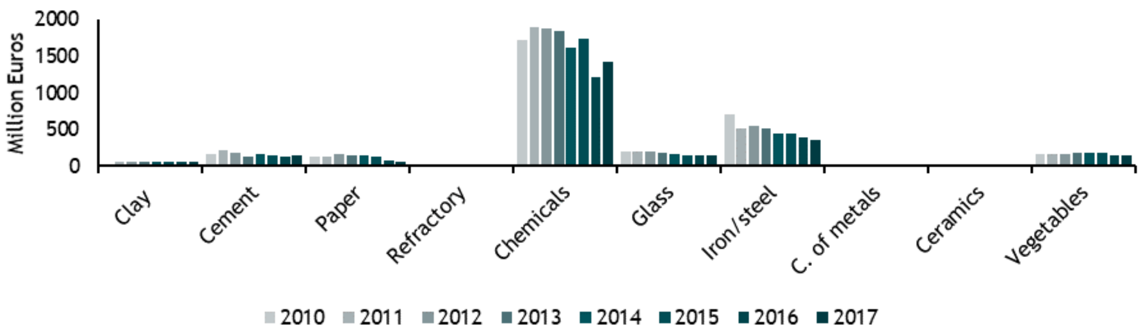
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

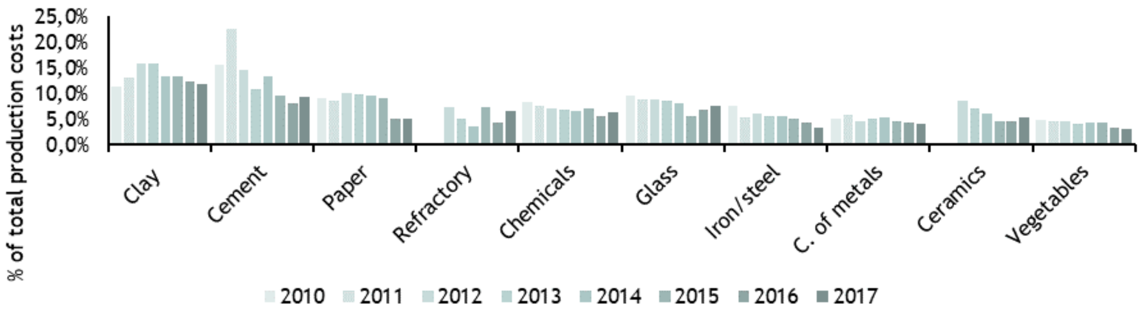
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

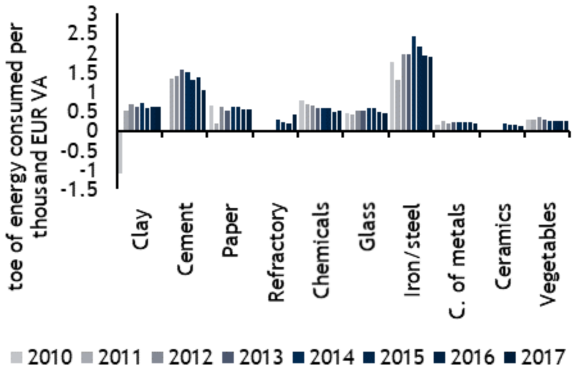


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

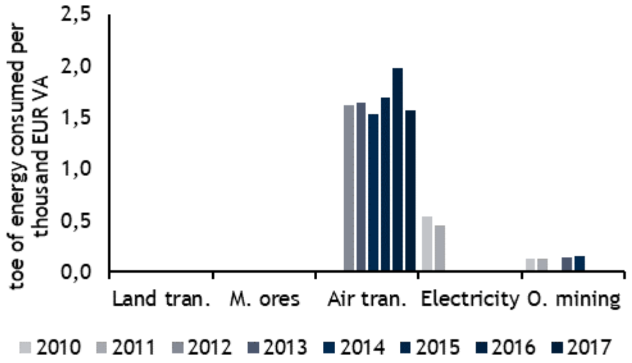
Energy intensity

Consumption of energy per value added

Manufacturing sectors



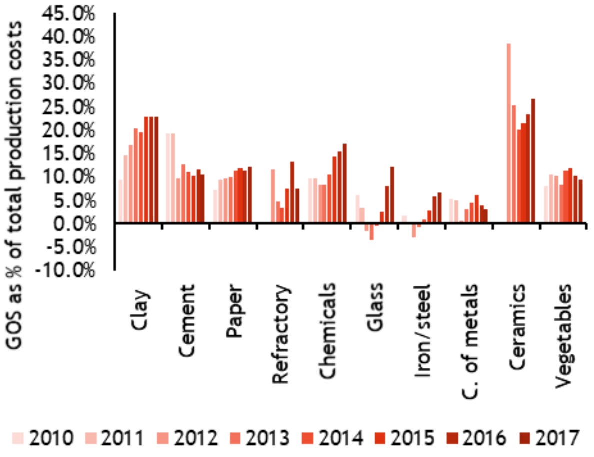
Non-manufacturing sectors



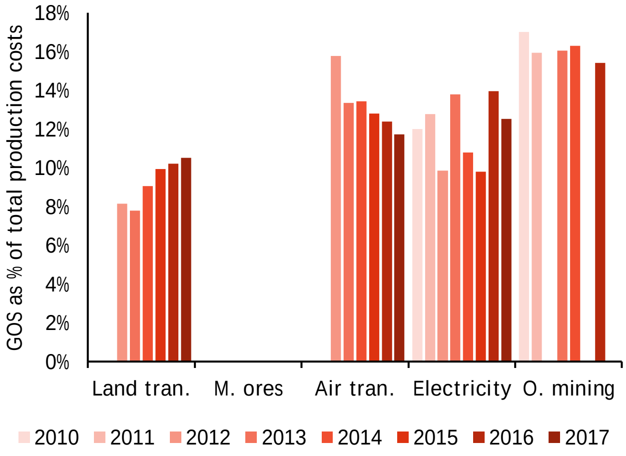
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Belgium (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C201 - Basic chemicals
2. C241 - Iron and steel
3. C192 - Refineries
4. C244 - Non-ferrous metals
5. C231 - Glass
6. C171 - Pulp and paper
7. C103 - Fruit and vegetables
8. C25 - Fabricated metal products

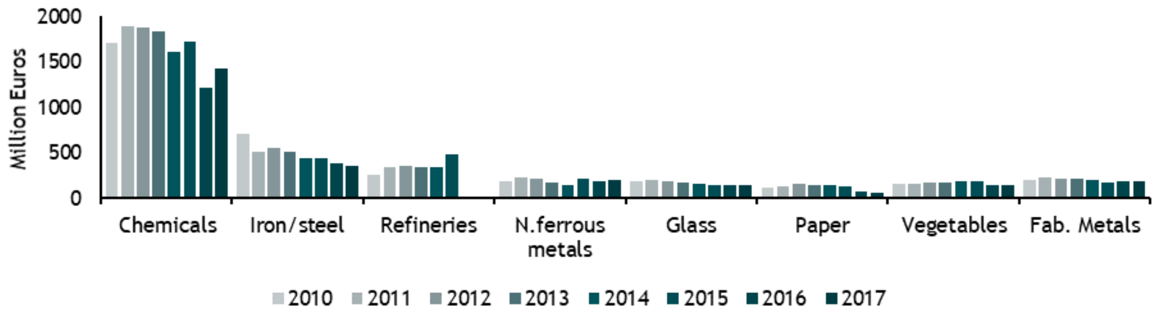
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. A - Agriculture

Energy cost shares

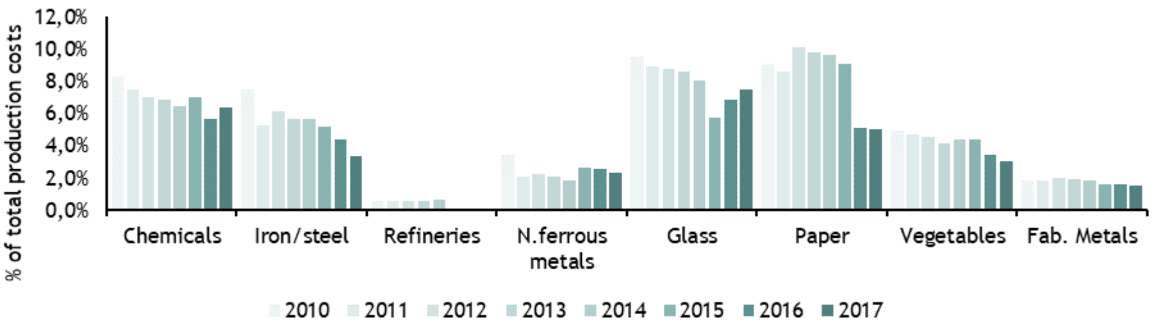
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

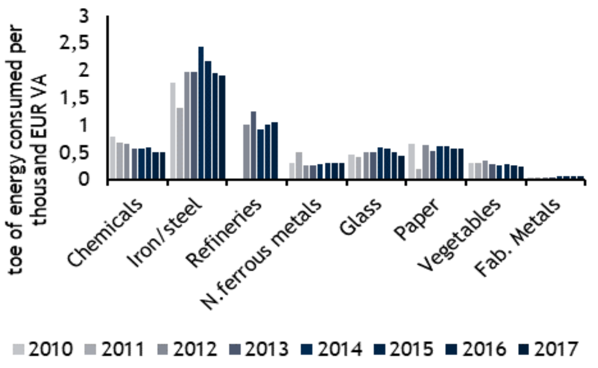


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

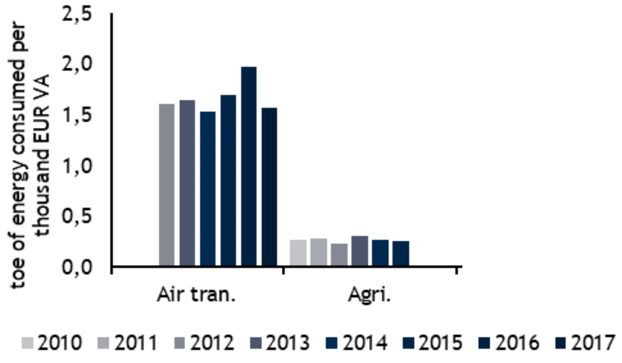
Energy intensity

Consumption of energy per value added

Manufacturing sectors



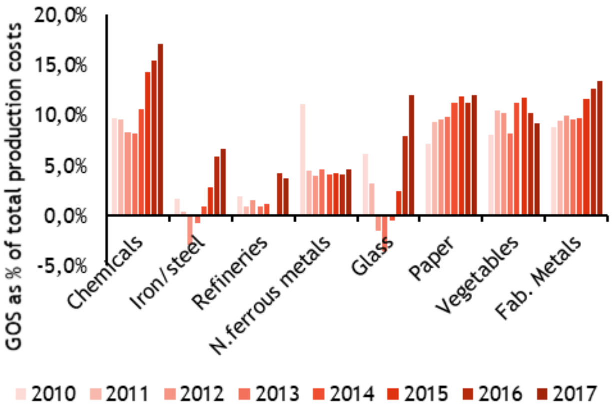
Non-manufacturing sectors



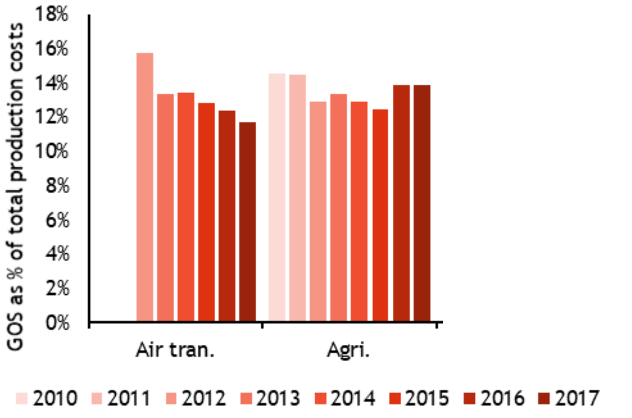
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Bulgaria (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C201 - Basic chemicals
2. C235 - Cement, lime and plaster
3. C231 - Glass
4. C233 - Clay building materials
5. C171 - Pulp and paper
6. C245 - Casting of metal
7. C232 - Refractory products
8. C239 - Abrasive products
9. C132 - Textiles
10. C161 - Sawmills

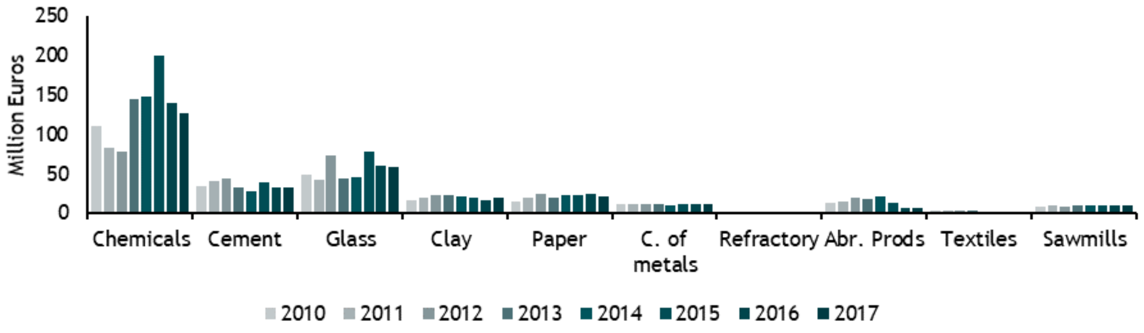
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

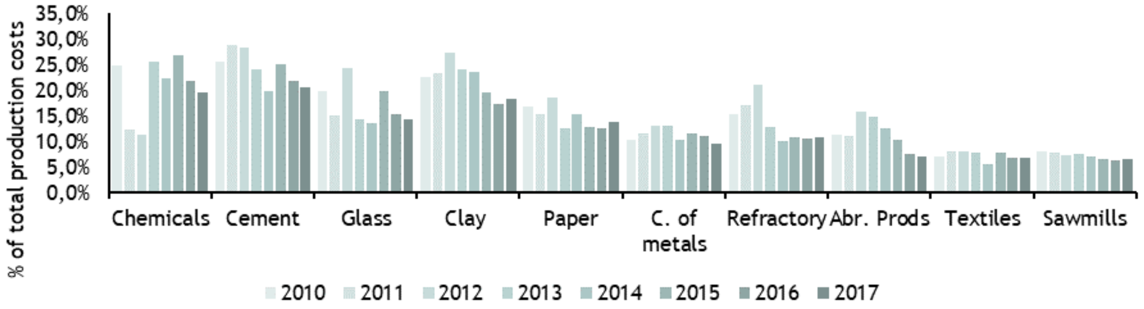
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

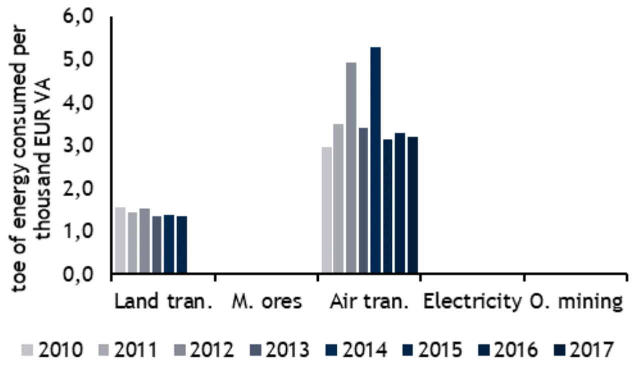
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Bulgaria are not widely available

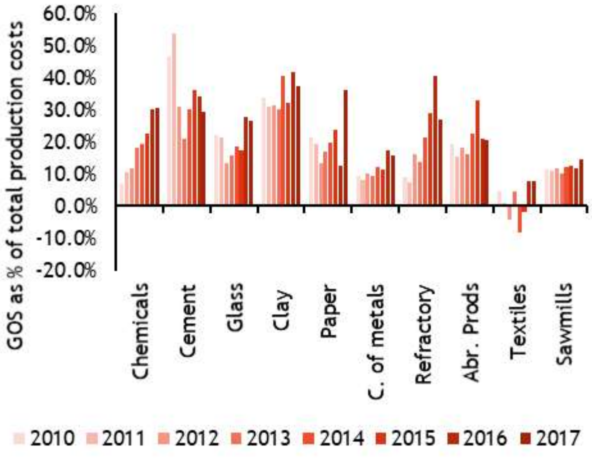
Non-manufacturing sectors



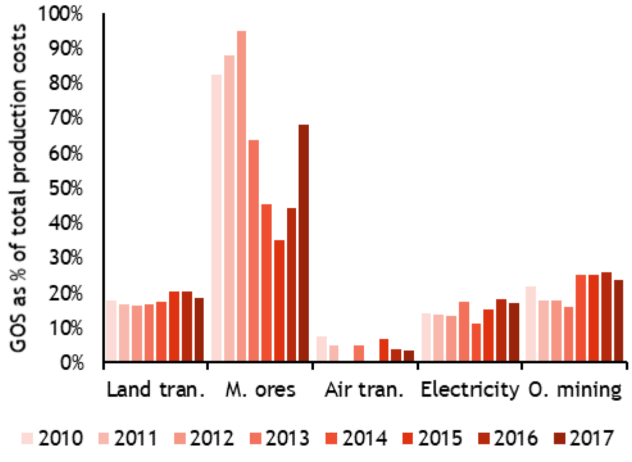
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Bulgaria (2/2)

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C241 - Iron and steel
3. C244 - Non-ferrous metals

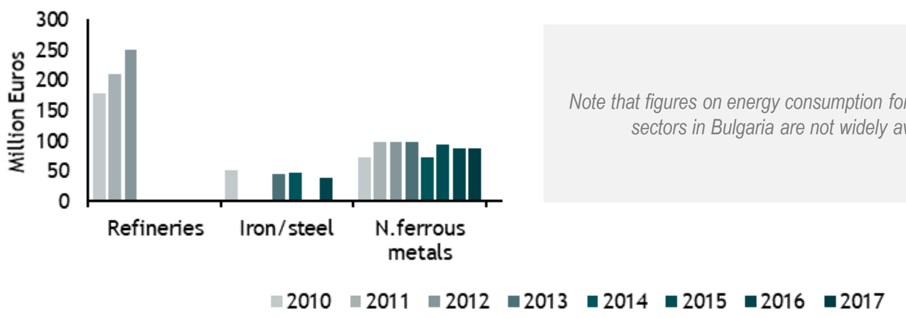
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. A - Agriculture
2. H51 - Air transport
3. B - Mining and quarrying

Energy cost shares

Energy costs in value

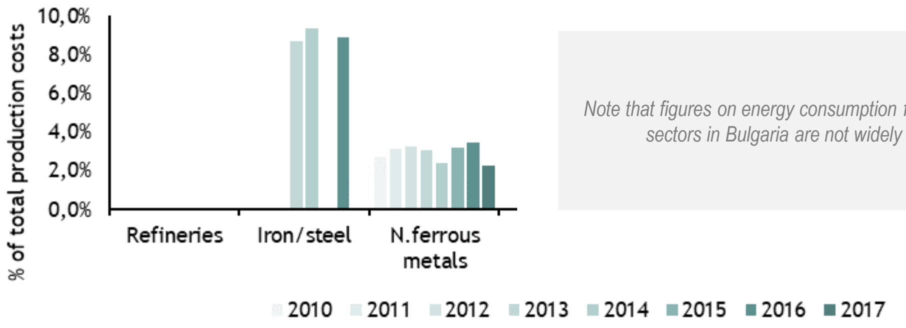
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Bulgaria are not widely available

Energy costs as a share of total production costs

Manufacturing sectors



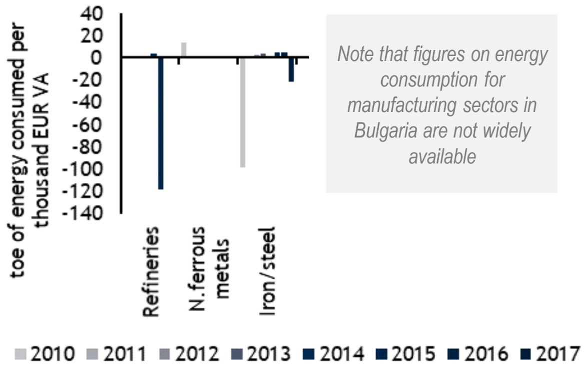
Note that figures on energy consumption for manufacturing sectors in Bulgaria are not widely available

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

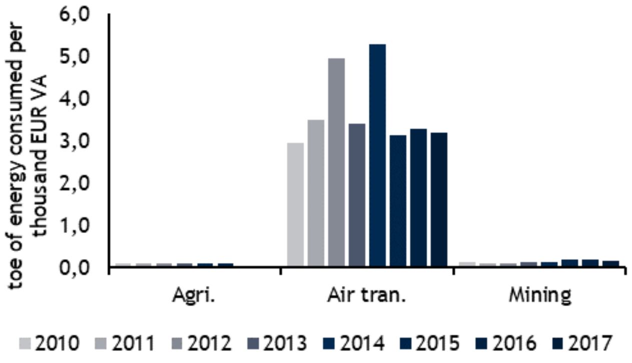
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Bulgaria are not widely available

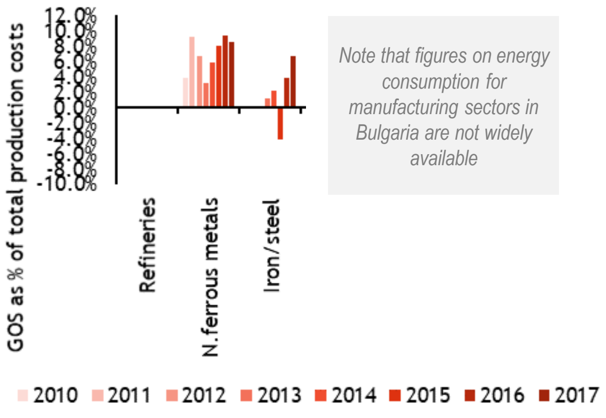
Non-manufacturing sectors



Profitability

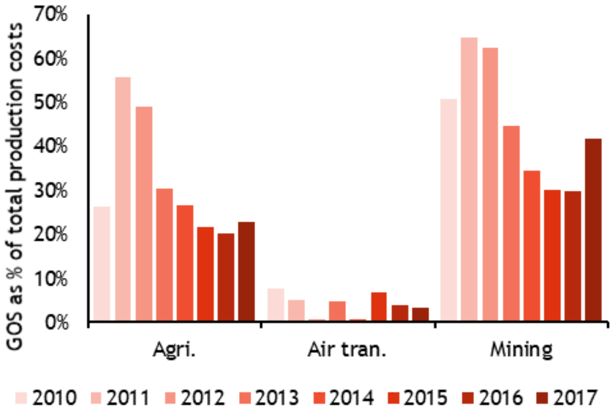
Gross operating surplus as a share of production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Bulgaria are not widely available

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Cyprus (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C244 - Non-ferrous metals
3. C222 - Plastics products
4. C239 - Abrasive products
5. C237 - Stone
6. C11 - Beverages
7. C231 - Glass
8. C103 - Fruit and vegetables
9. C106 - Grain products
10. C21 - Pharmaceutical products

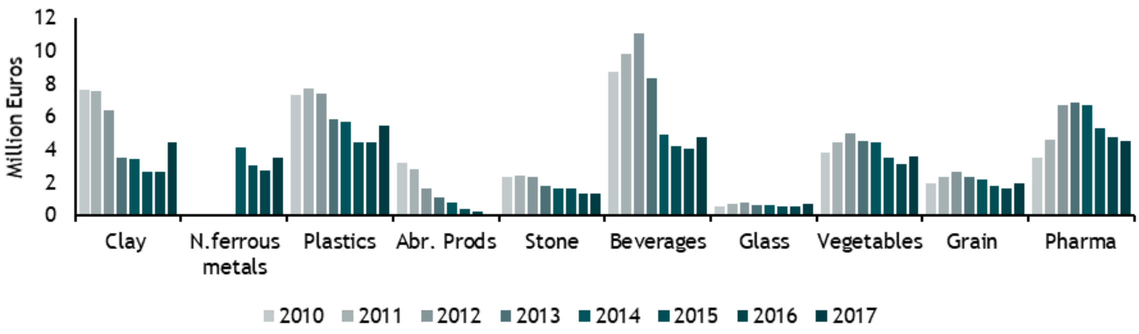
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

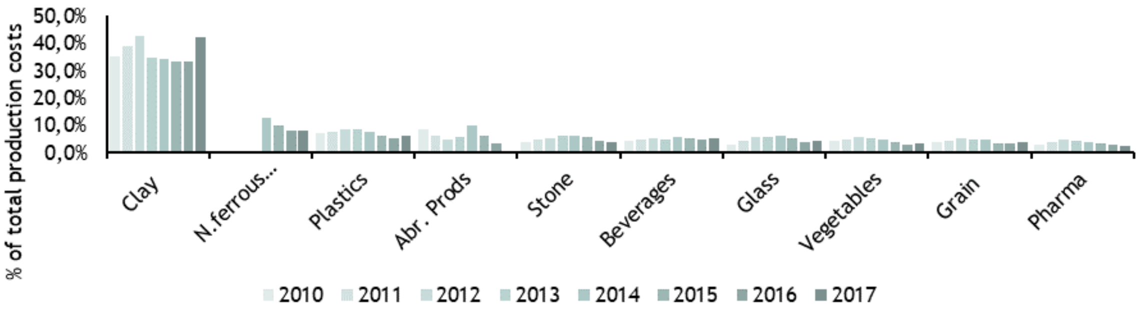
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors



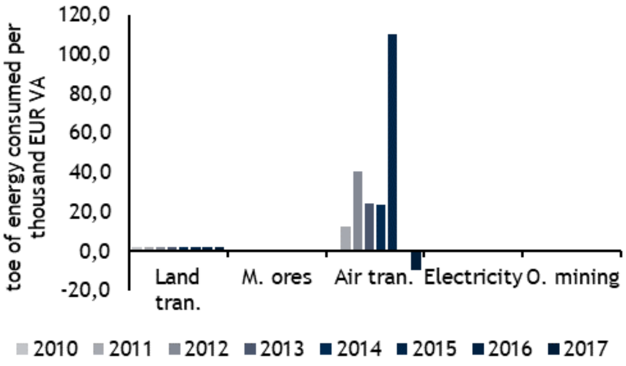
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Cyprus are not widely available

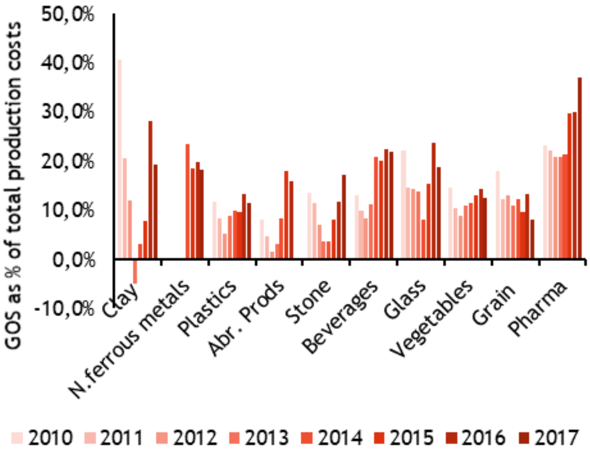
Non-manufacturing sectors



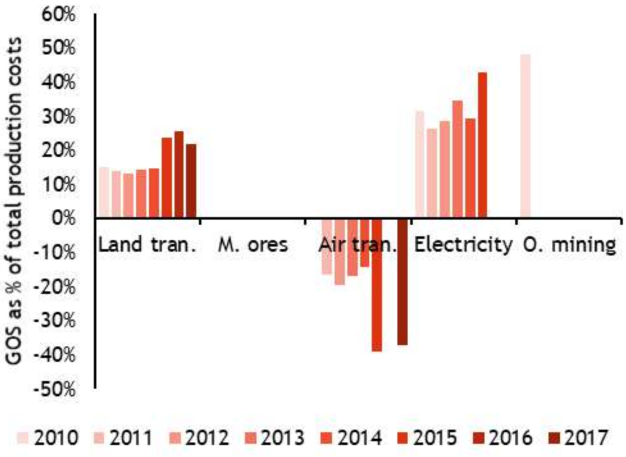
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Cyprus (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C235 - Cement, lime and plaster

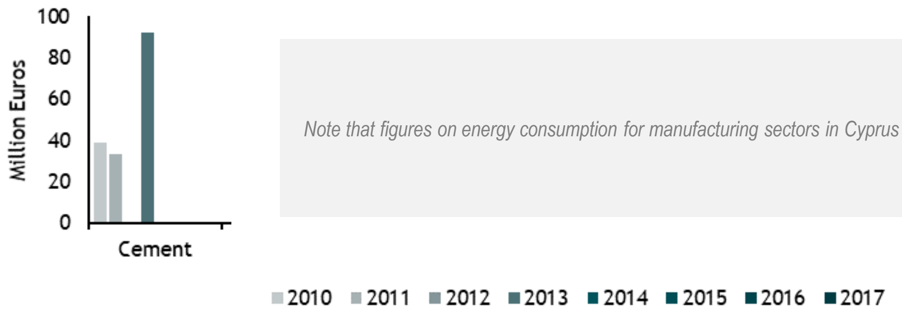
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. H49 - Land transport

Energy cost shares

Energy costs in value

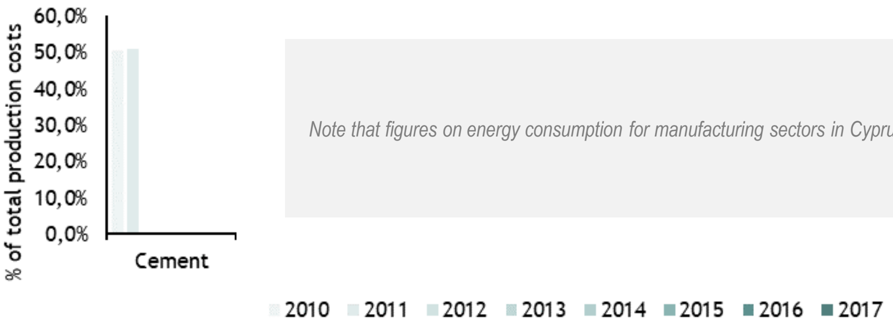
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Cyprus are not widely available

Energy costs as a share of total production costs

Manufacturing sectors



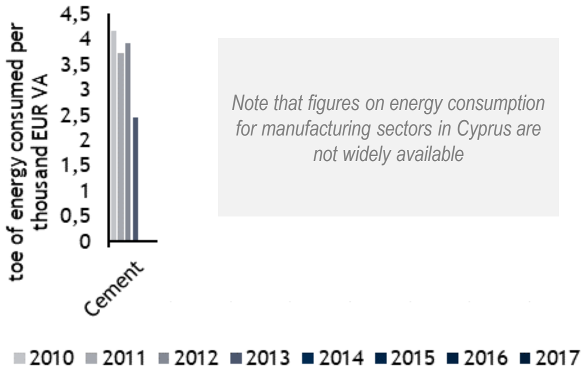
Note that figures on energy consumption for manufacturing sectors in Cyprus are not widely available

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

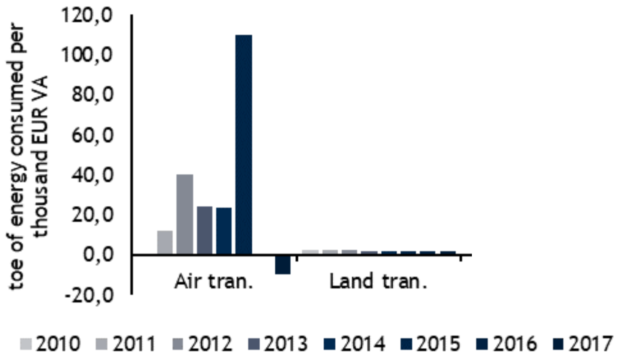
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Cyprus are not widely available

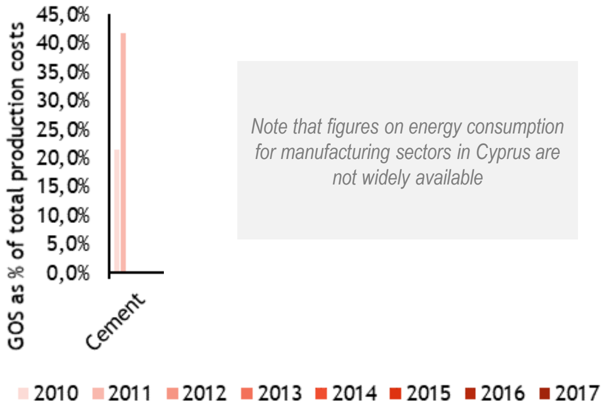
Non-manufacturing sectors



Profitability

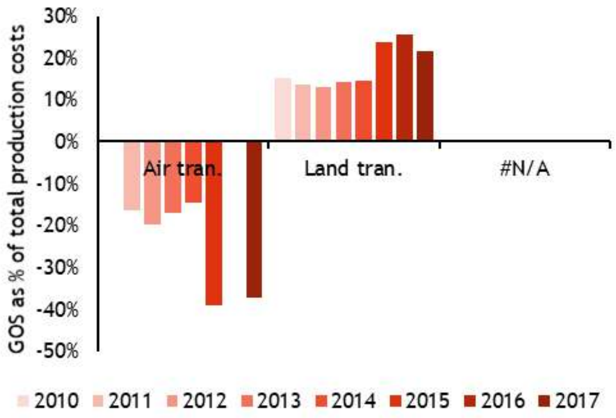
Gross operating surplus as a share of production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Cyprus are not widely available

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Czech Republic (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C235 - Cement, lime and plaster
3. C231 - Glass
4. C241 - Iron and steel
5. C234 - Porcelain and ceramics
6. C245 - Casting of metal
7. C232 - Refractory products
8. C171 - Pulp and paper
9. C201 - Basic chemicals
10. C239 - Abrasive products

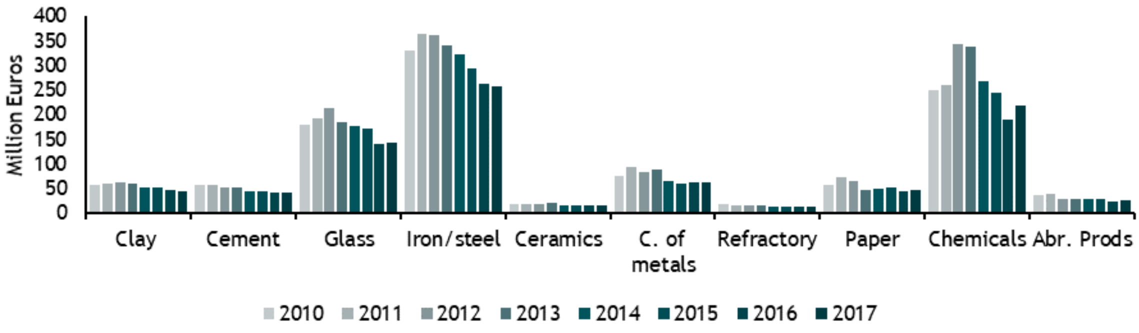
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

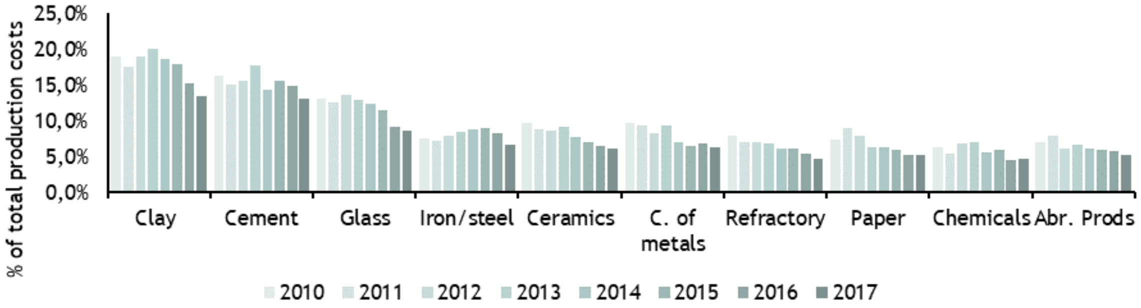
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

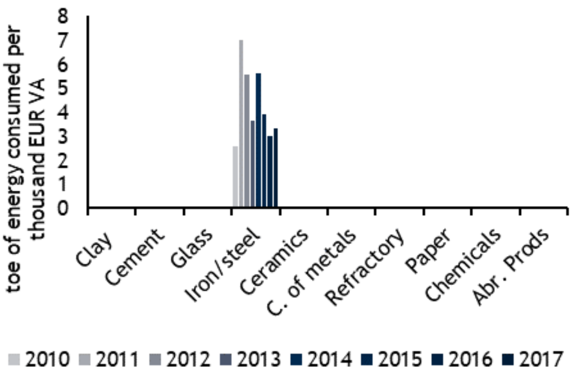


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

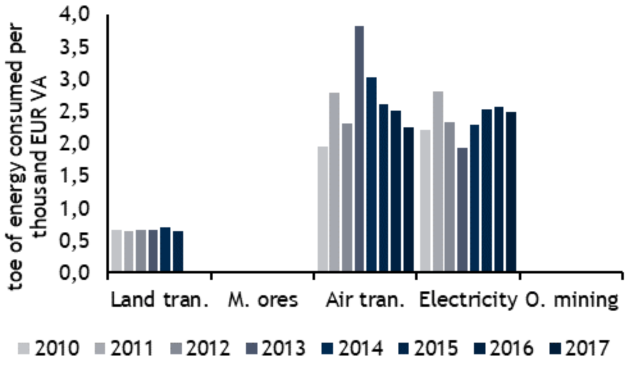
Energy intensity

Consumption of energy per value added

Manufacturing sectors



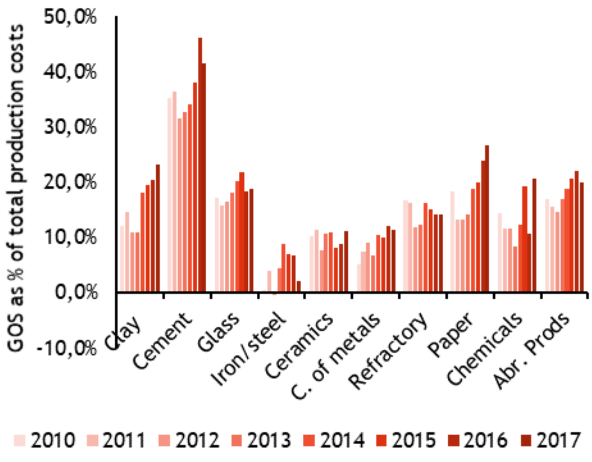
Non-manufacturing sectors



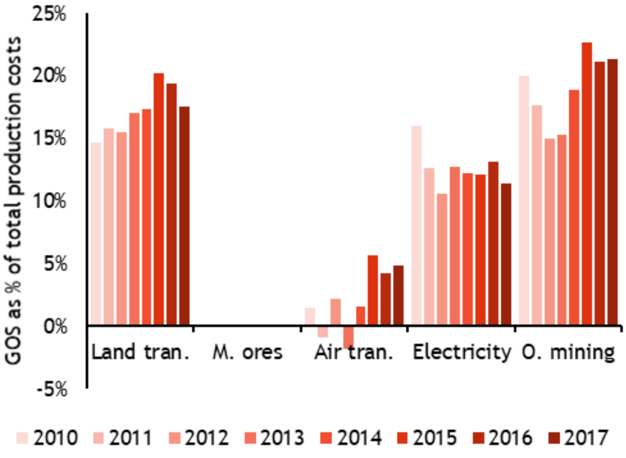
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Czech Republic (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C192 - Refineries
3. C244 - Non-ferrous metals

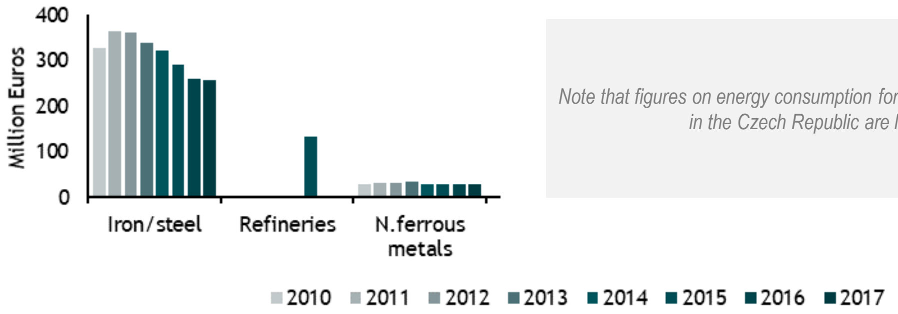
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. D35 - Electricity, gas and steam

Energy cost shares

Energy costs in value

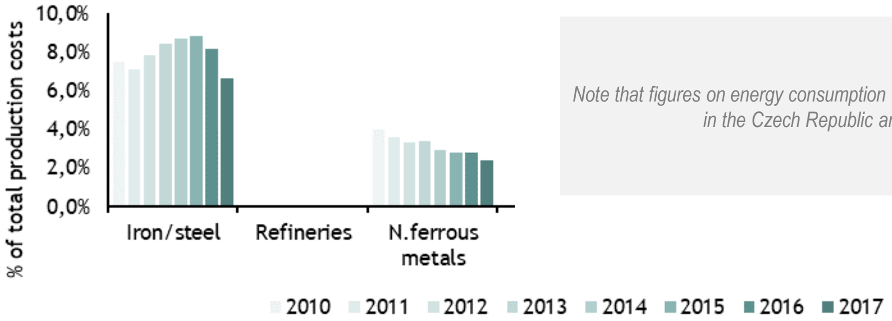
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in the Czech Republic are limited

Energy costs as a share of total production costs

Manufacturing sectors



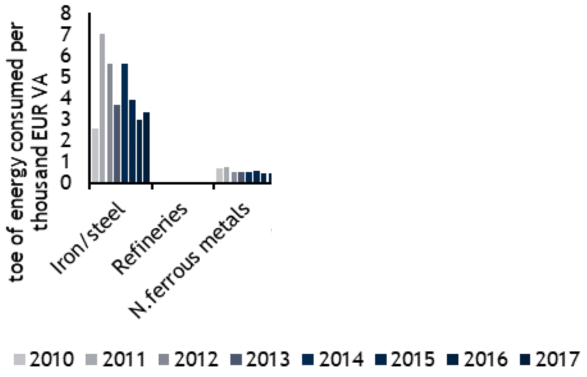
Note that figures on energy consumption for manufacturing sectors in the Czech Republic are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

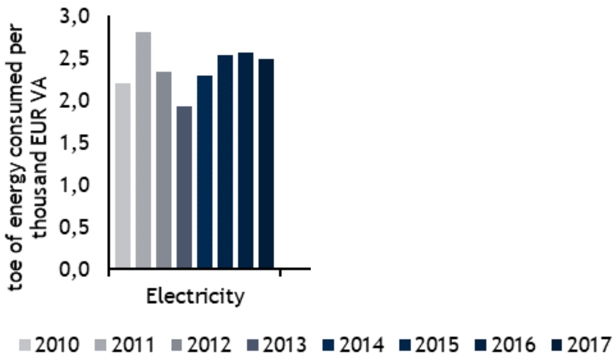
Energy intensity

Consumption of energy per value added

Manufacturing sectors



Non-manufacturing sectors

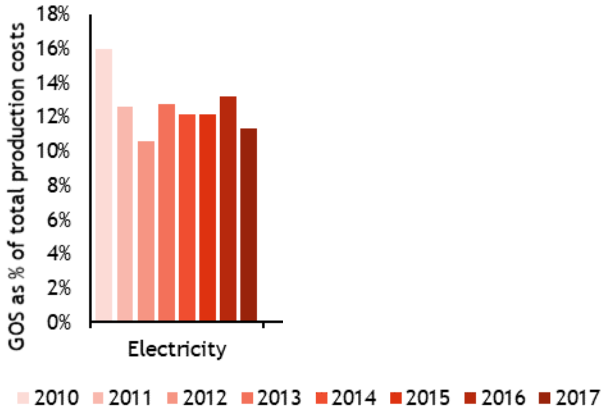


Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Germany (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C235 - Cement, lime and plaster
3. C206 - Man-made fibres
4. C171 - Pulp and paper
5. C231 - Glass
6. C241 - Iron and steel
7. C245 - Casting of metal
8. C201 - Basic chemicals
9. C232 - Refractory products
10. C106 - Grain products

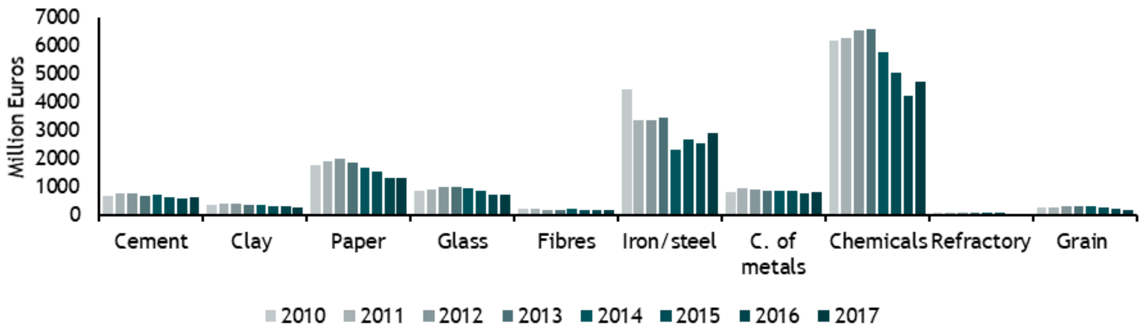
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores *(limited data availability)*
3. H51 - Air transport
4. D35 - Electricity, gas and steam *(limited data availability)*
5. B08 - Other mining

Energy cost shares

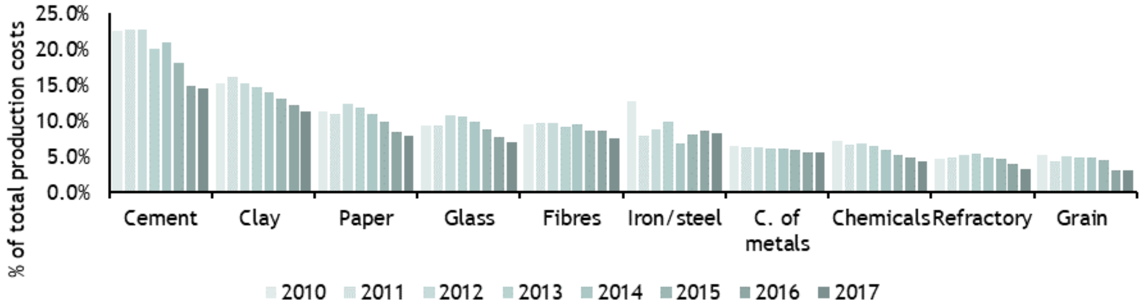
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

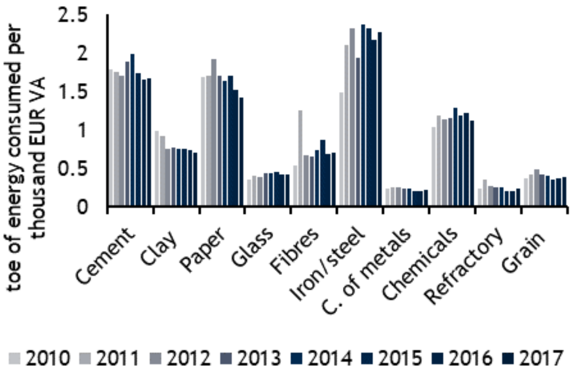


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

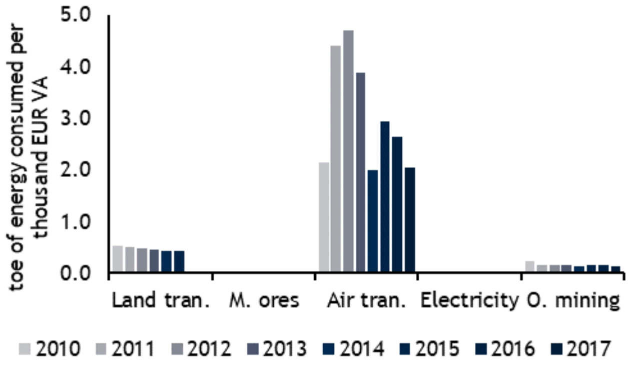
Energy intensity

Consumption of energy per value added

Manufacturing sectors



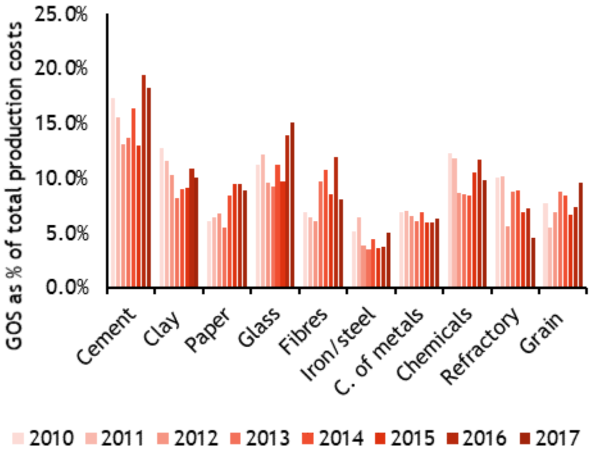
Non-manufacturing sectors



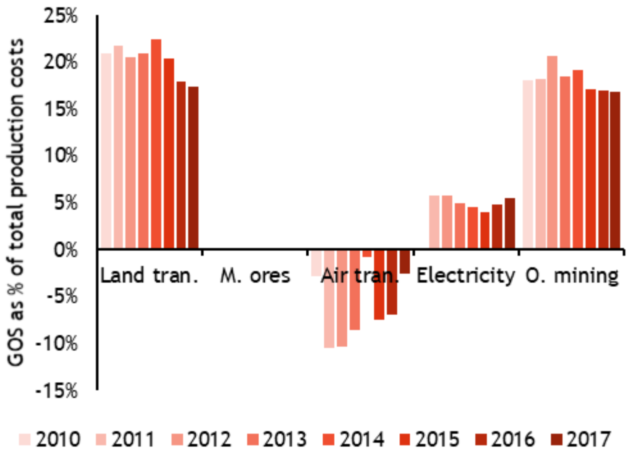
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Germany (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C201 - Basic chemicals
2. C241 - Iron and steel
3. C192 - Refineries
4. C29 - Motor vehicles
5. C25 - Fabricated metal products
6. C235 - Cement, lime and plaster
7. C244 - Non-ferrous metals
8. C28 - Machinery and equipment

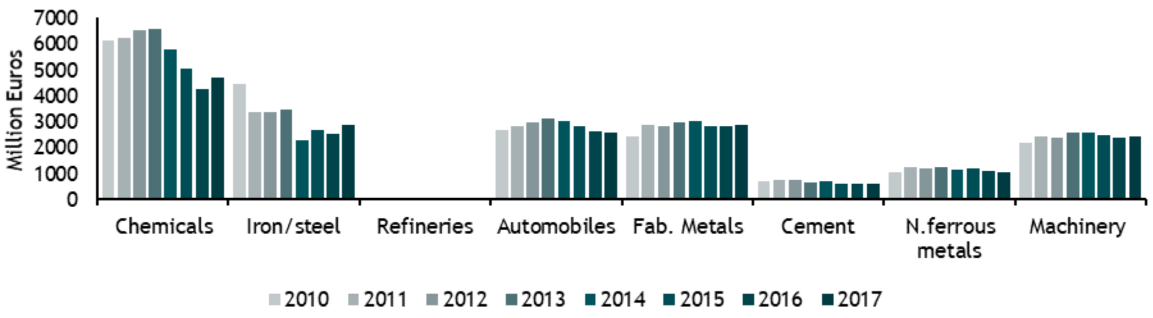
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. I - Accommodation and restaurants
3. G - Wholesale and retail trade

Energy cost shares

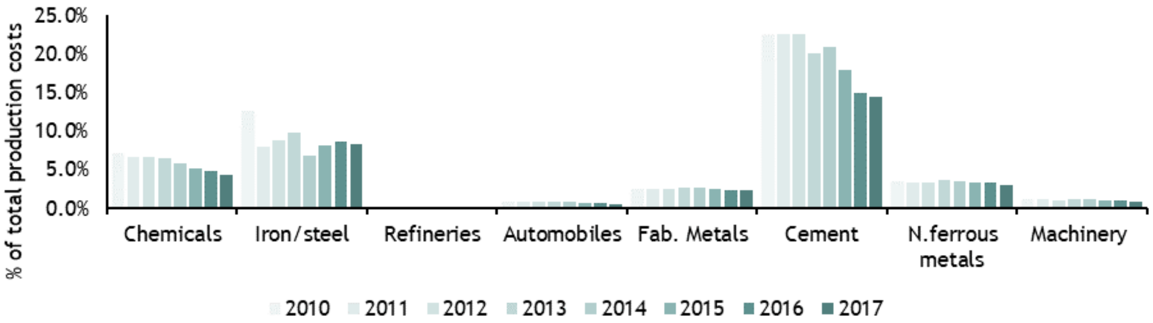
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

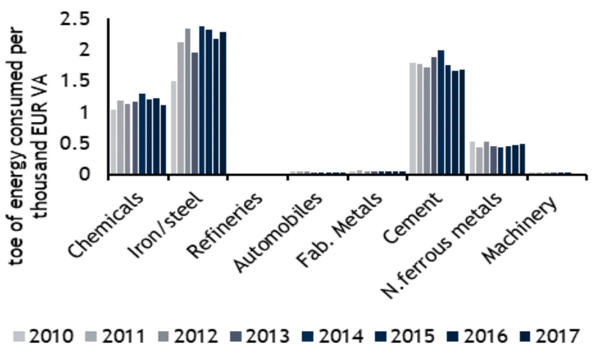


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

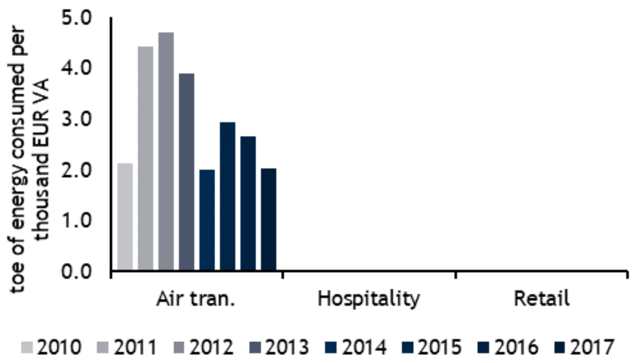
Energy intensity

Consumption of energy per value added

Manufacturing sectors



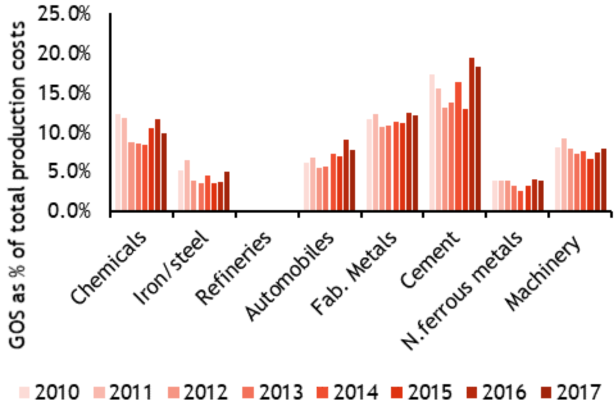
Non-manufacturing sectors



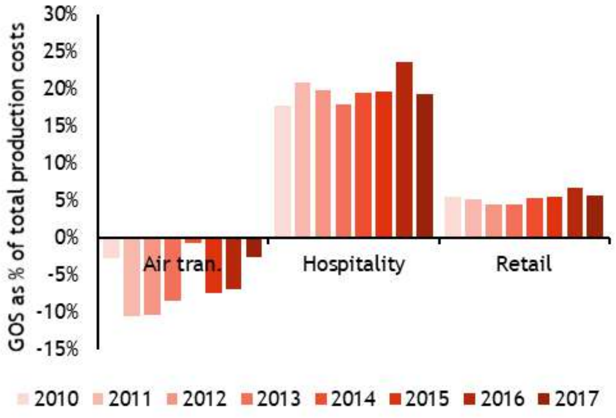
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Denmark (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C231 - Glass
3. C245 - Casting of metal
4. C171 - Pulp and paper
5. C239 - Abrasive products
6. C237 - Stone
7. C201 - Basic chemicals
8. C161 - Sawmills
9. C106 - Grain products
10. C234 - Porcelain and ceramics

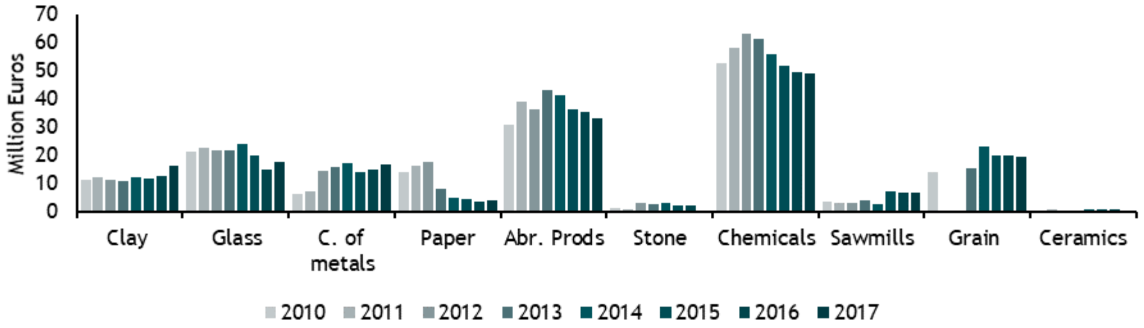
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

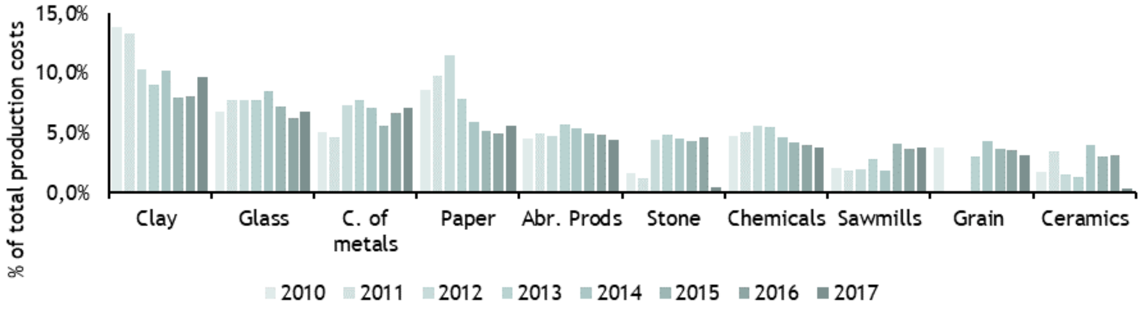
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

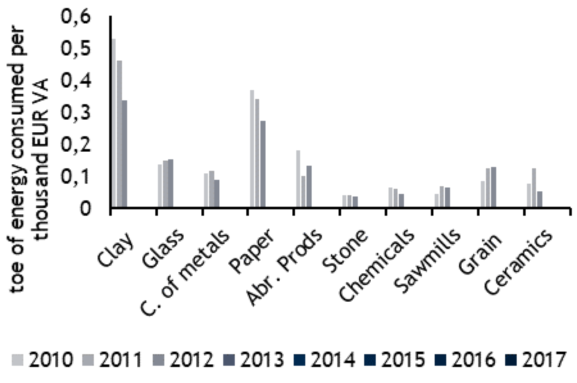
Manufacturing sectors



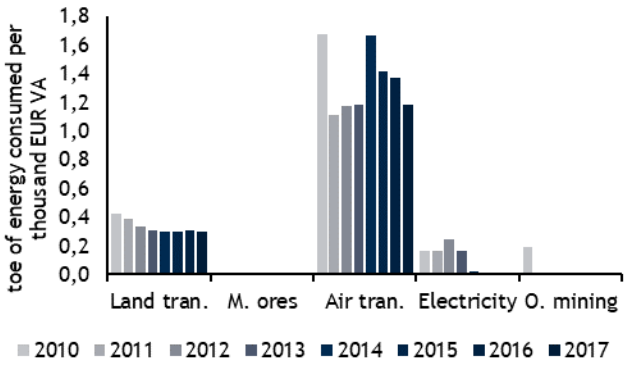
Energy intensity

Consumption of energy per value added

Manufacturing sectors



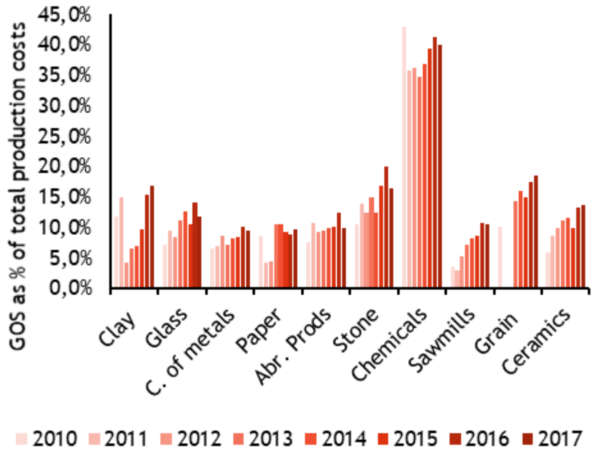
Non-manufacturing sectors



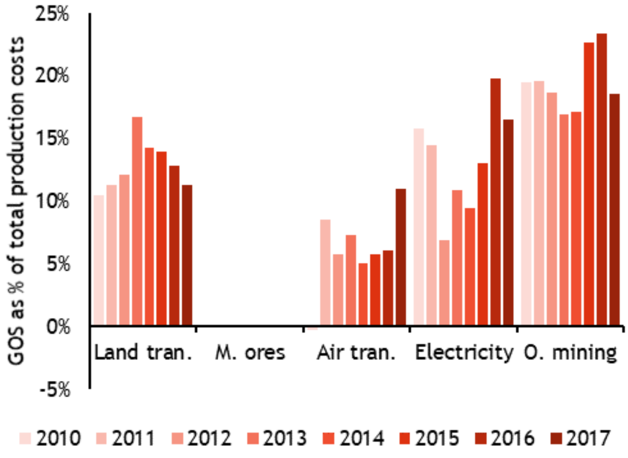
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Denmark (2/2)

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C28 - Machinery and equipment
3. C241 - Iron and steel
4. C239 - Abrasive products
5. C201 - Basic chemicals
6. C222 - Plastics products
7. C21 - Pharmaceutical products
8. C11 - Beverages

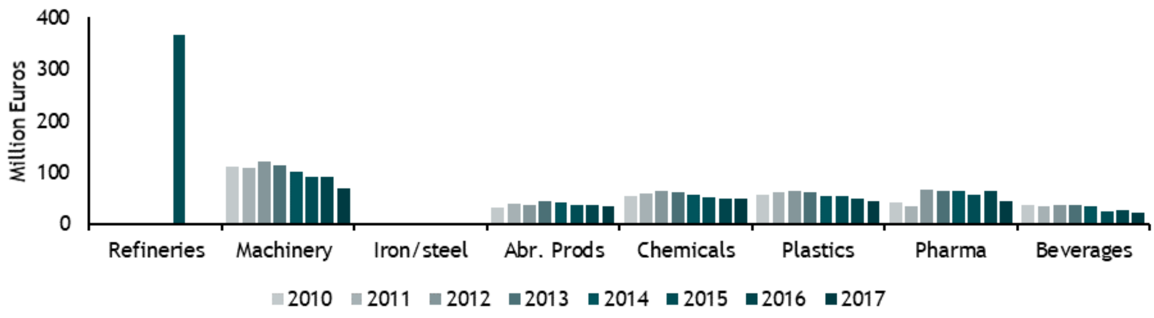
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H49 - Land transport
2. H51 - Air transport
3. A - Agriculture

Energy cost shares

Energy costs in value

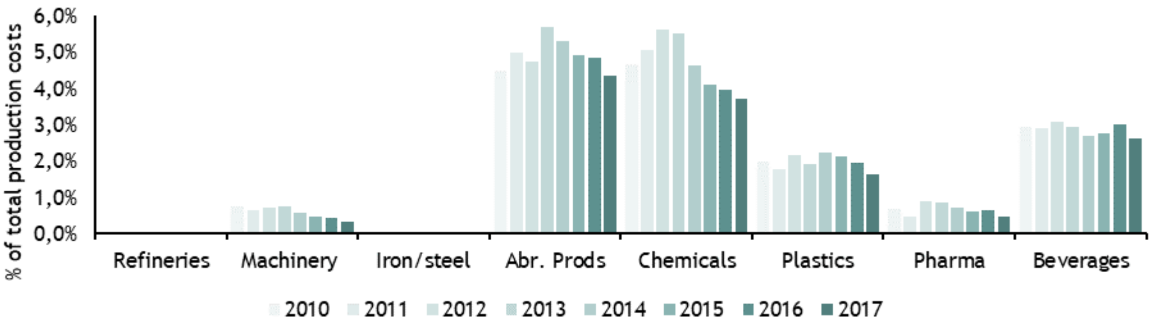
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

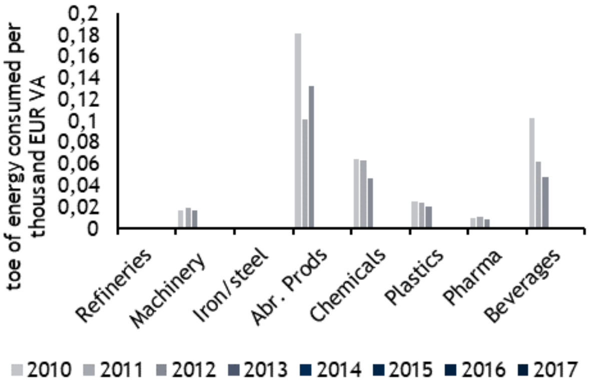
Energy costs as a share of total production costs

Manufacturing sectors

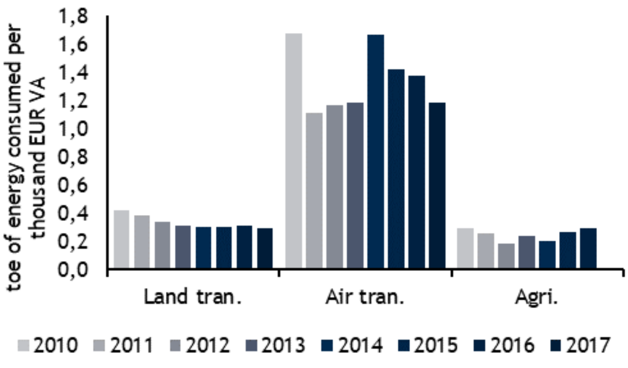


Energy intensity

Consumption of energy per value added



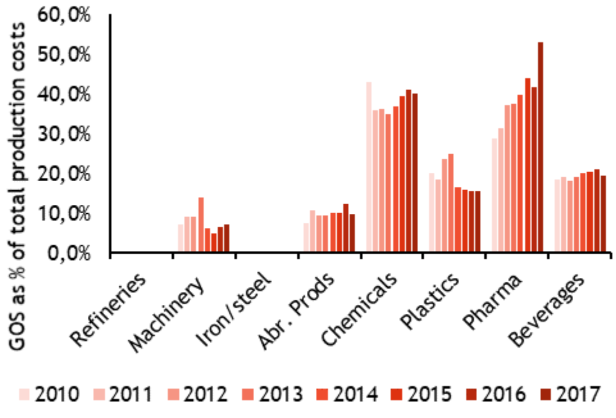
Non-manufacturing sectors



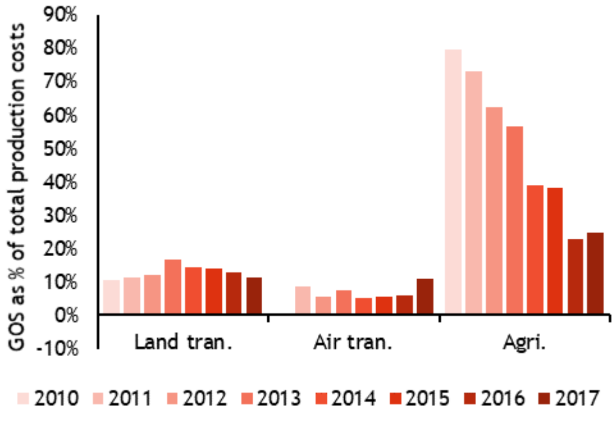
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Estonia (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C192 - Refineries
2. C171 - Pulp and paper
3. C234 - Porcelain and ceramics
4. C231 - Glass
5. C201 - Basic chemicals
6. C245 - Casting of metal
7. C237 - Stone
8. C103 - Fruit and vegetables
9. C161 - Sawmills
10. C106 - Grain products

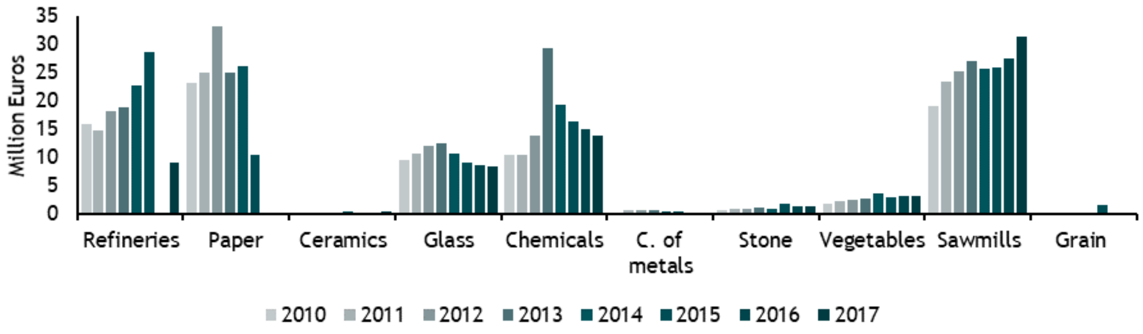
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

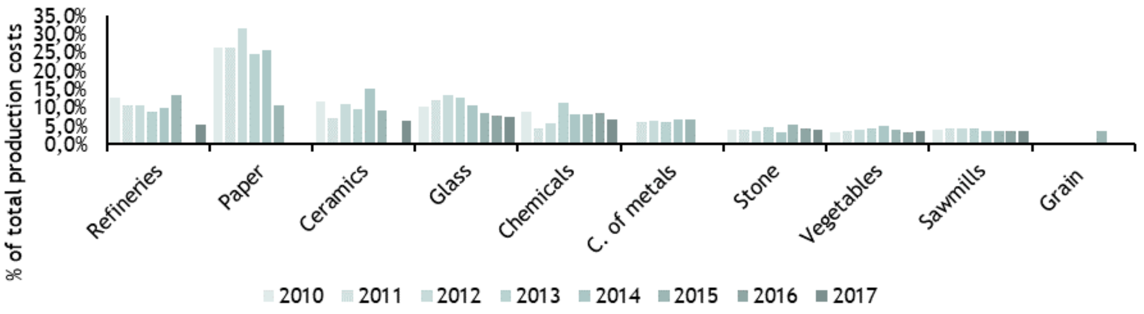
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

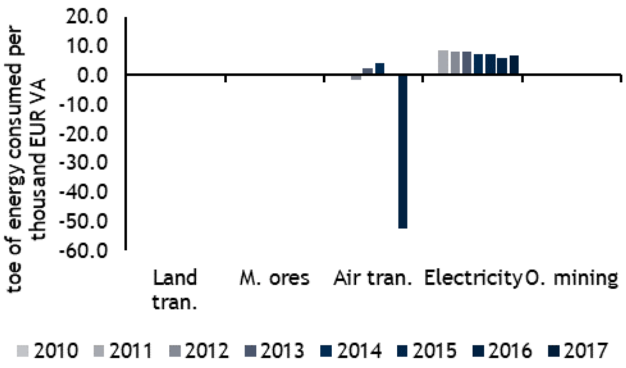
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Estonia are not widely available

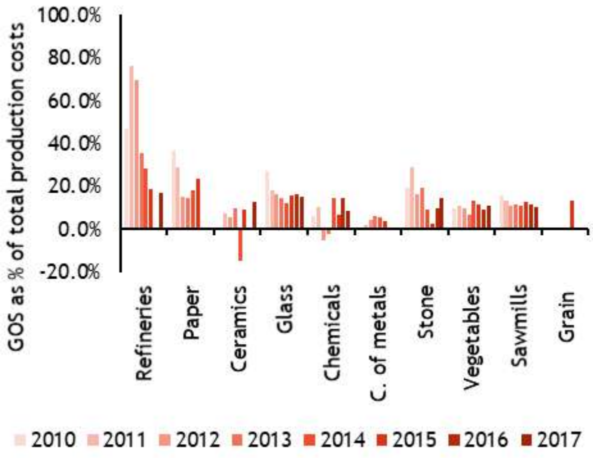
Non-manufacturing sectors



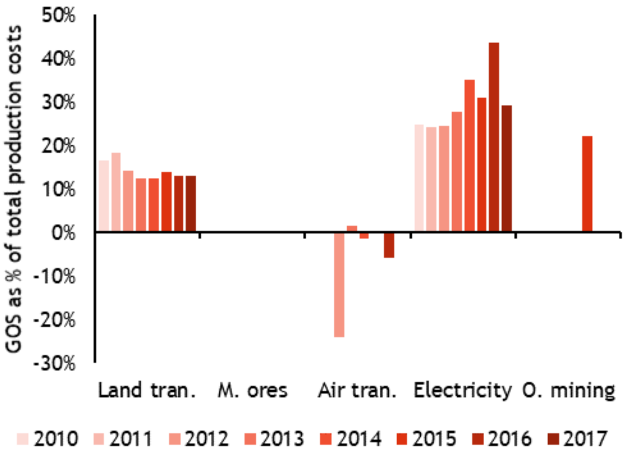
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Estonia (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C235 - Cement, lime and plaster
2. C26 - Computer and electronics
3. C25 - Fabricated metal products
4. C241 - Iron and steel

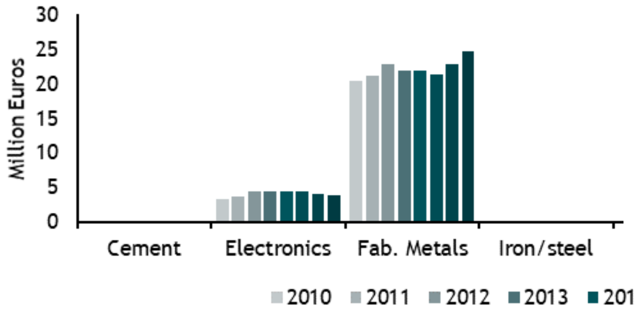
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. D35 - Electricity, gas and steam

Energy cost shares

Energy costs in value

Manufacturing sectors

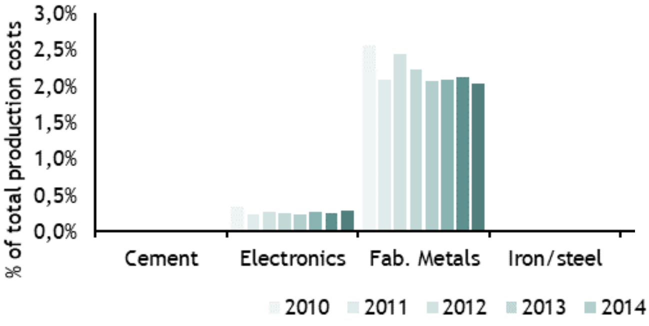


Note that figures on energy consumption for manufacturing sectors in Estonia are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors

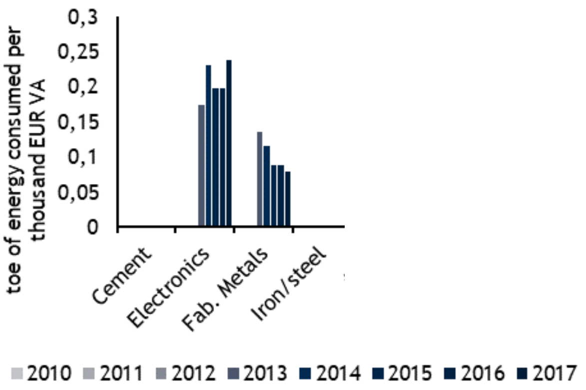


Note that figures on energy consumption for manufacturing sectors in Estonia are limited

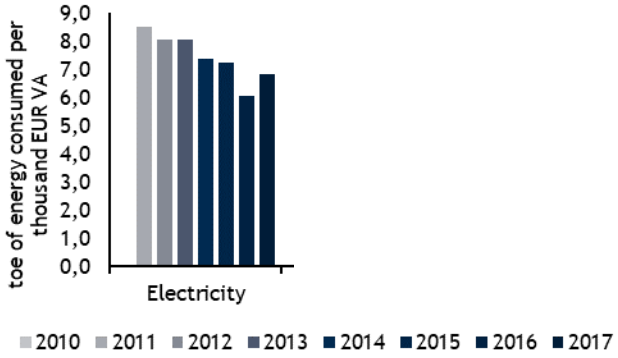
Energy intensity

Consumption of energy per value added

Manufacturing sectors



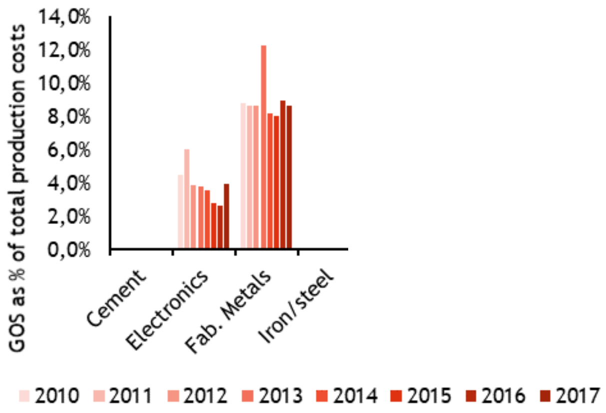
Non-manufacturing sectors



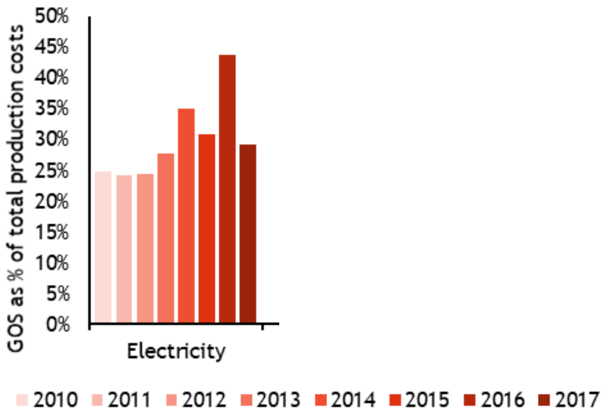
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Greece (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C235 - Cement, lime and plaster
3. C241 - Iron and steel
4. C171 - Pulp and paper
5. C244 - Non-ferrous metals
6. C239 - Abrasive products
7. C231 - Glass
8. C206 - Man-made fibres
9. C237 - Stone
10. C234 - Porcelain and ceramics

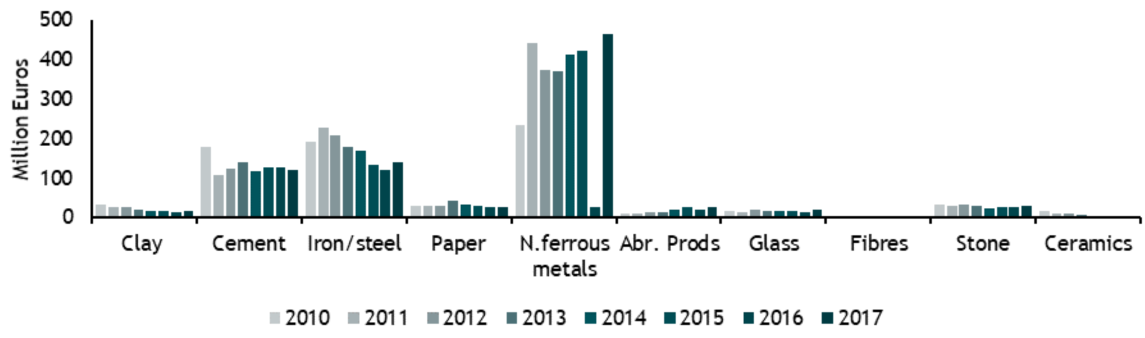
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

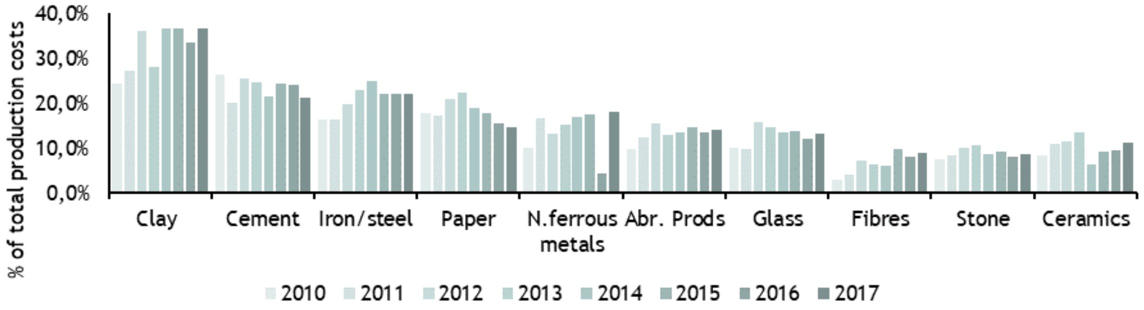
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

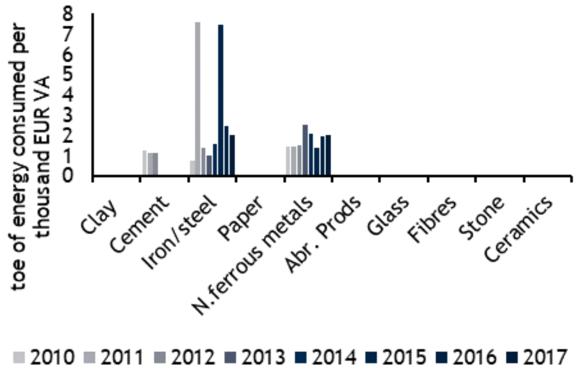


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

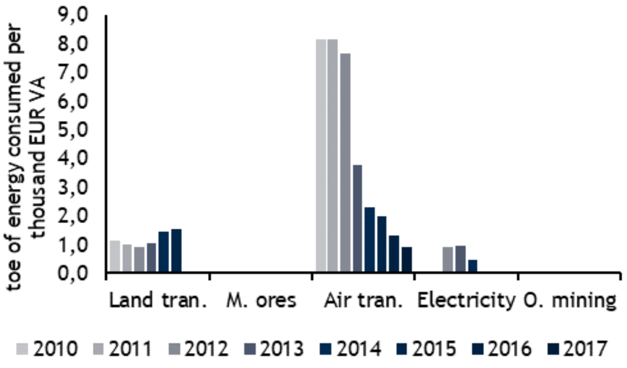
Energy intensity

Consumption of energy per value added

Manufacturing sectors



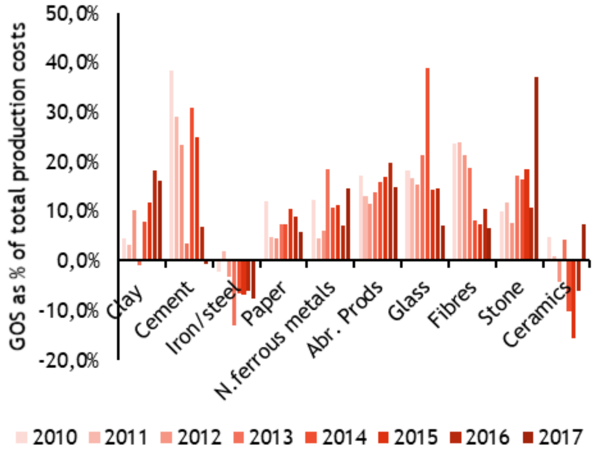
Non-manufacturing sectors



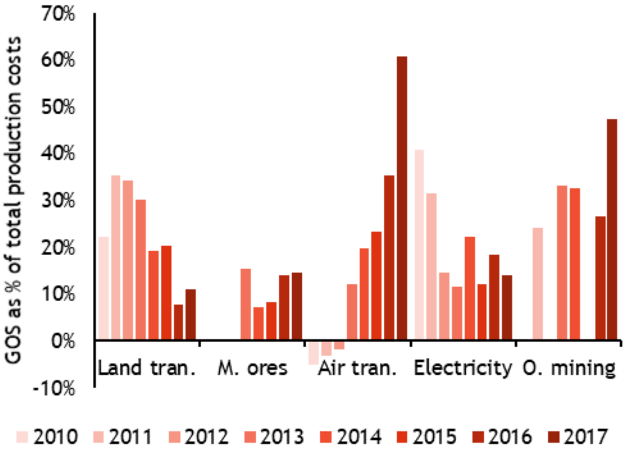
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Greece (2/2)

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C244 - Non-ferrous metals
3. C235 - Cement, lime and plaster

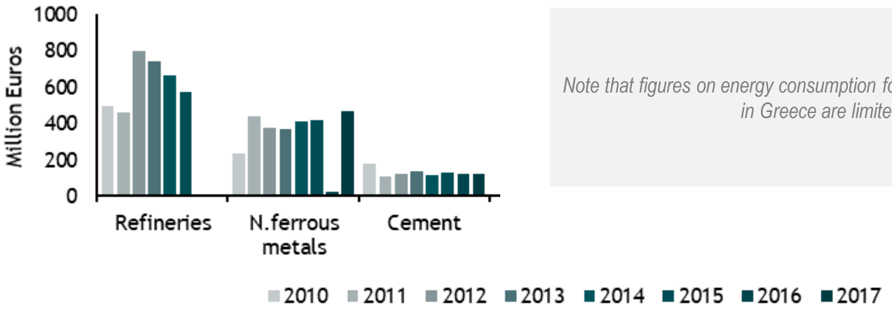
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. A - Agriculture

Energy cost shares

Energy costs in value

Manufacturing sectors

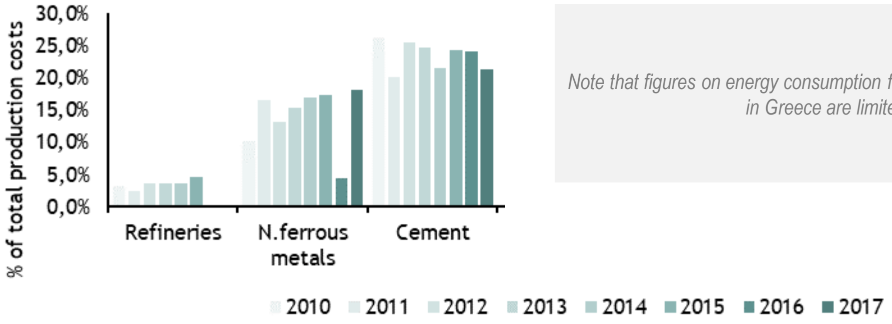


Note that figures on energy consumption for manufacturing sectors in Greece are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors

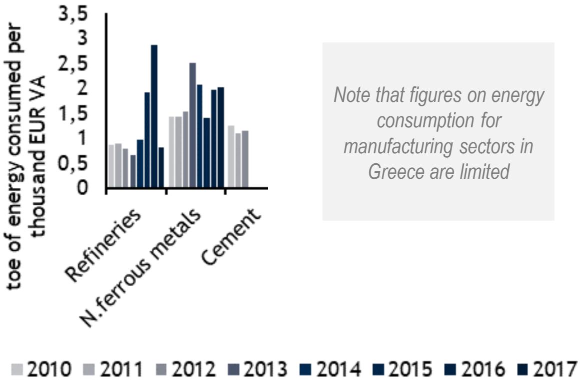


Note that figures on energy consumption for manufacturing sectors in Greece are limited

Energy intensity

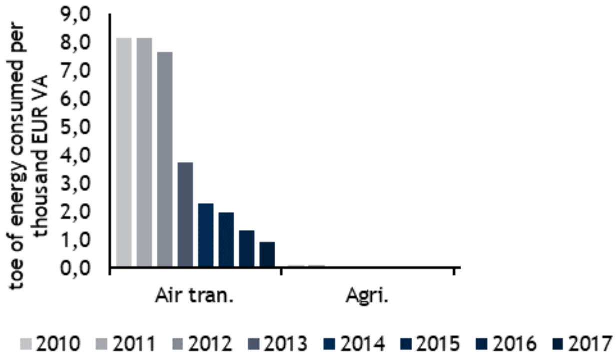
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Greece are limited

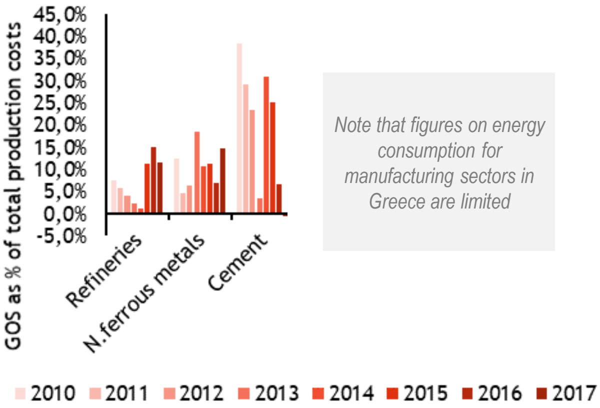
Non-manufacturing sectors



Profitability

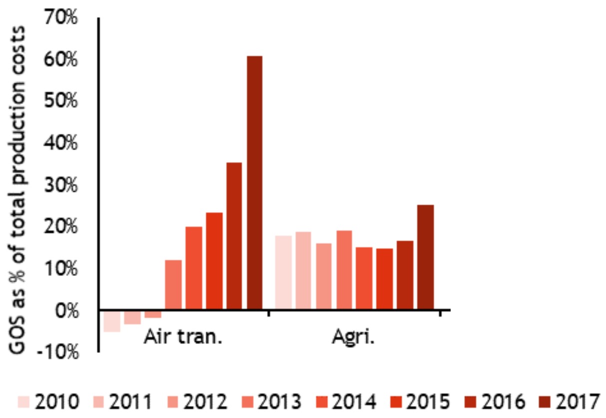
Gross operating surplus as a share of production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Greece are limited

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Spain (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C233 - Clay building materials
3. C206 - Man-made fibres
4. C231 - Glass
5. C171 - Pulp and paper
6. C232 - Refractory products
7. C241 - Iron and steel
8. C201 - Basic chemicals
9. C239 - Abrasive products
10. C245 - Casting of metal

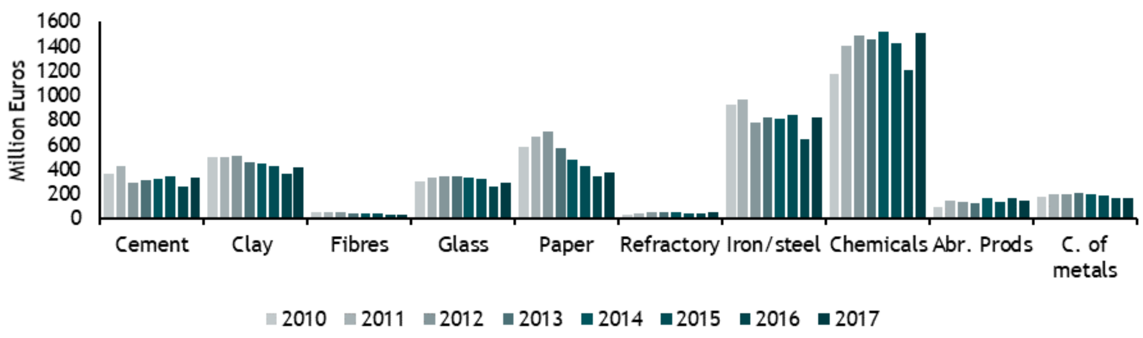
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

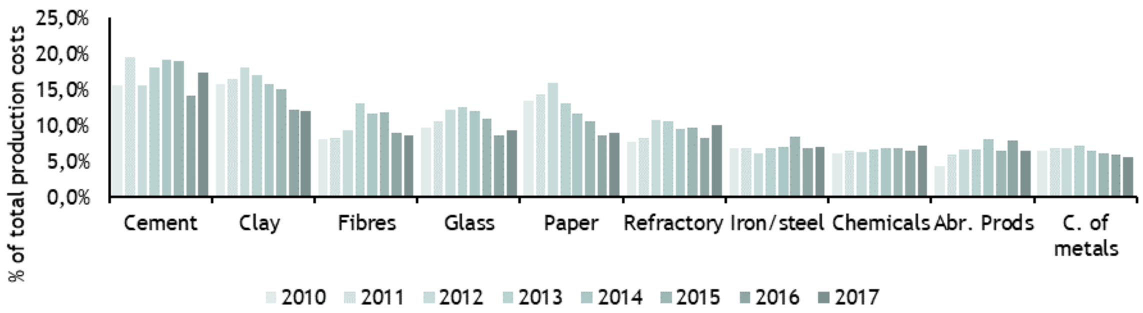
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

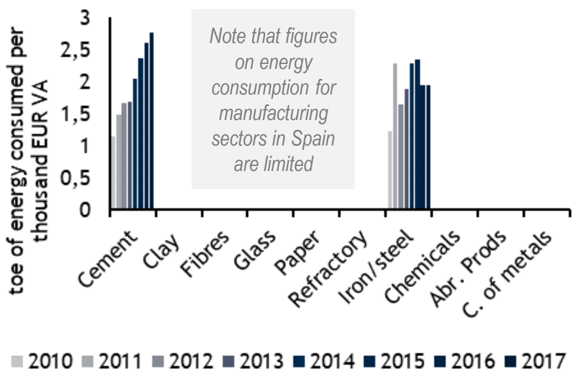


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

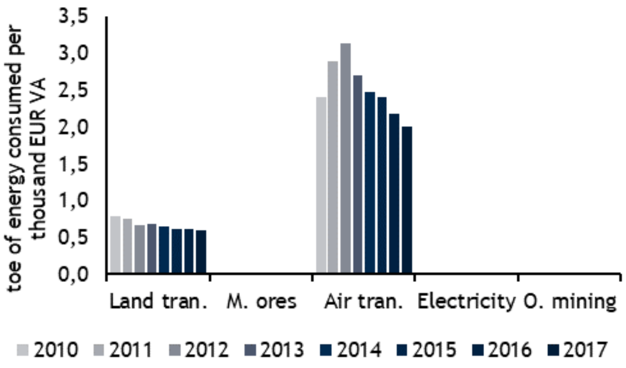
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Spain are limited

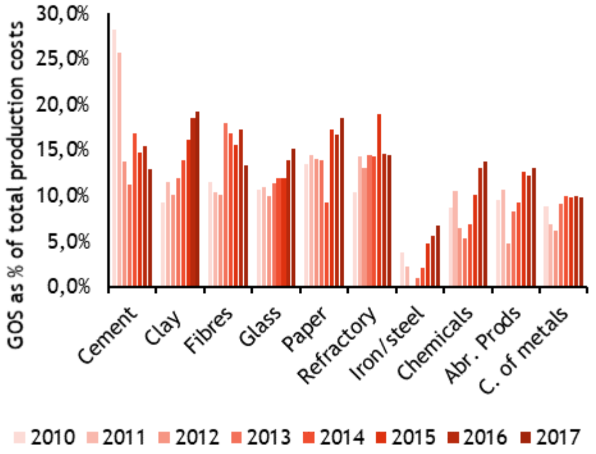
Non-manufacturing sectors



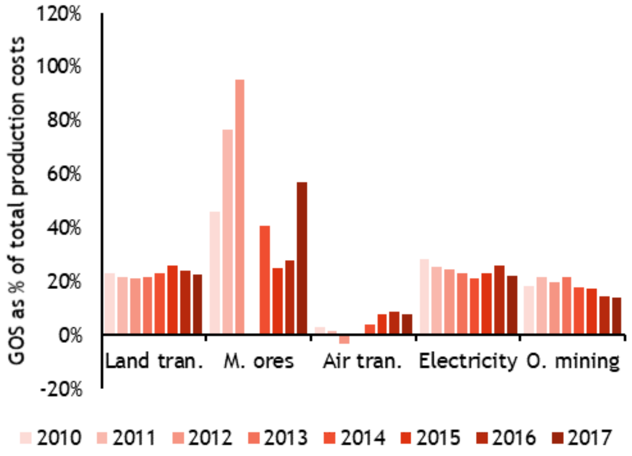
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Spain (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C241 - Iron and steel
3. C235 - Cement, lime and plaster

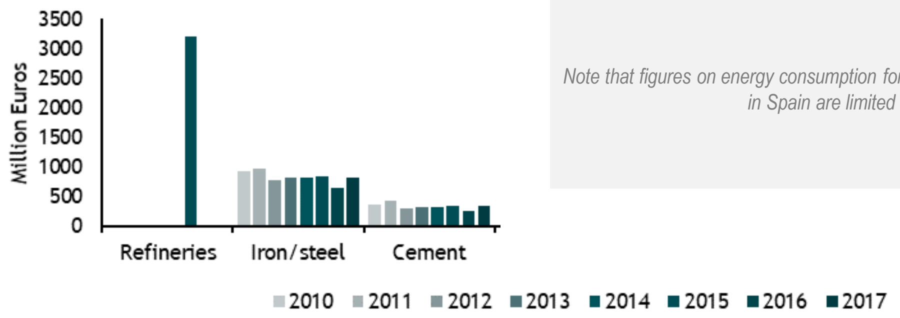
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H49 - Land transport
2. H51 - Air transport
3. G - Wholesale and retail trade

Energy cost shares

Energy costs in value

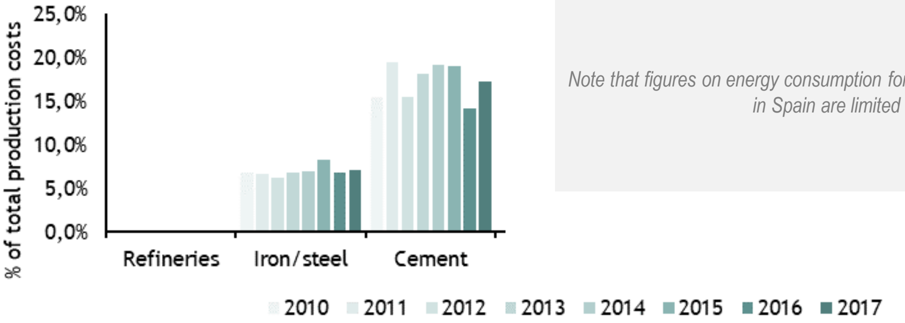
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Spain are limited

Energy costs as a share of total production costs

Manufacturing sectors



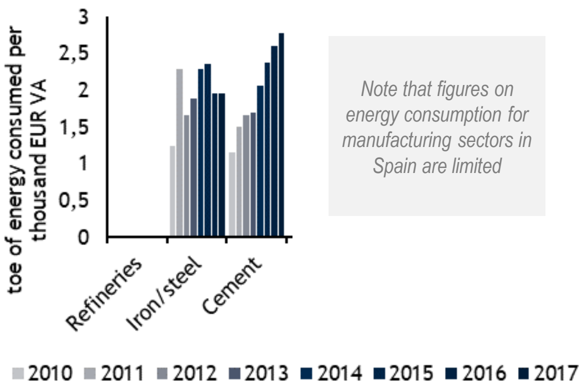
Note that figures on energy consumption for manufacturing sectors in Spain are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

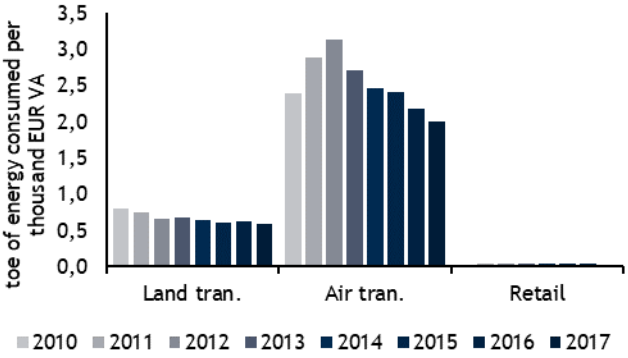
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Spain are limited

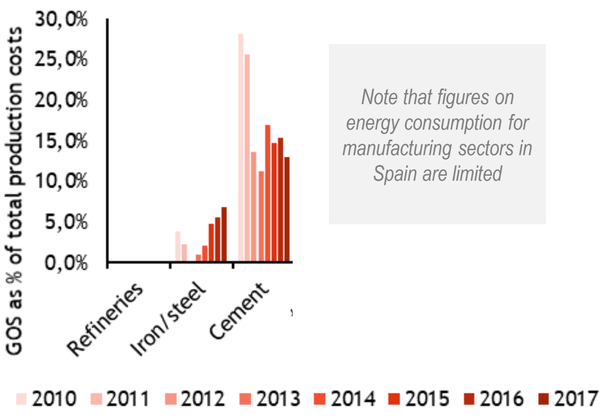
Non-manufacturing sectors



Profitability

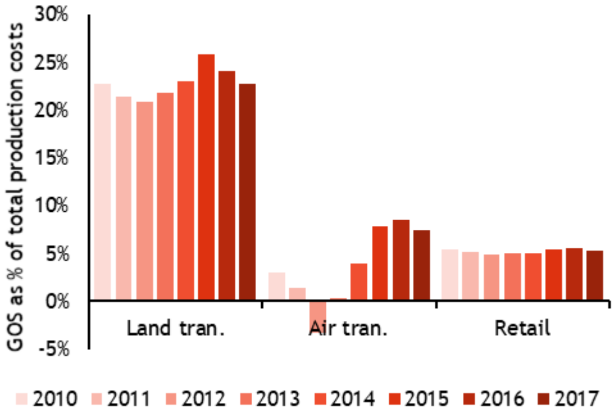
Gross operating surplus as a share of production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Spain are limited

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Finland (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C244 - Non-ferrous metals
3. C201 - Basic chemicals
4. C171 - Pulp and paper
5. C245 - Casting of metal
6. C239 - Abrasive products
7. C231 - Glass
8. C237 - Stone
9. C172 - Articles of paper
10. C222 - Plastics products

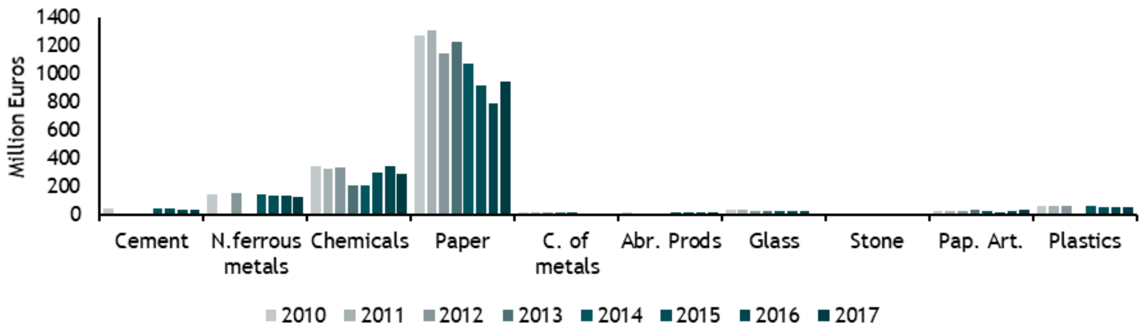
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

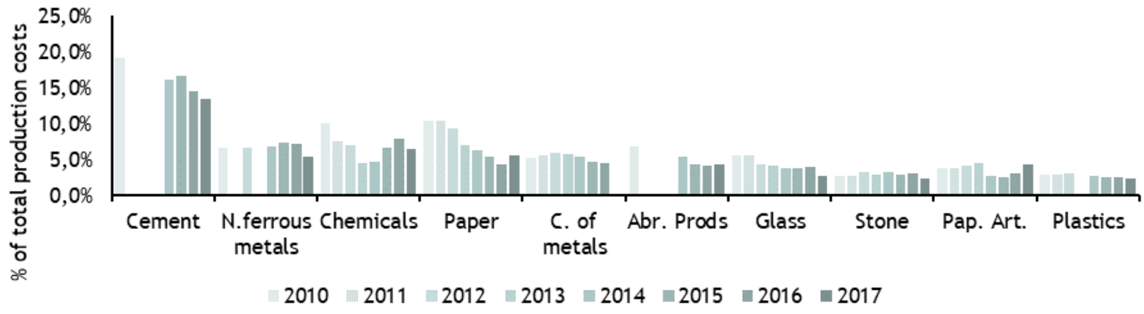
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

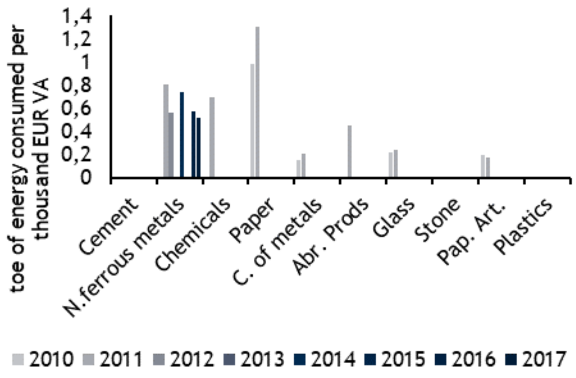


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

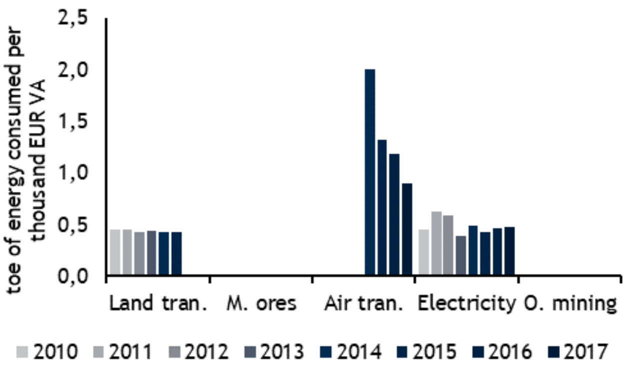
Energy intensity

Consumption of energy per value added

Manufacturing sectors



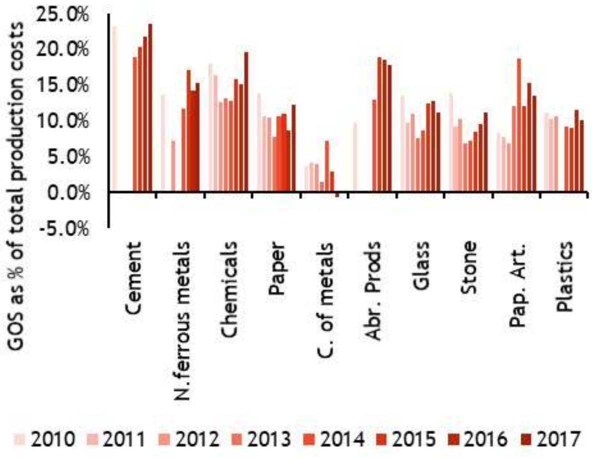
Non-manufacturing sectors



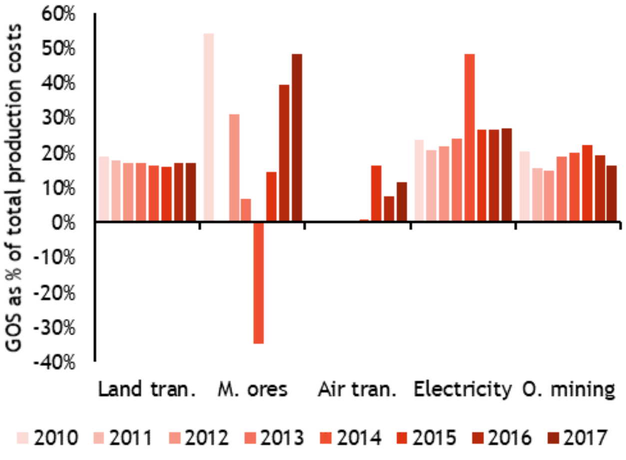
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Finland (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C171 - Pulp and paper
2. C241 - Iron and steel
3. C192 - Refineries
4. C244 - Non-ferrous metals
5. C25 - Fabricated metal products
6. C28 - Machinery and equipment
7. C231 - Glass
8. C11 - Beverages

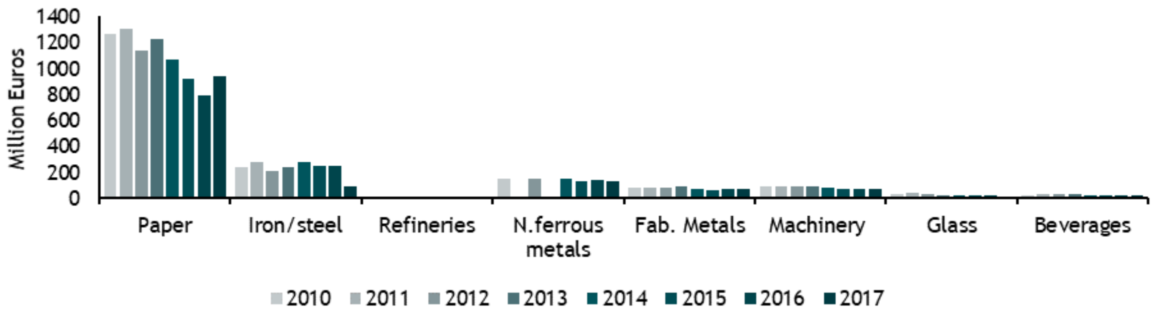
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. D35 - Electricity, gas and steam
2. A - Agriculture
3. H51 - Air transport

Energy cost shares

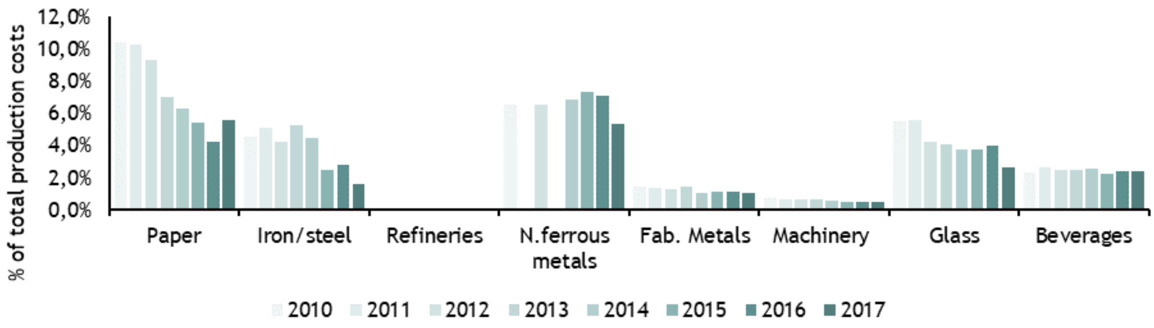
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

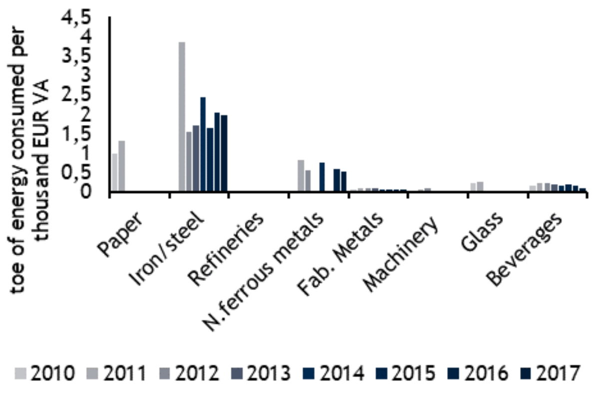


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

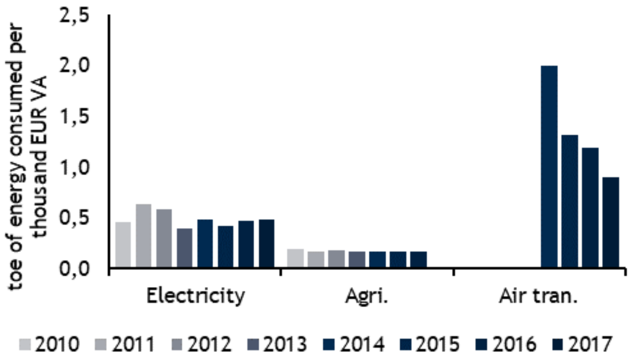
Energy intensity

Consumption of energy per value added

Manufacturing sectors



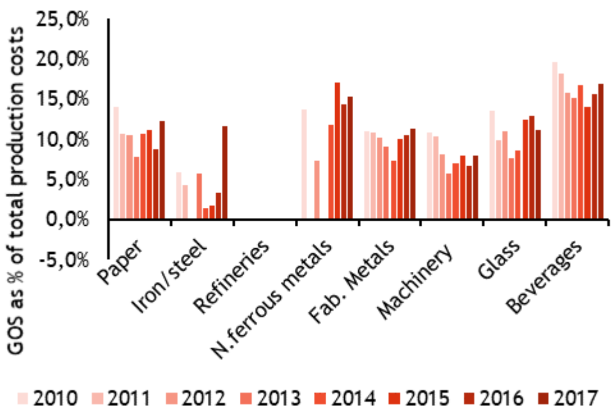
Non-manufacturing sectors



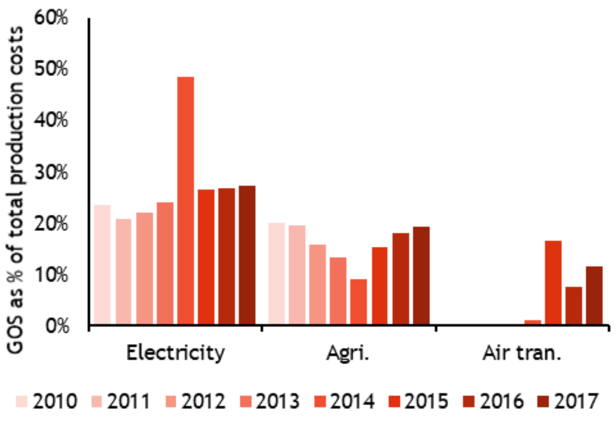
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in France (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C235 - Cement, lime and plaster
3. C206 - Man-made fibres
4. C171 - Pulp and paper
5. C231 - Glass
6. C241 - Iron and steel
7. C245 - Casting of metal
8. C237 - Stone
9. C201 - Basic chemicals
10. C234 - Porcelain and ceramics

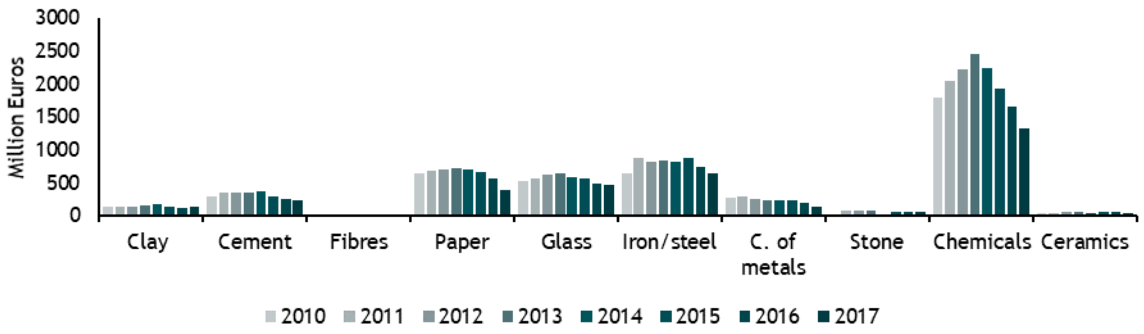
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores *(limited data availability)*
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

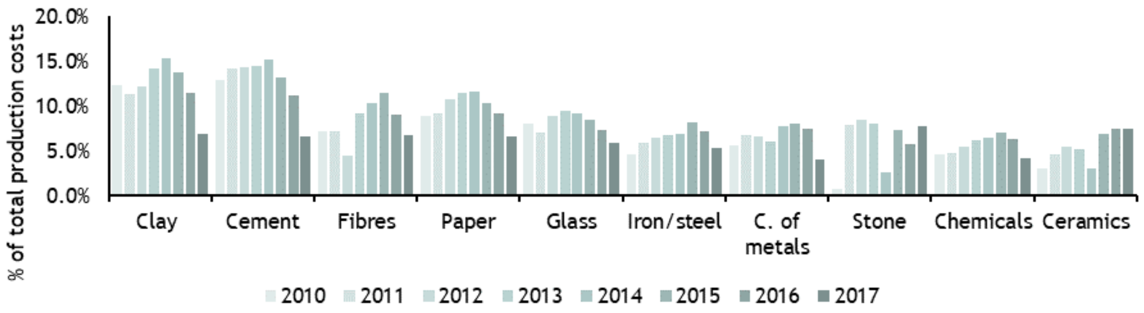
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

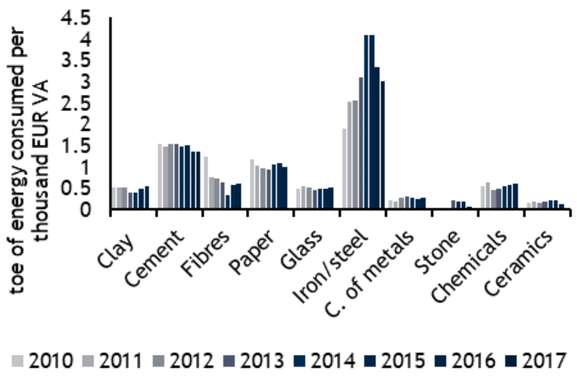


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

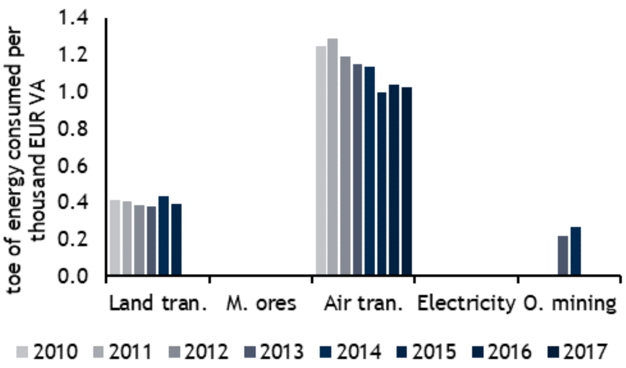
Energy intensity

Consumption of energy per value added

Manufacturing sectors



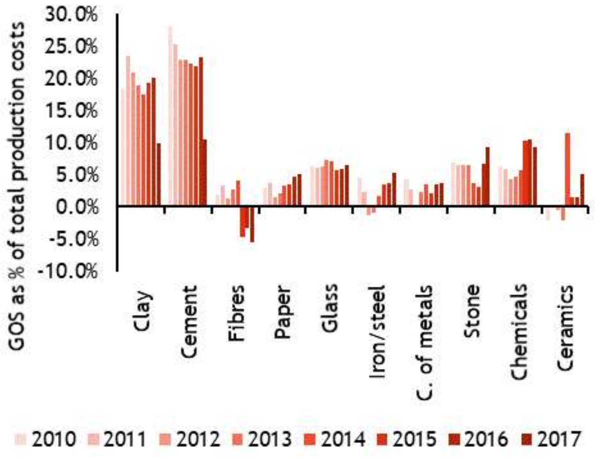
Non-manufacturing sectors



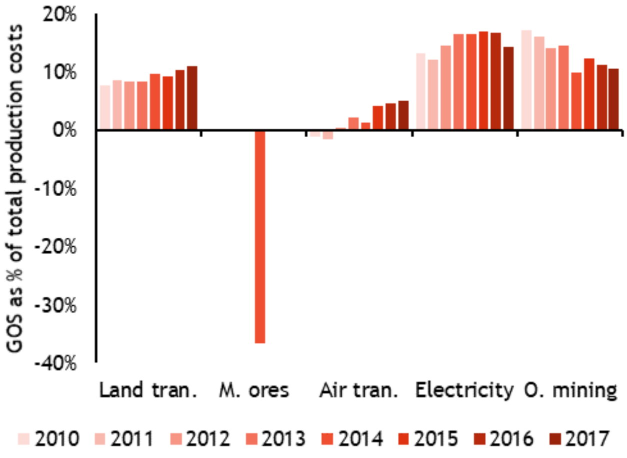
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in France (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C201 - Basic chemicals
3. C192 - Refineries
4. C231 - Glass
5. C171 - Pulp and paper
6. C244 - Non-ferrous metals
7. C25 - Fabricated metal products
8. C29 - Motor vehicles

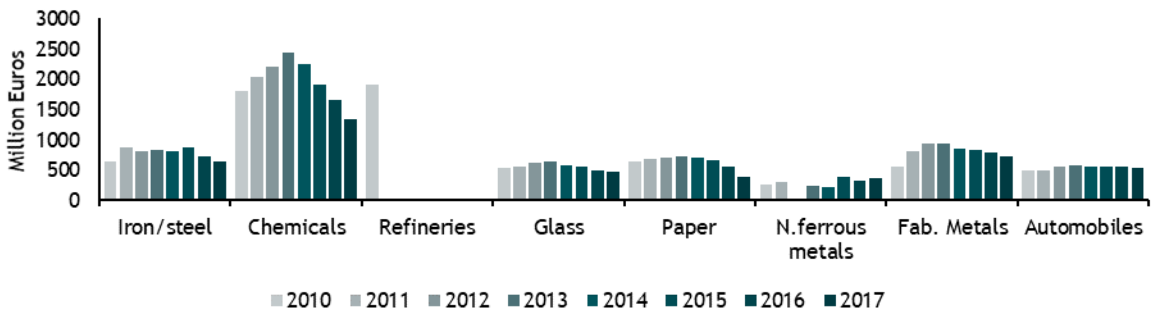
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. G - Wholesale and retail trade
3. A - Agriculture

Energy cost shares

Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

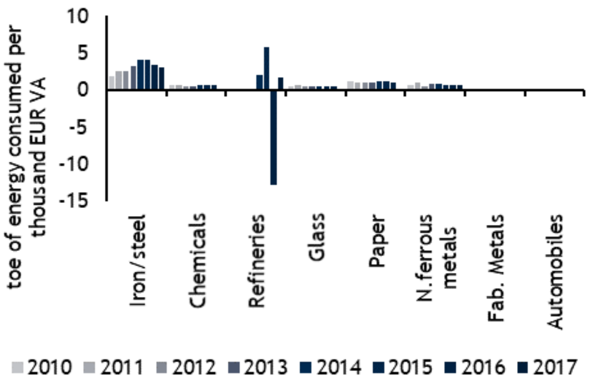
Manufacturing sectors

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

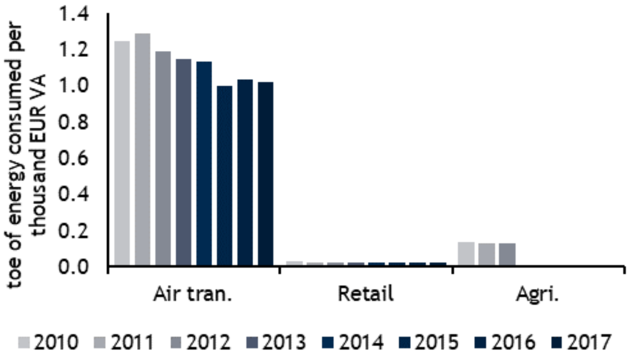
Energy intensity

Consumption of energy per value added

Manufacturing sectors



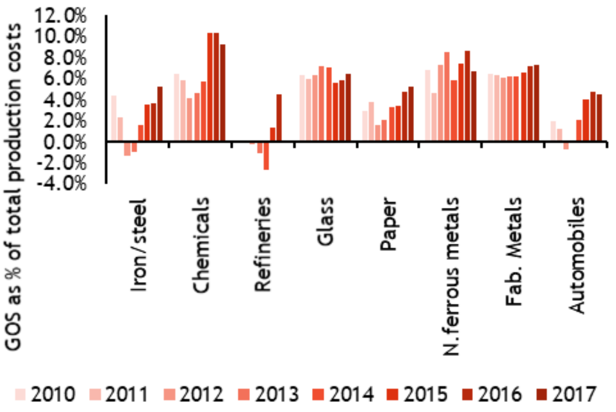
Non-manufacturing sectors



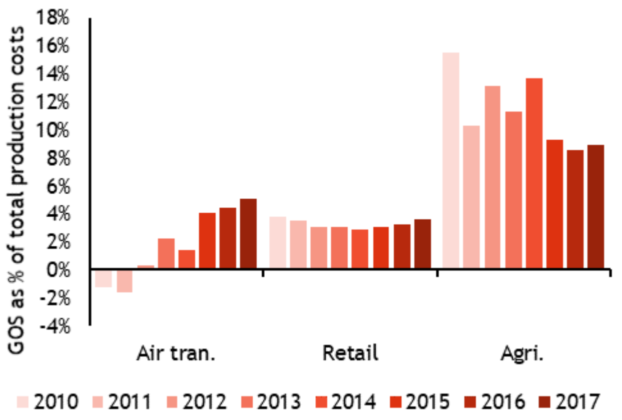
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Croatia (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C201 - Basic chemicals
2. C233 - Clay building materials
3. C235 - Cement, lime and plaster
4. C171 - Pulp and paper
5. C231 - Glass
6. C239 - Abrasive products
7. C234 - Porcelain and ceramics
8. C237 - Stone
9. C245 - Casting of metal
10. C161 - Sawmills

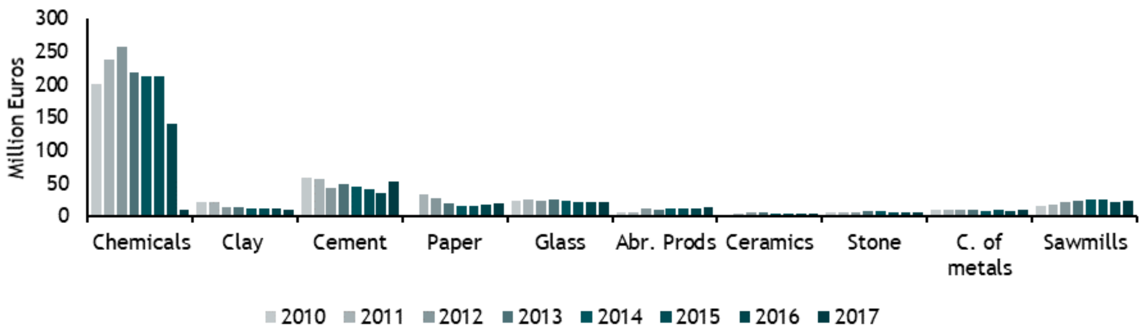
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

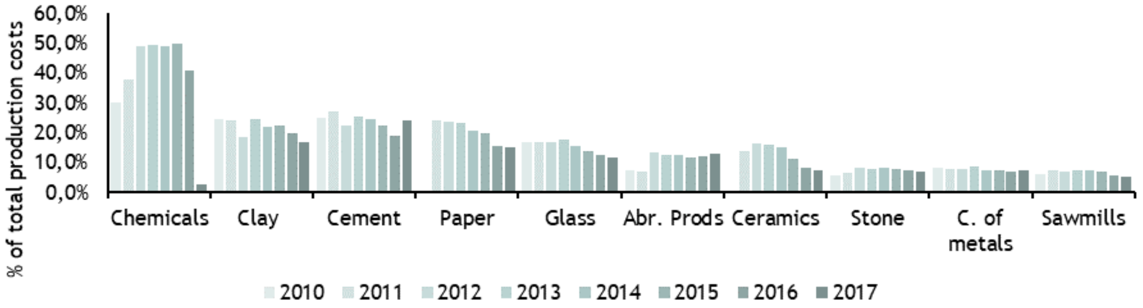
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

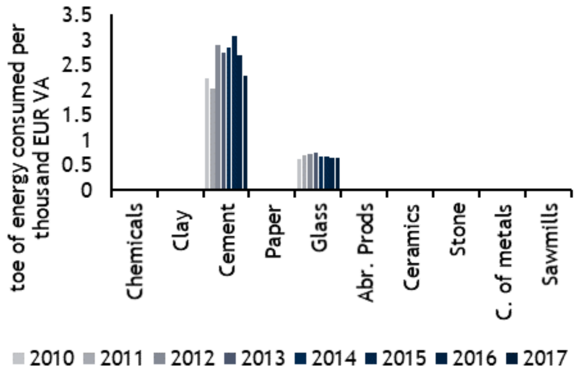


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

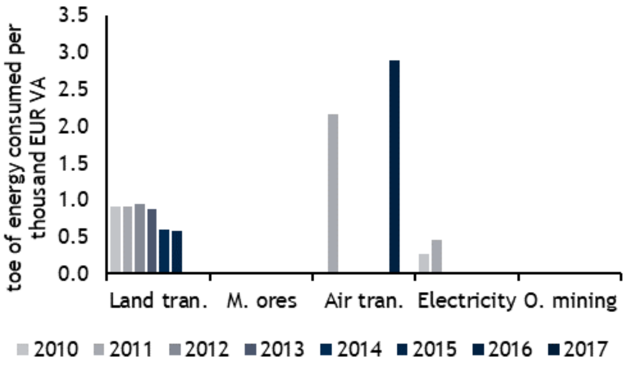
Energy intensity

Consumption of energy per value added

Manufacturing sectors



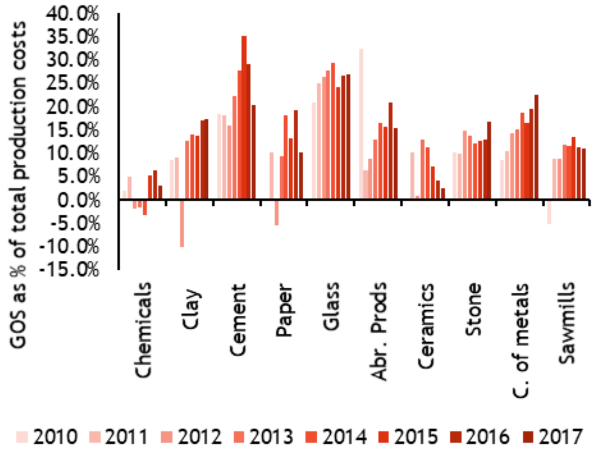
Non-manufacturing sectors



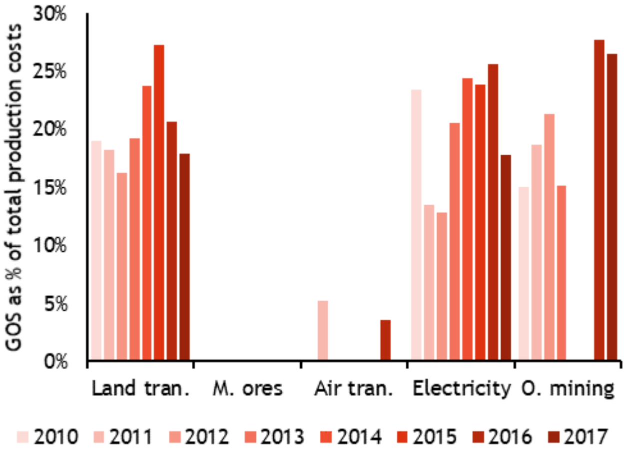
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Croatia (2/2)

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C235 - Cement, lime and plaster
3. C231 - Glass
4. C244 - Non-ferrous metals

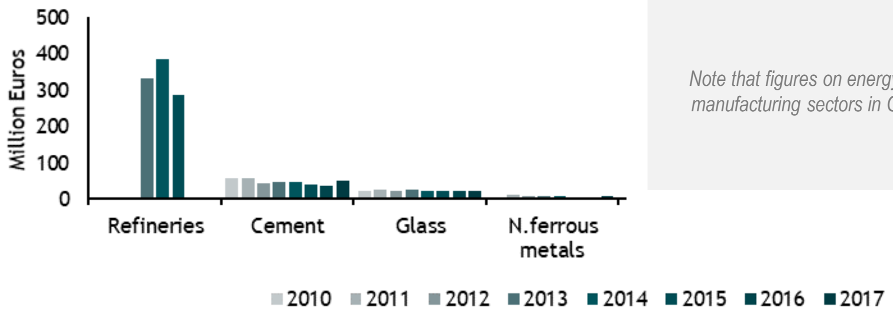
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. A - Agriculture
2. H51 - Air transport
3. G - Wholesale and retail trade

Energy cost shares

Energy costs in value

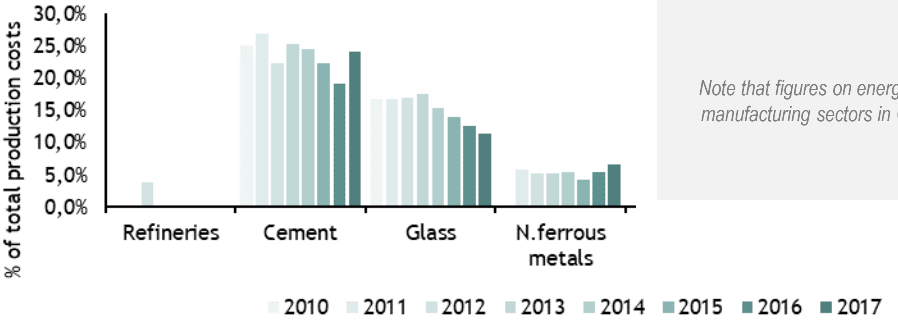
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Croatia are limited

Energy costs as a share of total production costs

Manufacturing sectors



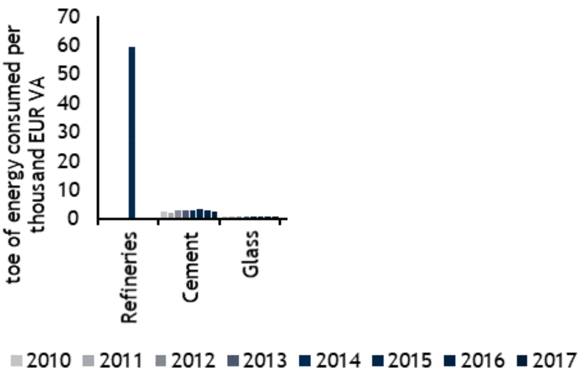
Note that figures on energy consumption for manufacturing sectors in Croatia are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

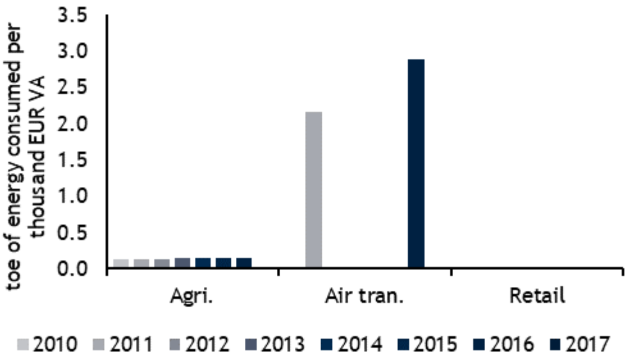
Energy intensity

Consumption of energy per value added

Manufacturing sectors



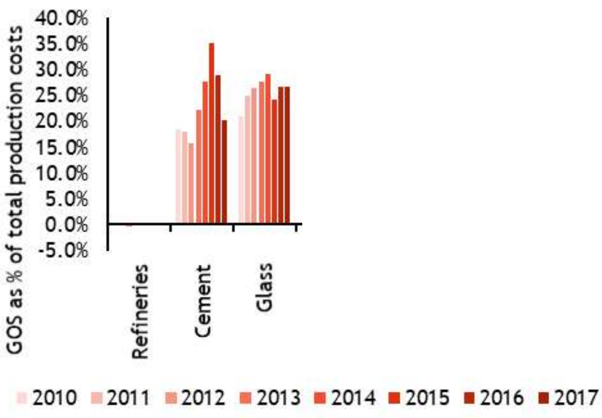
Non-manufacturing sectors



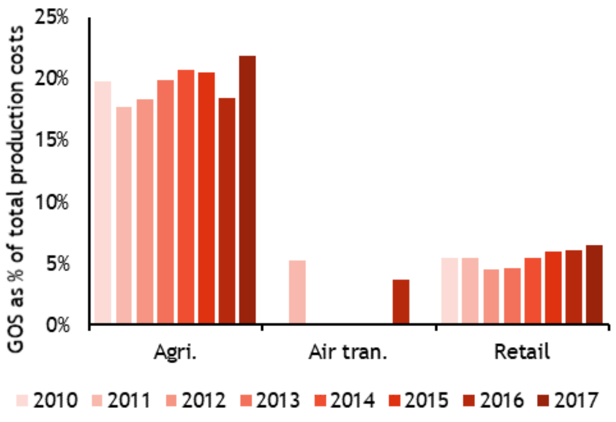
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Hungary (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C235 - Cement, lime and plaster
3. C241 - Iron and steel
4. C171 - Pulp and paper
5. C239 - Abrasive products
6. C232 - Refractory products
7. C237 - Stone
8. C106 - Grain products
9. C231 - Glass
10. C234 - Porcelain and ceramics

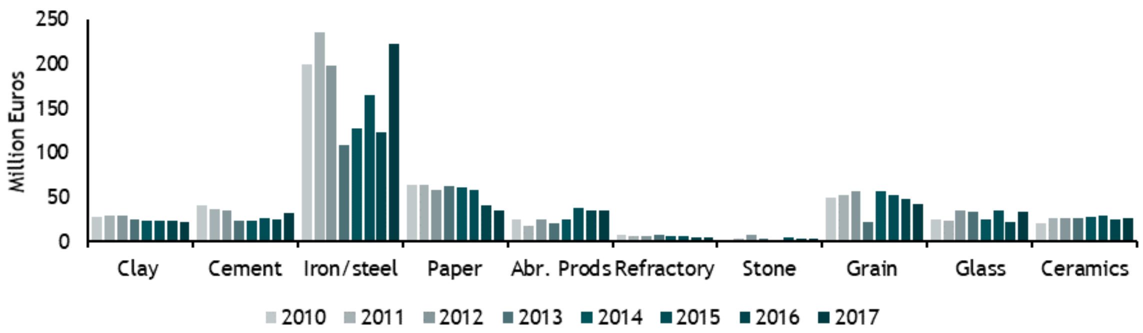
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

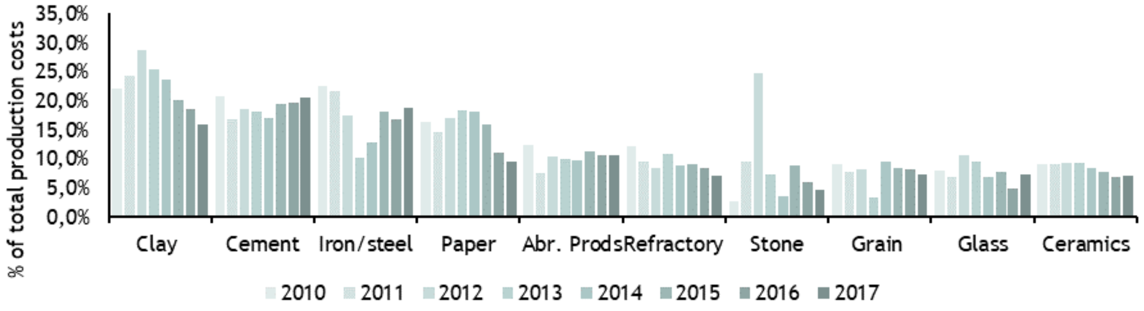
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

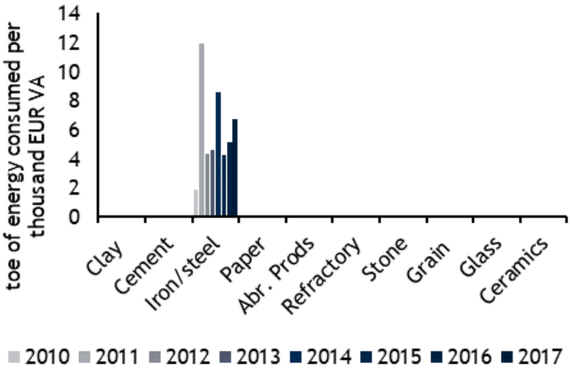


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

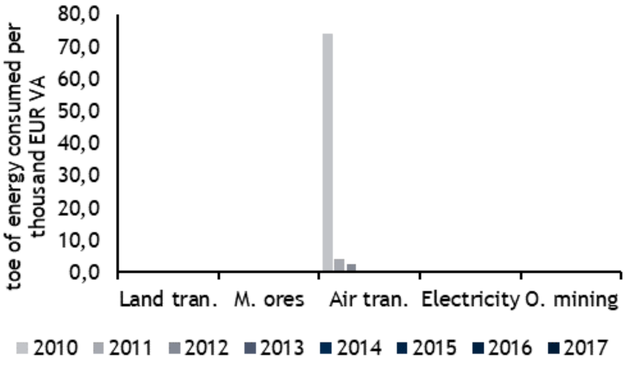
Energy intensity

Consumption of energy per value added

Manufacturing sectors



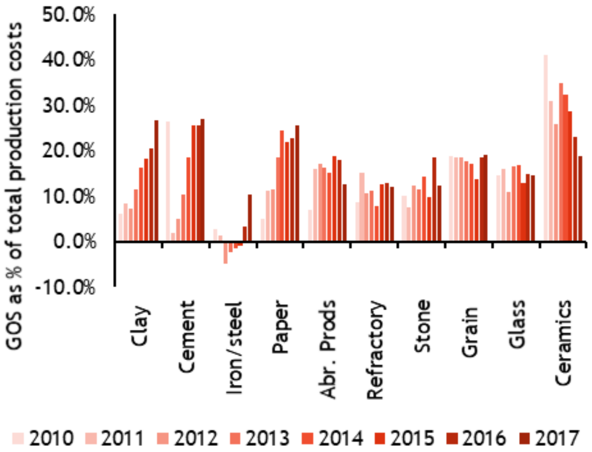
Non-manufacturing sectors



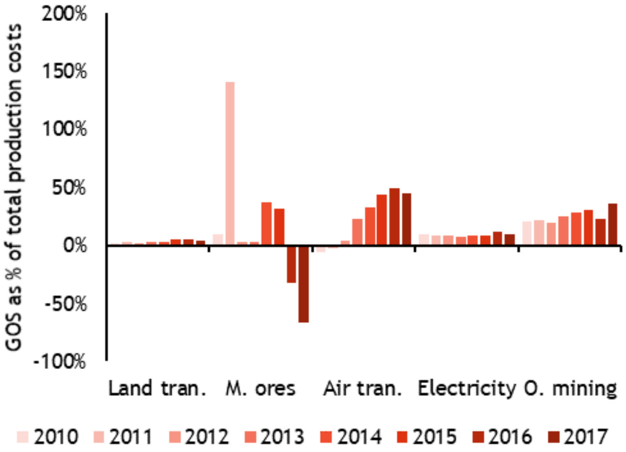
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Hungary (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C192 - Refineries
3. C244 - Non-ferrous metals

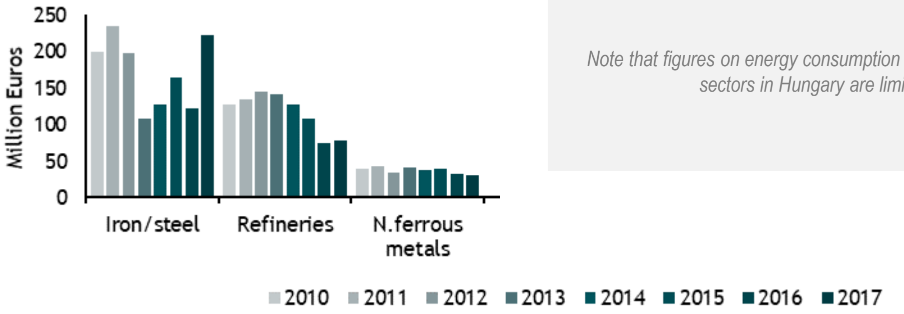
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. D35 - Electricity, gas and steam
2. A - Agriculture
3. F - Construction

Energy cost shares

Energy costs in value

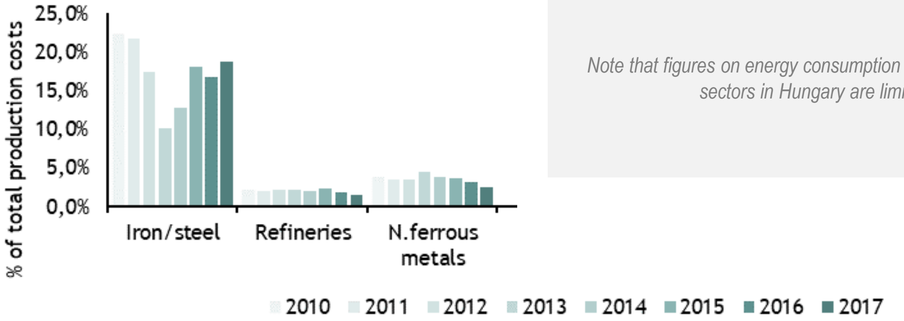
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Hungary are limited

Energy costs as a share of total production costs

Manufacturing sectors



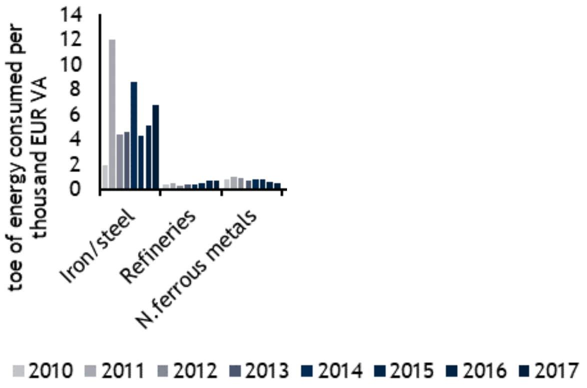
Note that figures on energy consumption for manufacturing sectors in Hungary are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

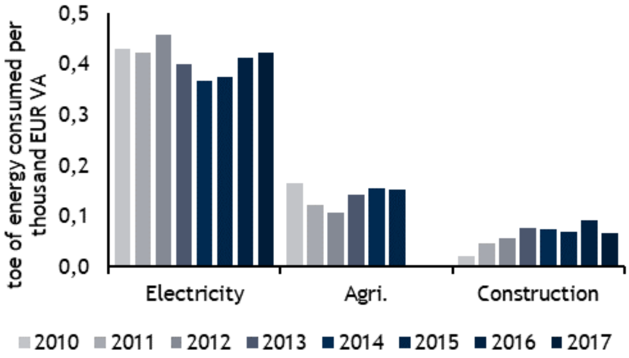
Energy intensity

Consumption of energy per value added

Manufacturing sectors



Non-manufacturing sectors

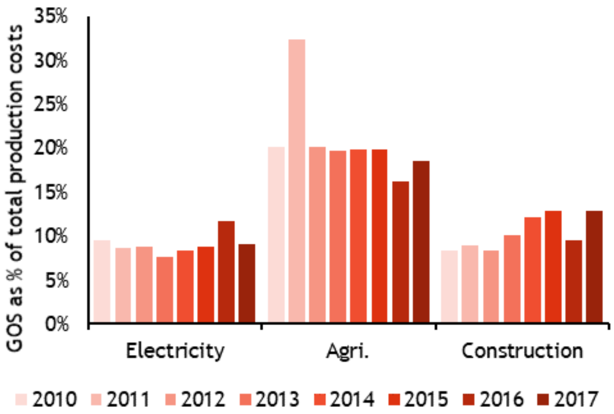


Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Ireland (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C244 - Non-ferrous metals
2. C239 - Abrasive products
3. C132 - Textiles
4. C231 - Glass
5. C233 - Clay building materials
6. C222 - Plastics products
7. C171 - Pulp and paper
8. C161 - Sawmills
9. C237 - Stone
10. C103 - Fruit and vegetables

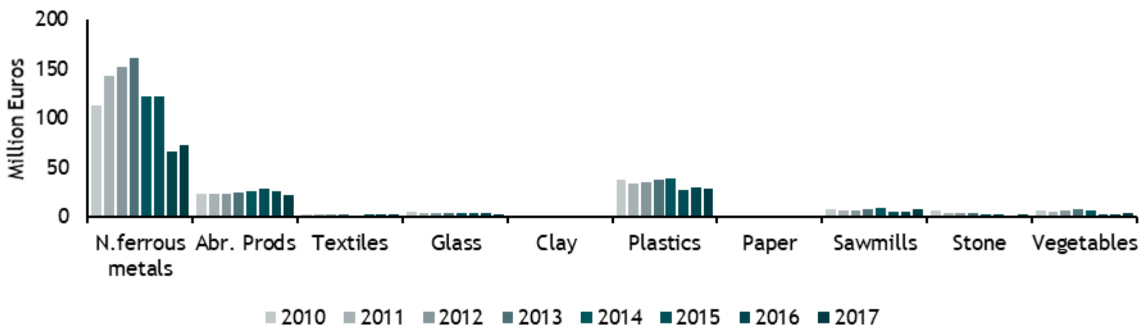
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

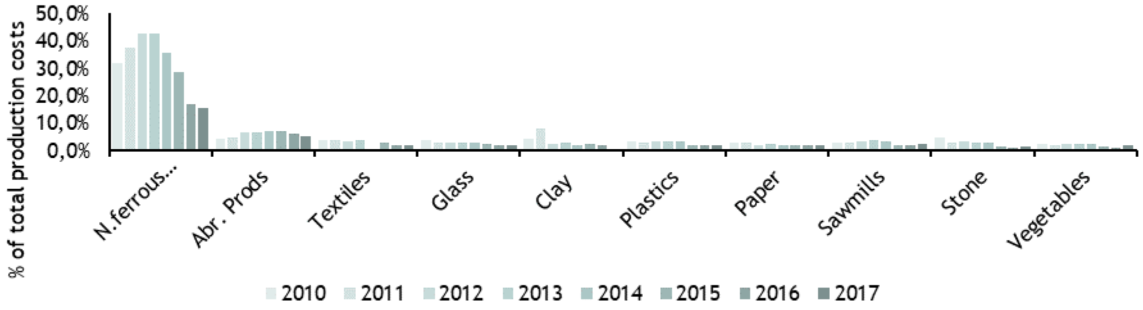
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors



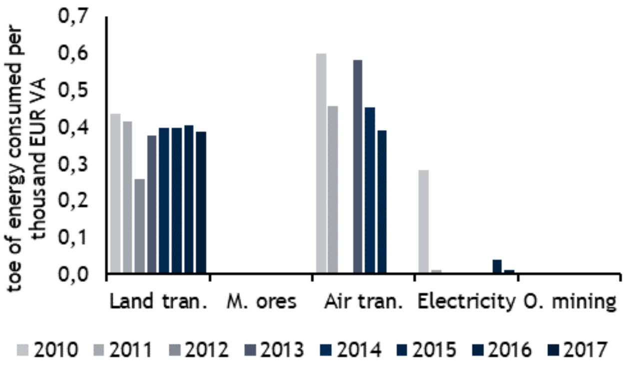
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Ireland are limited

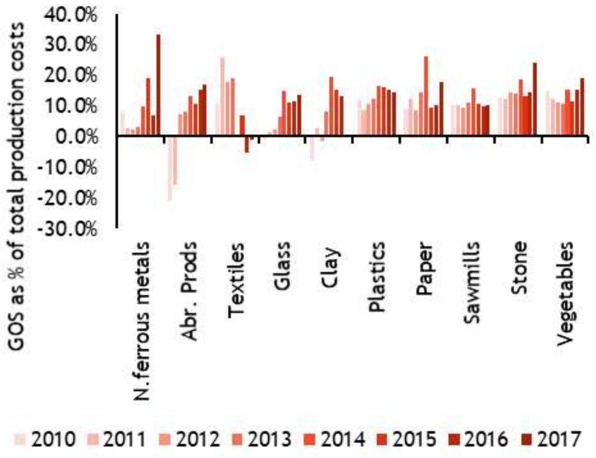
Non-manufacturing sectors



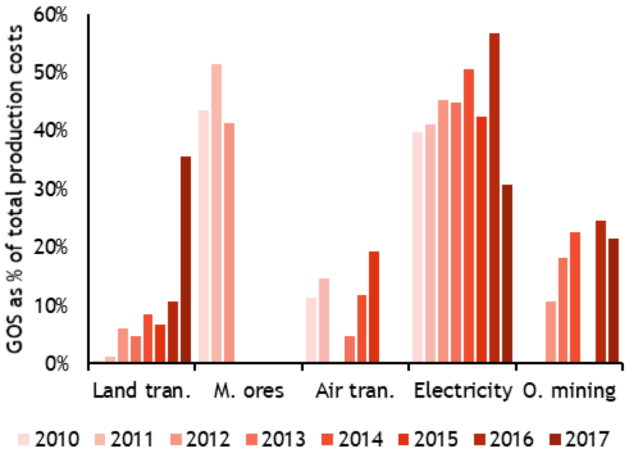
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Ireland (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C192 - Refineries

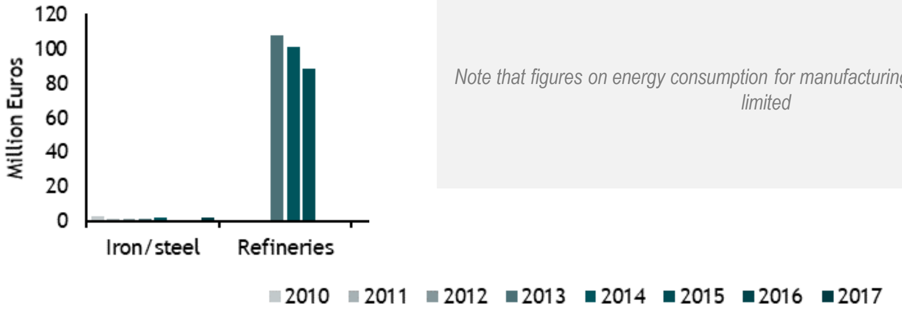
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H49 - Land transport
2. H51 - Air transport
3. A - Agriculture

Energy cost shares

Energy costs in value

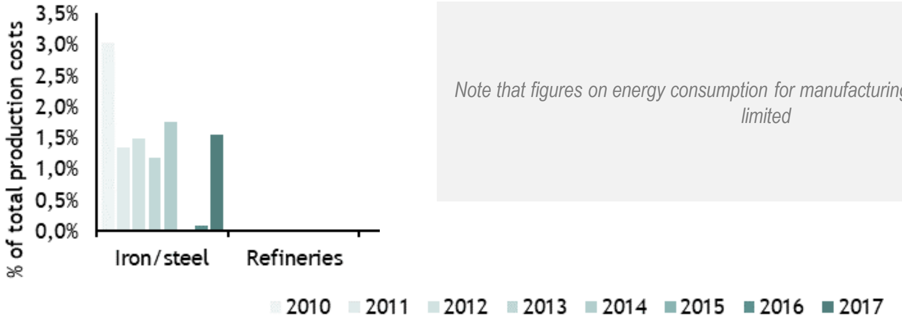
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Ireland are limited

Energy costs as a share of total production costs

Manufacturing sectors



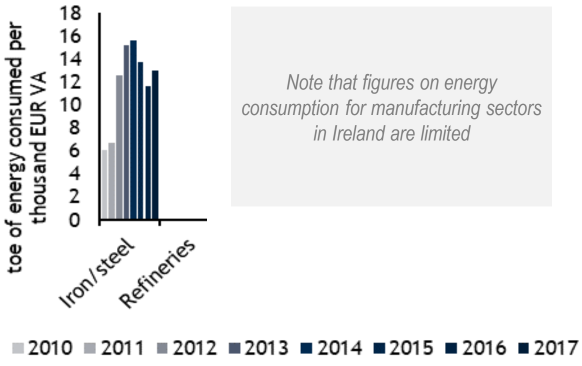
Note that figures on energy consumption for manufacturing sectors in Ireland are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

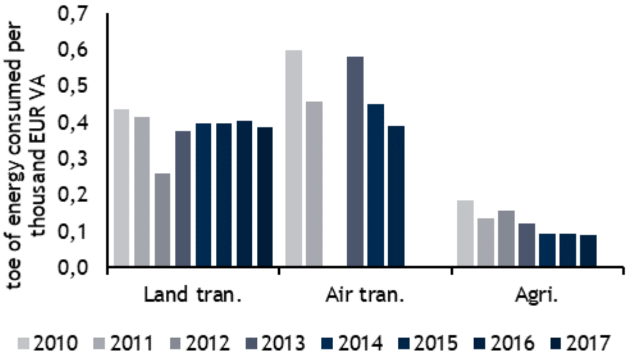
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Ireland are limited

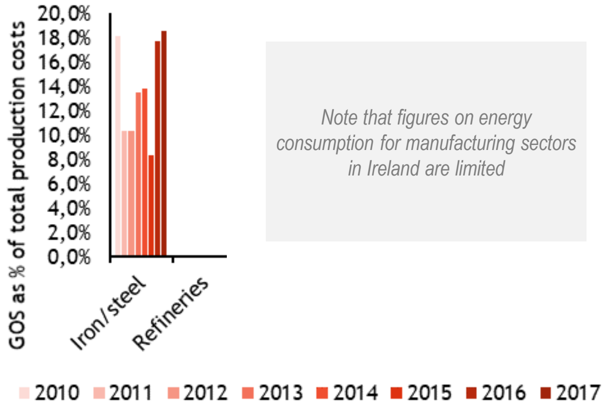
Non-manufacturing sectors



Profitability

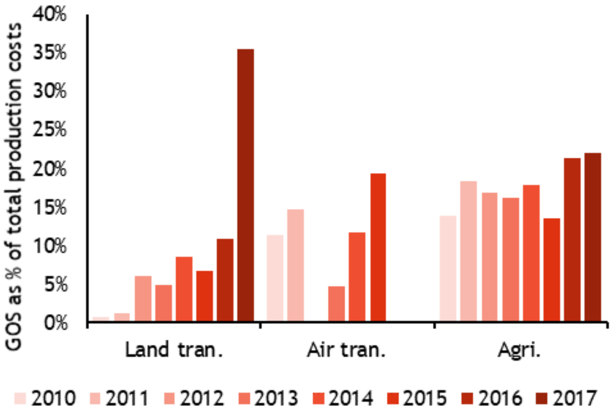
Gross operating surplus as a share of production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Ireland are limited

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Italy (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C171 - Pulp and paper
3. C233 - Clay building materials
4. C232 - Refractory products
5. C231 - Glass
6. C201 - Basic chemicals
7. C241 - Iron and steel
8. C239 - Abrasive products
9. C237 - Stone
10. C234 - Porcelain and ceramics

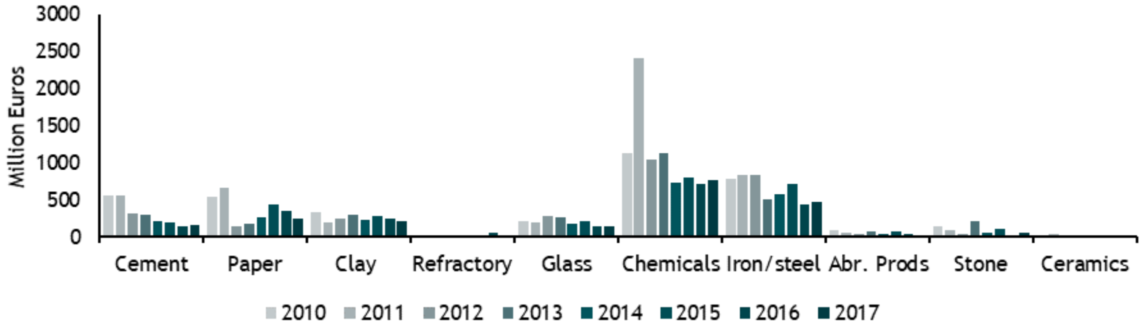
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

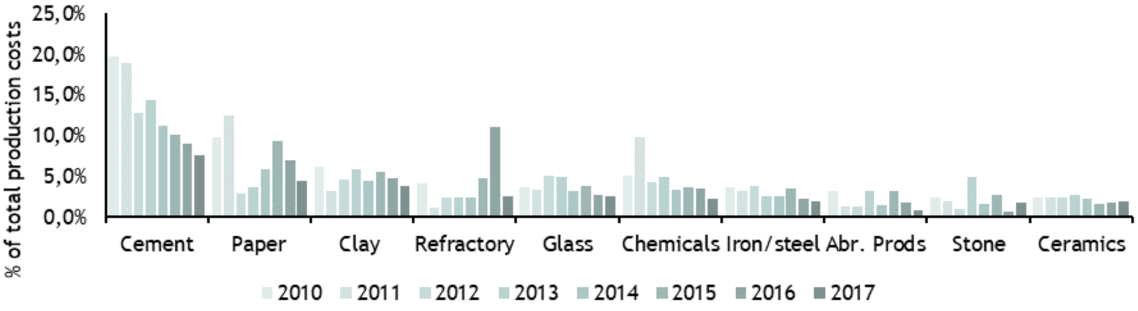
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

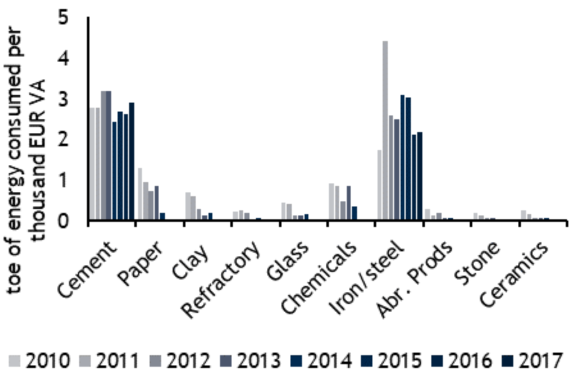


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

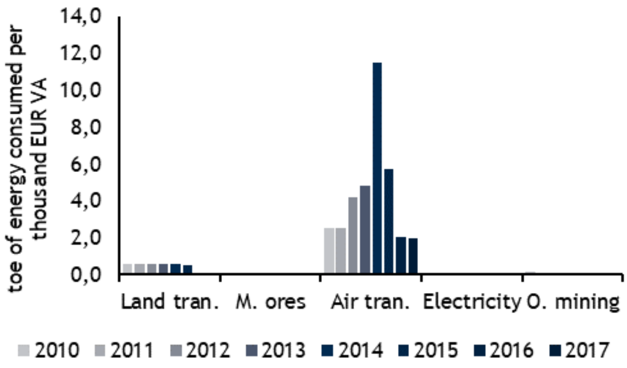
Energy intensity

Consumption of energy per value added

Manufacturing sectors



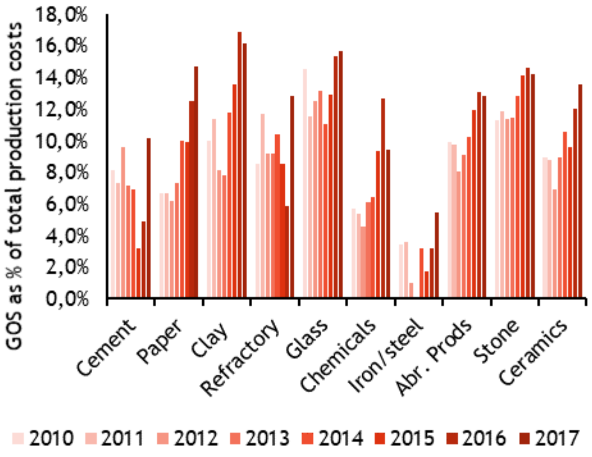
Non-manufacturing sectors



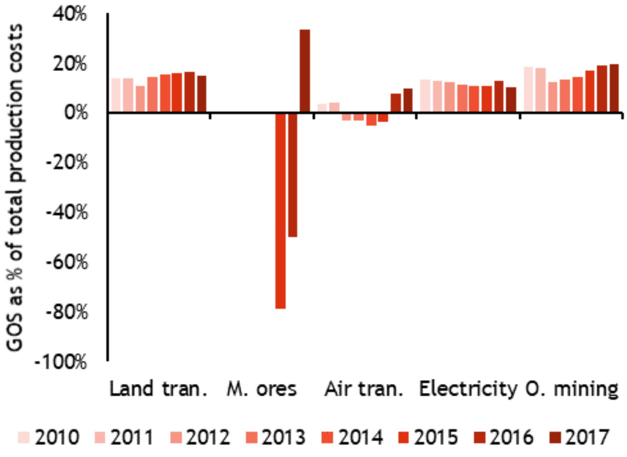
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Italy (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C192 - Refineries
3. C201 - Basic chemicals
4. C25 - Fabricated metal products
5. C244 - Non-ferrous metals
6. C233 - Clay building materials
7. C171 - Pulp and paper
8. C28 - Machinery and equipment

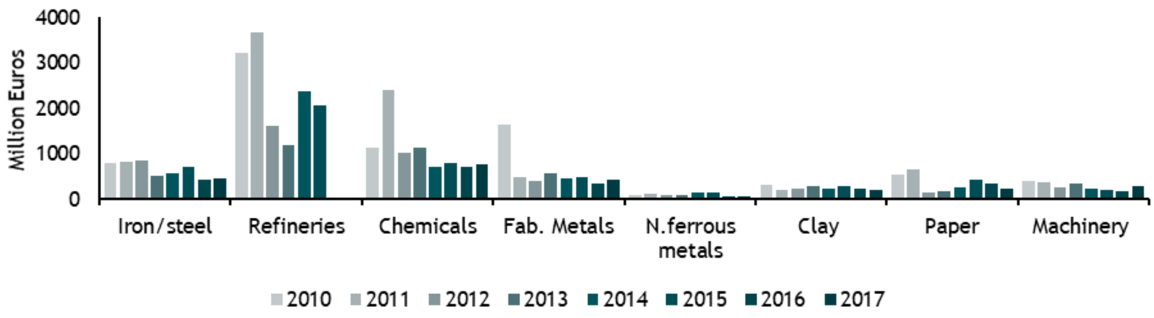
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. A - Agriculture
3. G - Wholesale and retail trade

Energy cost shares

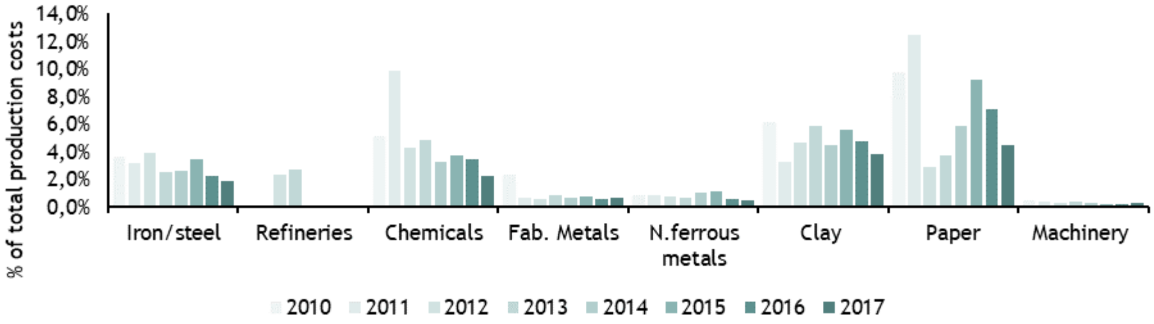
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

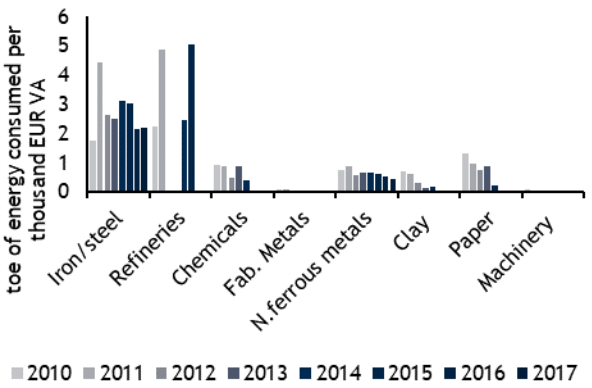


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

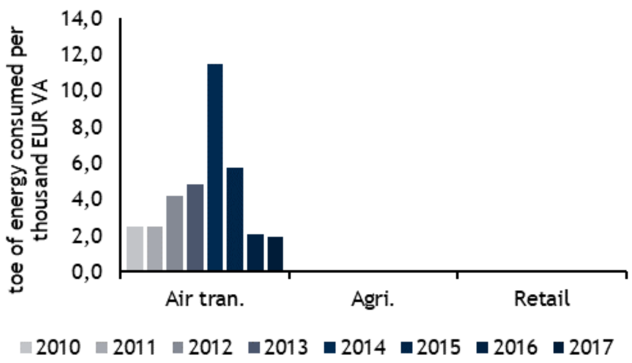
Energy intensity

Consumption of energy per value added

Manufacturing sectors



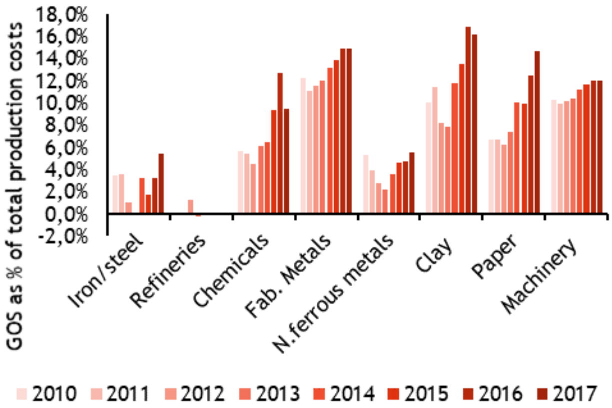
Non-manufacturing sectors



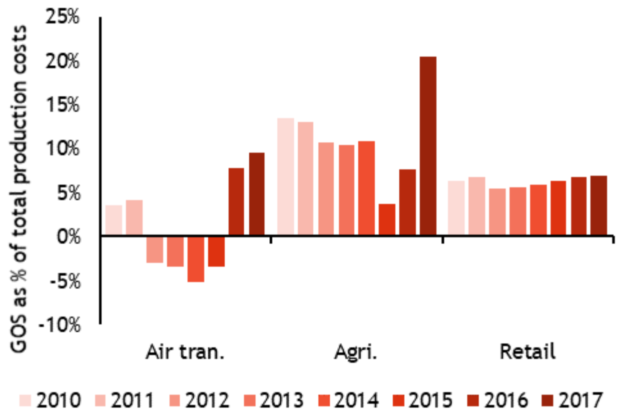
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Lithuania (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C171 - Pulp and paper
3. C106 - Grain products
4. C132 - Textiles
5. C231 - Glass
6. C245 - Casting of metal
7. C161 - Sawmills
8. C239 - Abrasive products
9. C237 - Stone
10. C234 - Porcelain and ceramics

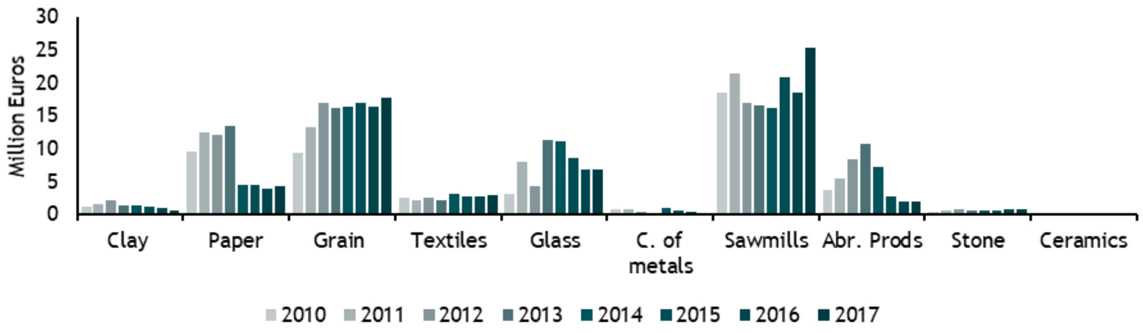
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

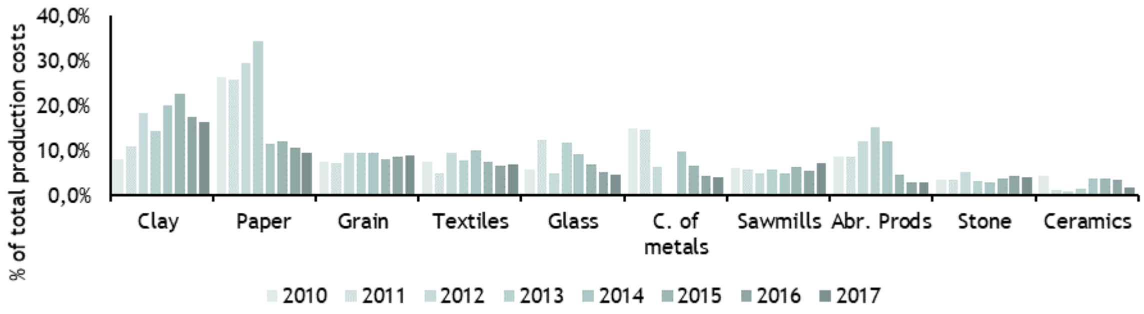
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors



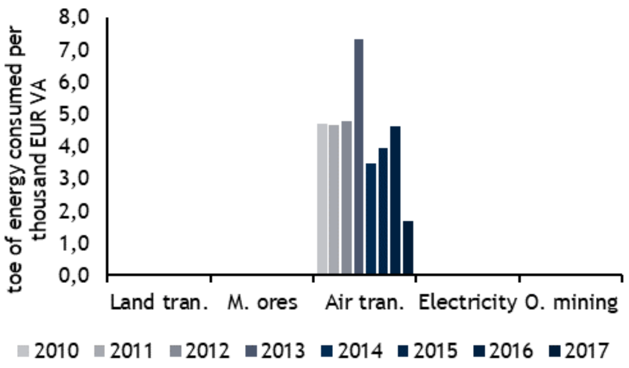
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Lithuania are limited

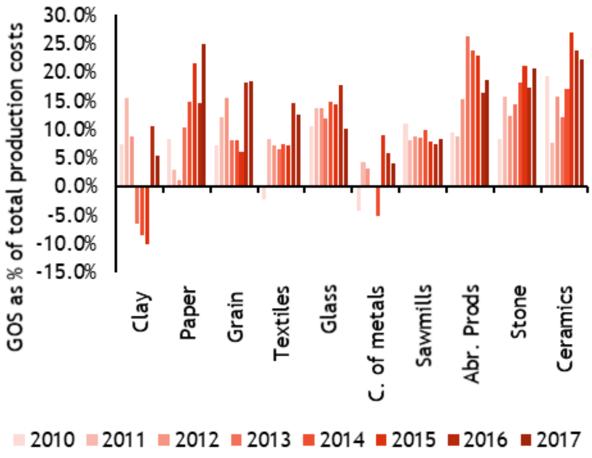
Non-manufacturing sectors



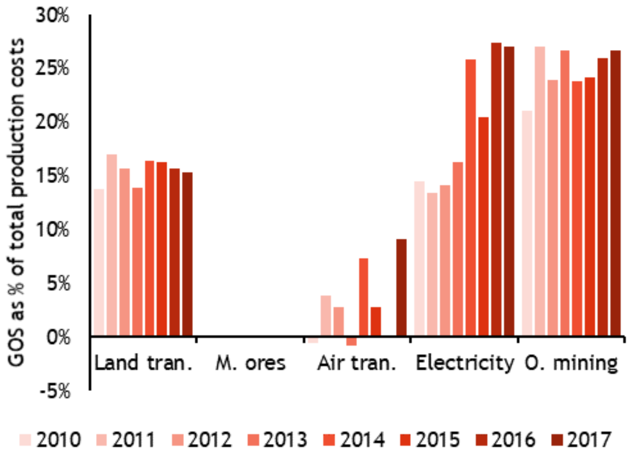
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Lithuania (2/2)

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C241 - Iron and steel
3. C244 - Non-ferrous metals

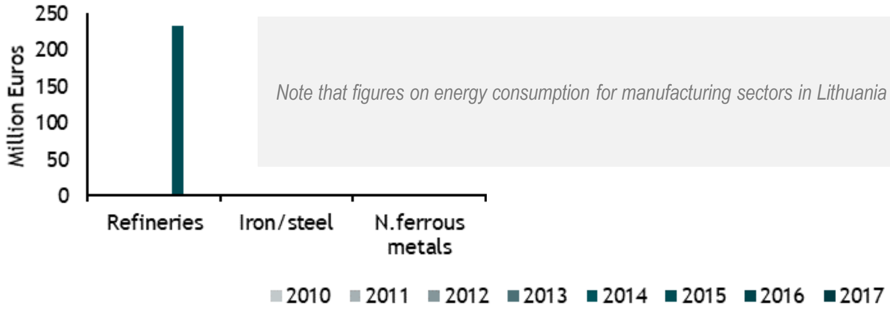
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. A - Agriculture
2. H51 - Air transport

Energy cost shares

Energy costs in value

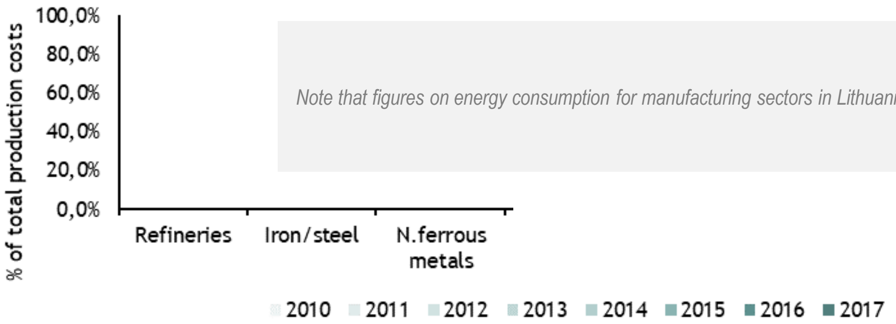
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Lithuania are limited

Energy costs as a share of total production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Lithuania are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

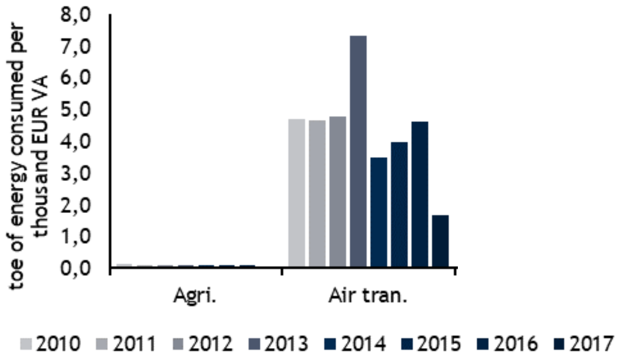
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Lithuania are limited

Non-manufacturing sectors



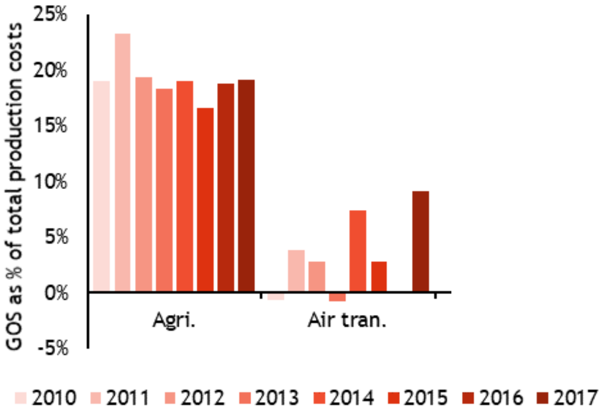
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors

Note that figures on GOS for manufacturing sectors in Lithuania are limited

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Luxembourg (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C27 - Electrical equipment
2. C222 - Plastics products
3. C32 - Other manufacturing
4. C33 - Repair of machinery
5. C237 - Stone
6. C11 - Beverages
7. C25 - Fabricated metal products
8. C28 - Machinery and equipment

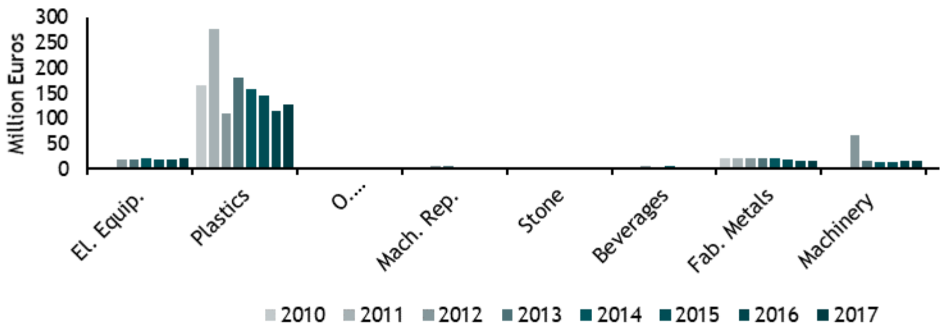
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

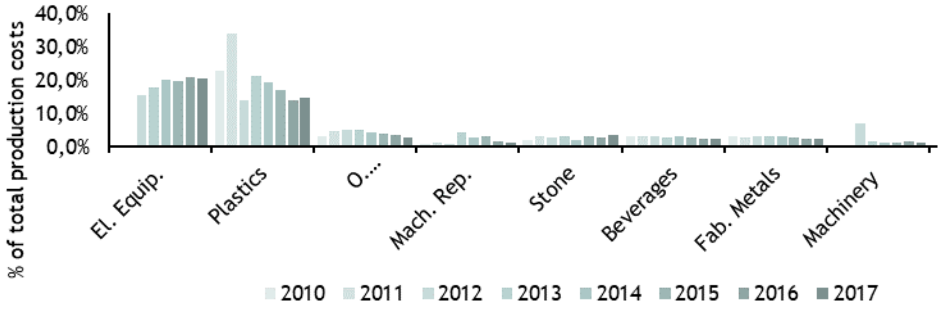
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors



Energy intensity

Consumption of energy per value added

Manufacturing sectors

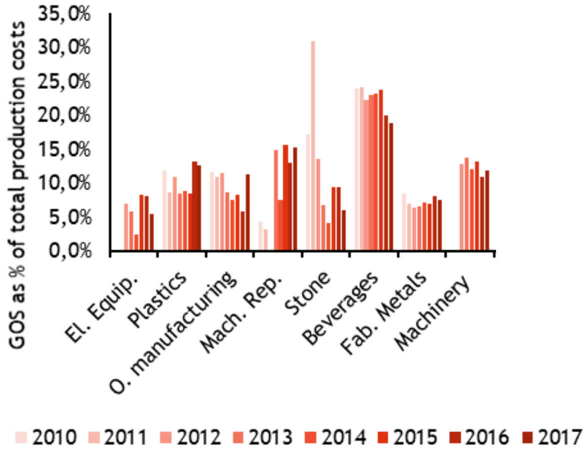
Non-manufacturing sectors

Note that figures on energy consumption for sectors in Luxembourg are limited

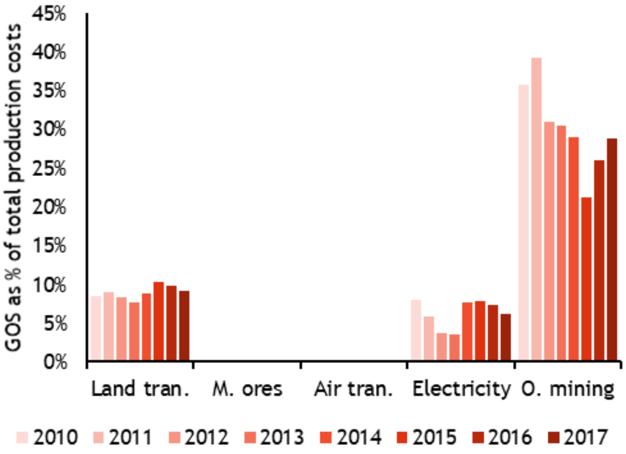
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Luxembourg (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel

Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. G - Wholesale and retail trade

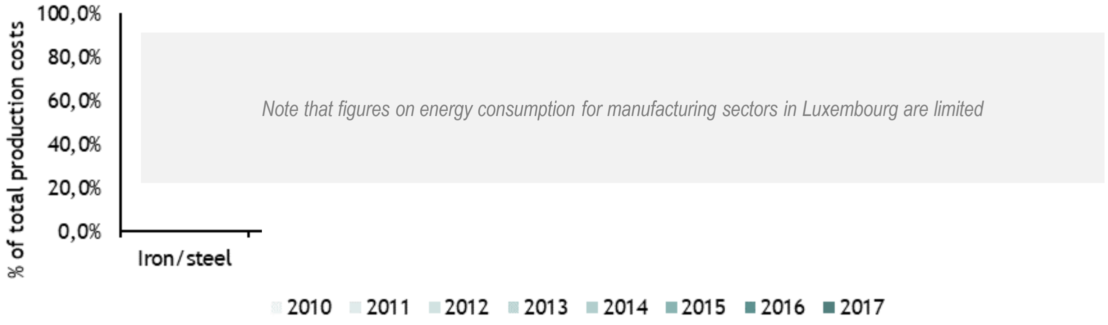
Energy cost shares

Energy costs in value

Manufacturing sectors

Energy costs as a share of total production costs

Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

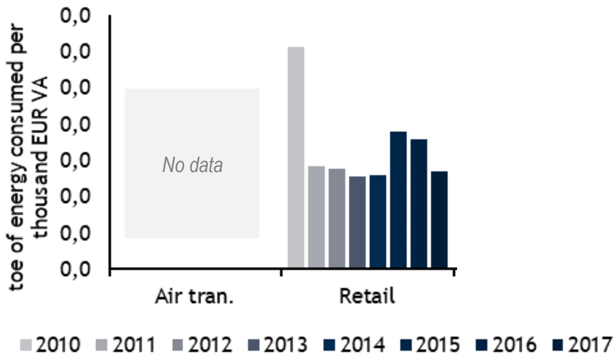
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Luxembourg are limited

Non-manufacturing sectors



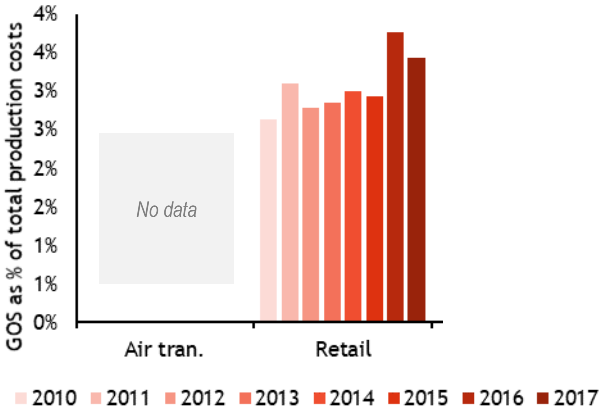
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors

Note that figures on GOS for manufacturing sectors in Luxembourg are limited

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Latvia (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C32 - Other manufacturing
2. C231 - Glass
3. C201 - Basic chemicals
4. C30 - Other transport equipment
5. C237 - Stone
6. C244 - Non-ferrous metals
7. C234 - Porcelain and ceramics
8. C161 - Sawmills
9. C103 - Fruit and vegetables
10. C222 - Plastics products

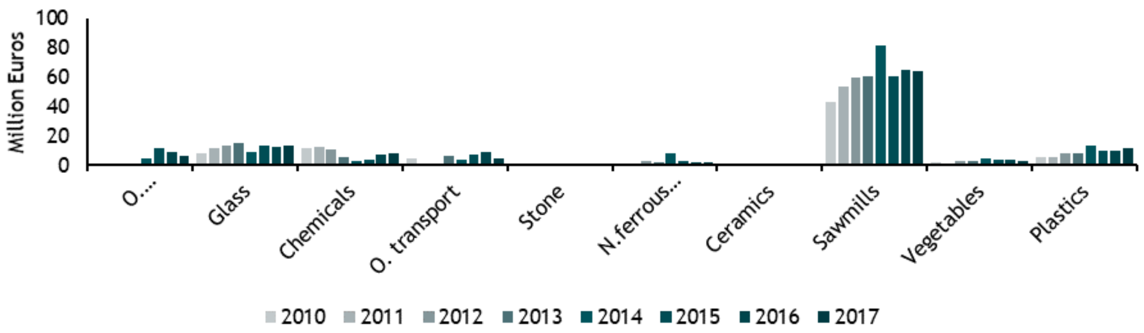
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

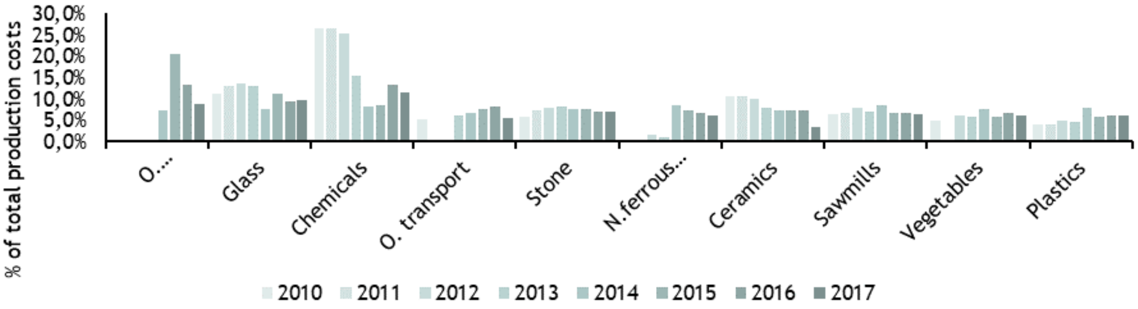
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

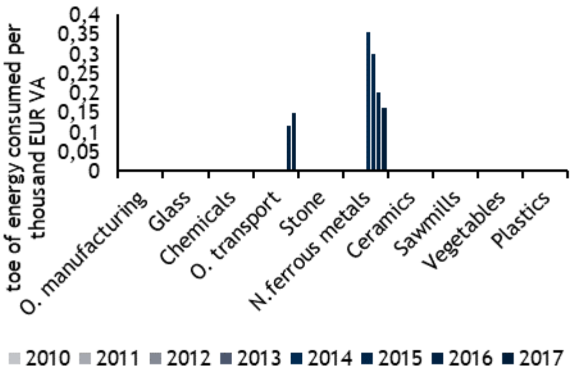


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

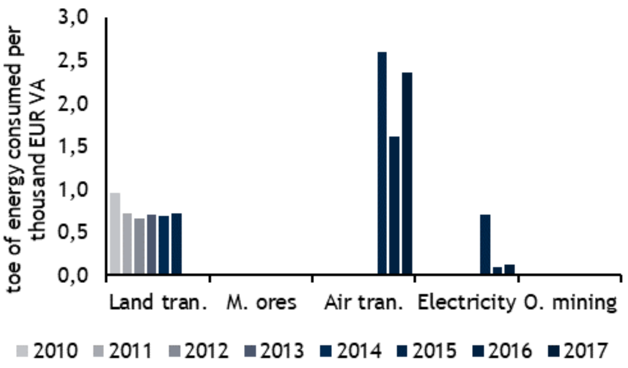
Energy intensity

Consumption of energy per value added

Manufacturing sectors



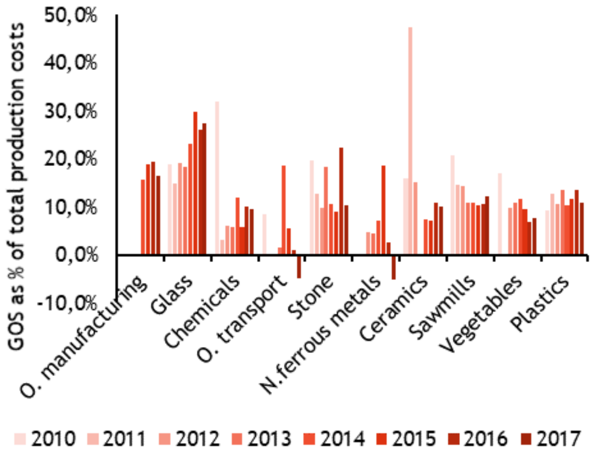
Non-manufacturing sectors



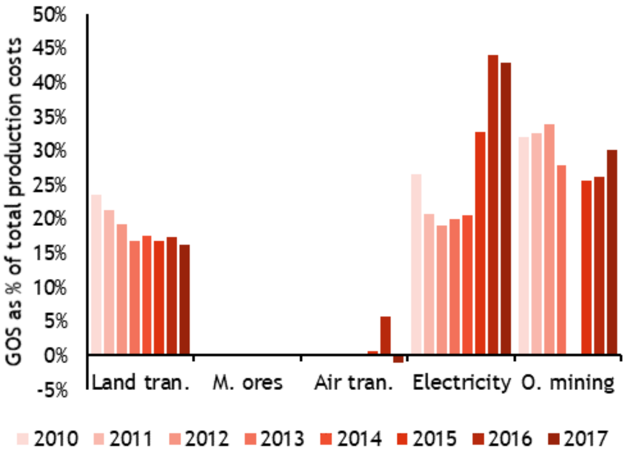
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Latvia (2/2)

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C25 - Fabricated metal products
3. C21 - Pharmaceutical products
4. C28 - Machinery and equipment
5. C30 - Other transport equipment
6. C27 - Electrical equipment
7. C244 - Non-ferrous metals
8. C29 - Motor vehicles

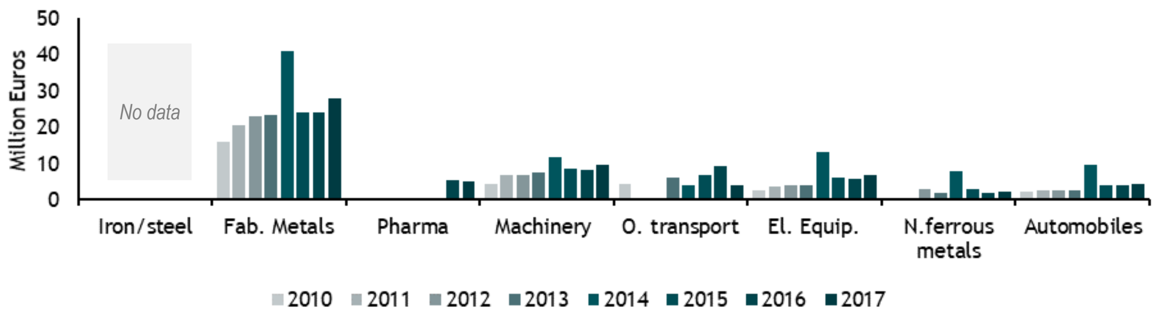
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. A - Agriculture
2. H51 - Air transport
3. D35 - Electricity, gas and steam

Energy cost shares

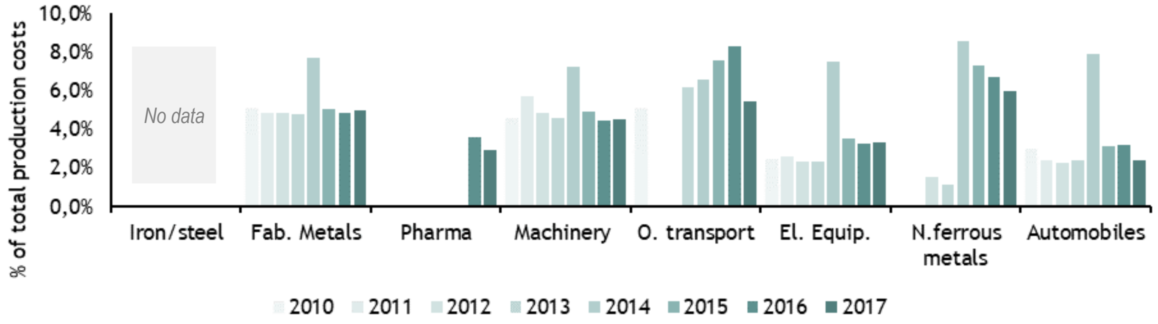
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

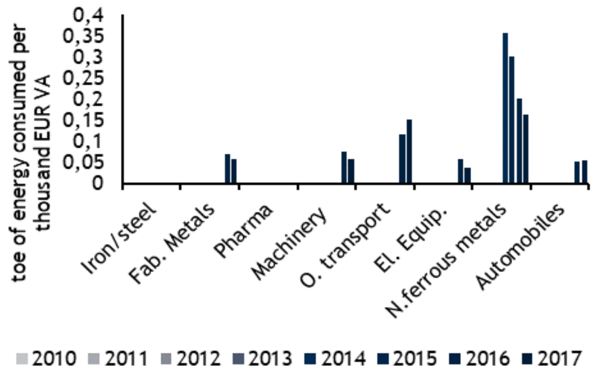


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

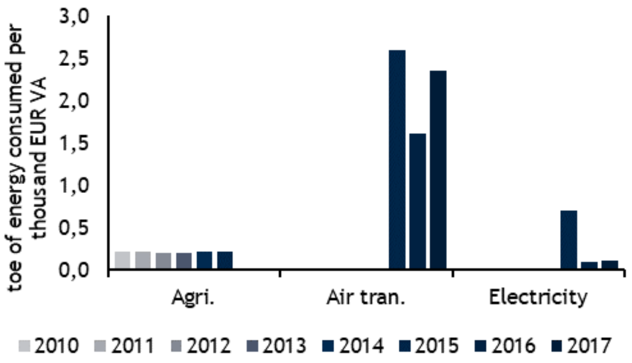
Energy intensity

Consumption of energy per value added

Manufacturing sectors



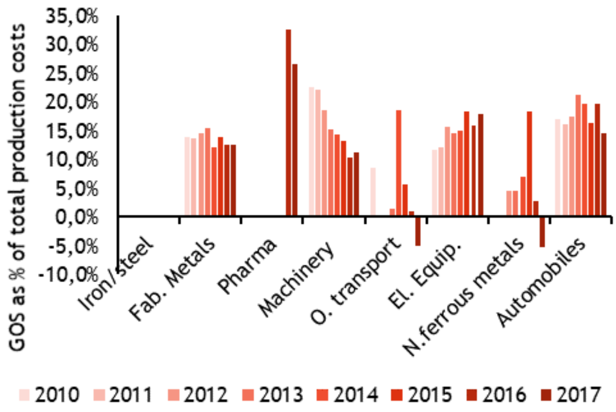
Non-manufacturing sectors



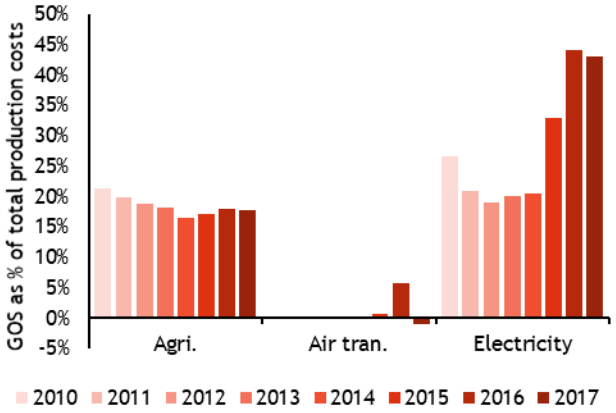
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Malta (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

Note that figures on manufacturing sectors for Malta are not available

Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

Manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Energy intensity

Consumption of energy per value added

Manufacturing sectors

Non-manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors

Non-manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Cost dynamics of energy intensive industries in Malta (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C132 - Textiles

Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. I - Accommodation and restaurants

Energy cost shares

Energy costs in value

Manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Energy costs as a share of total production costs

Manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

Consumption of energy per value added

Manufacturing sectors

Non-manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors

Non-manufacturing sectors

Note that figures on manufacturing and non-manufacturing sectors for Malta are not available

Cost dynamics of energy intensive industries in the Netherlands (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C231 - Glass
3. C171 - Pulp and paper
4. C201 - Basic chemicals
5. C106 - Grain products
6. C206 - Man-made fibres
7. C244 - Non-ferrous metals
8. C245 - Casting of metal
9. C239 - Abrasive products
10. C103 - Fruit and vegetables

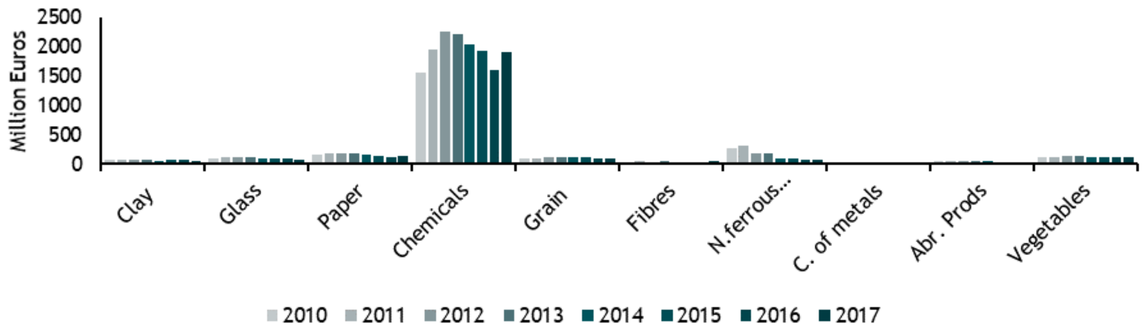
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

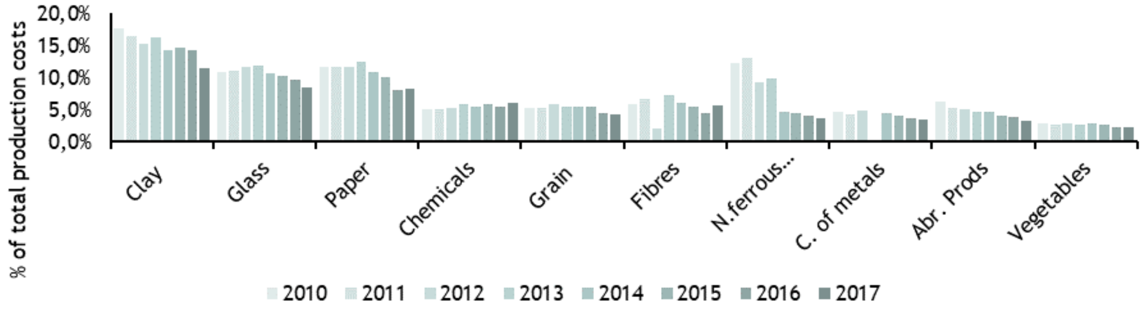
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

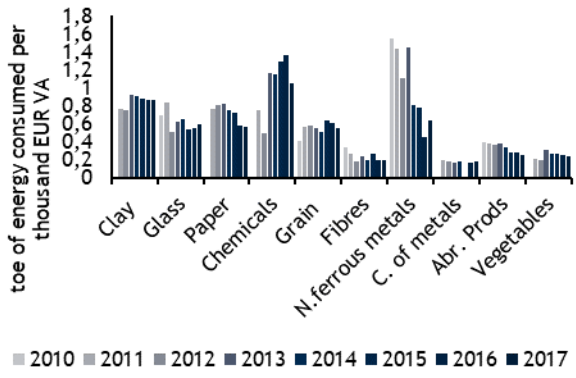


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

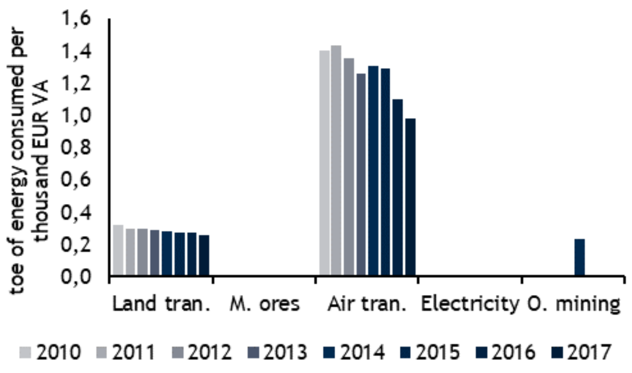
Energy intensity

Consumption of energy per value added

Manufacturing sectors



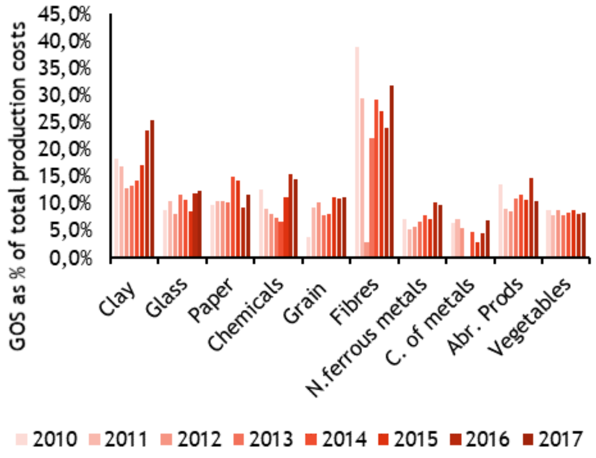
Non-manufacturing sectors



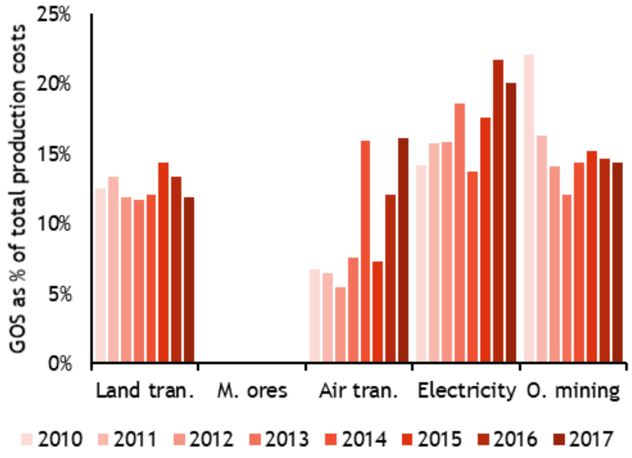
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in the Netherlands (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C201 - Basic chemicals
2. C192 - Refineries
3. C241 - Iron and steel
4. C171 - Pulp and paper
5. C231 - Glass
6. C25 - Fabricated metal products
7. C103 - Fruit and vegetables
8. C106 - Grain products

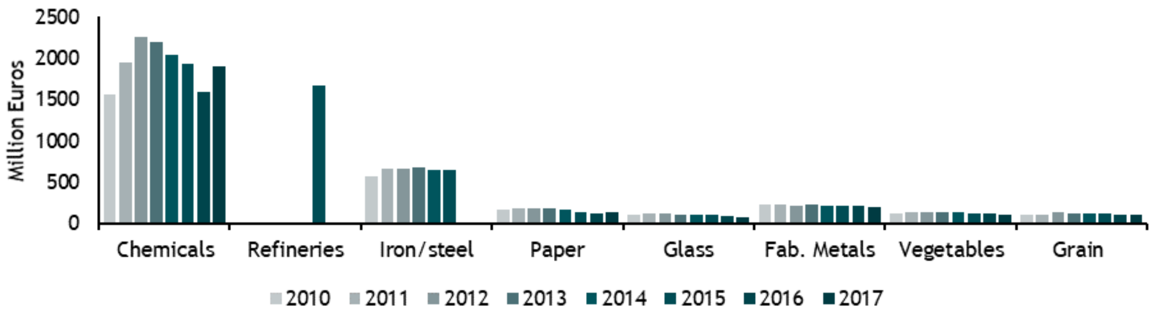
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. A - Agriculture
2. H51 - Air transport
3. H49 - Land transport

Energy cost shares

Energy costs in value

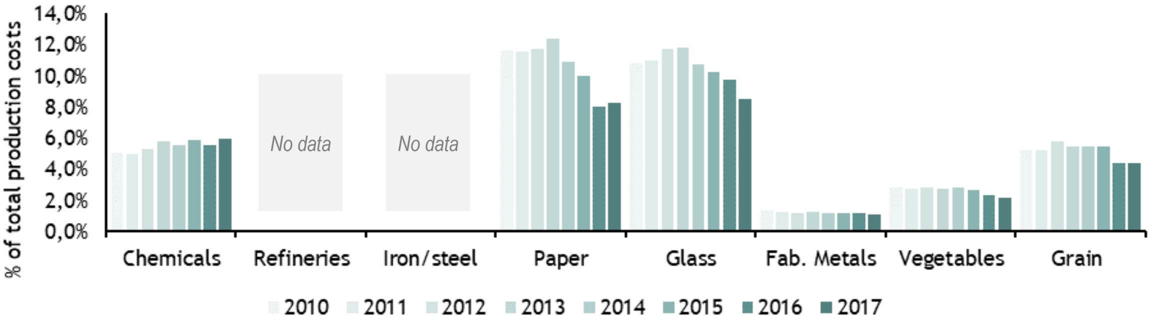
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

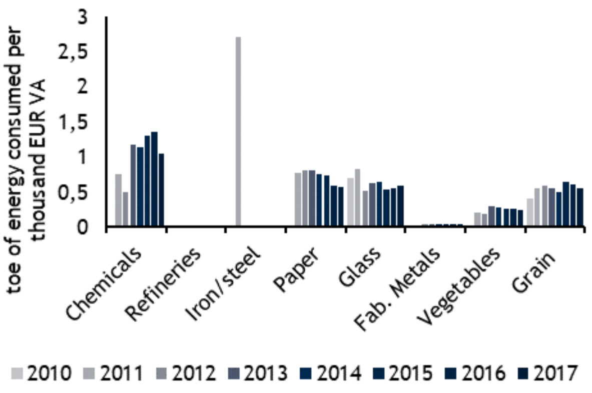
Manufacturing sectors



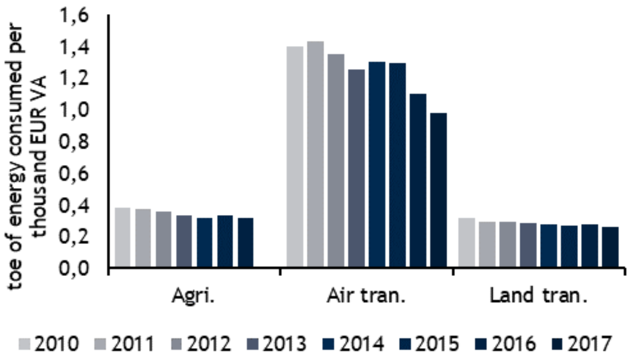
Energy intensity

Consumption of energy per value added

Manufacturing sectors



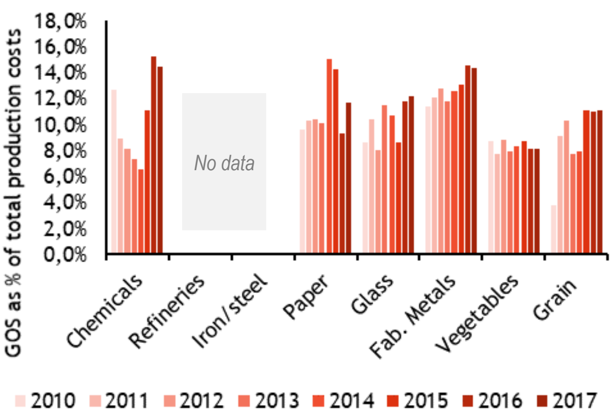
Non-manufacturing sectors



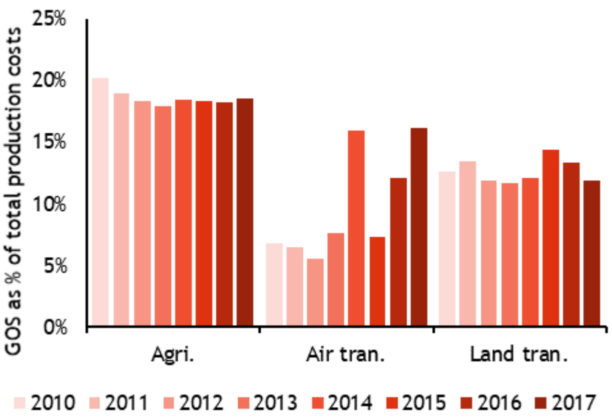
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Poland (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C233 - Clay building materials
3. C206 - Man-made fibres
4. C231 - Glass
5. C241 - Iron and steel
6. C245 - Casting of metal
7. C201 - Basic chemicals
8. C239 - Abrasive products
9. C234 - Porcelain and ceramics
10. C232 - Refractory products

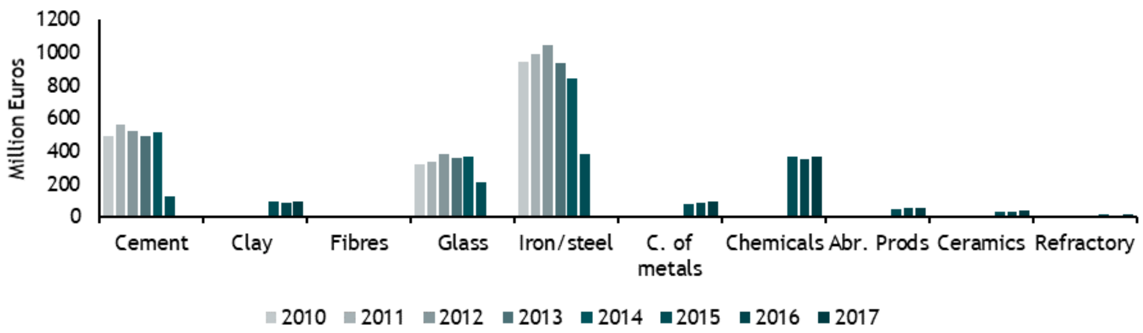
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

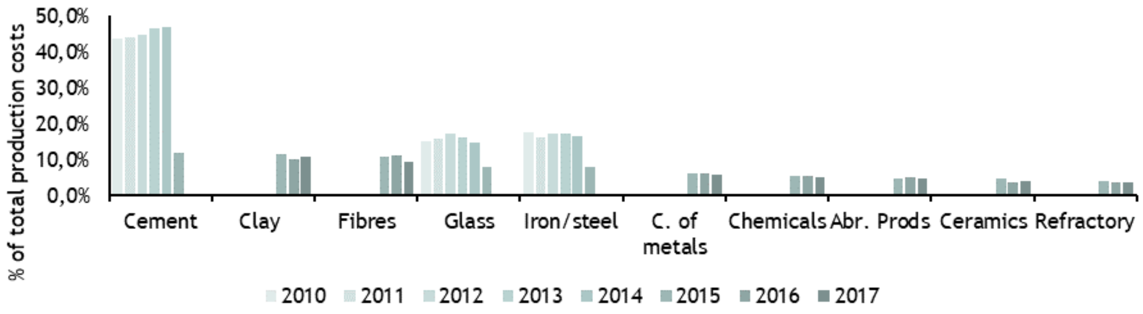
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

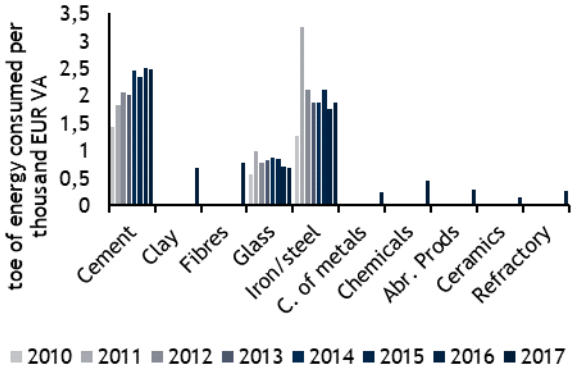
Manufacturing sectors



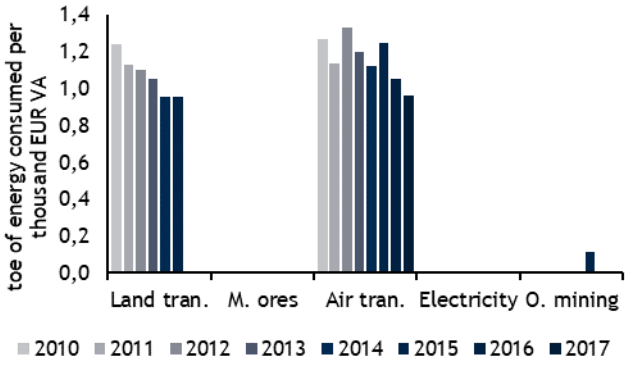
Energy intensity

Consumption of energy per value added

Manufacturing sectors



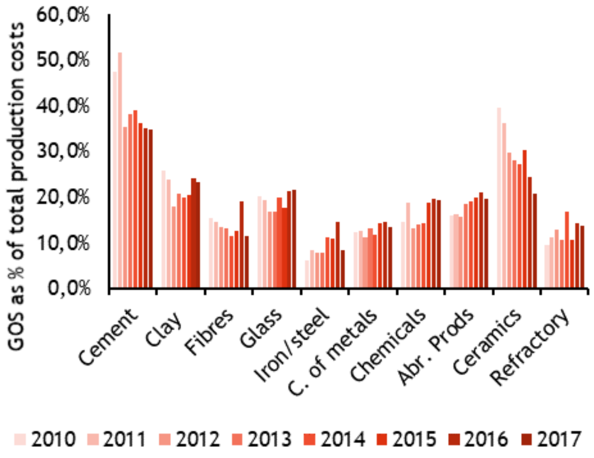
Non-manufacturing sectors



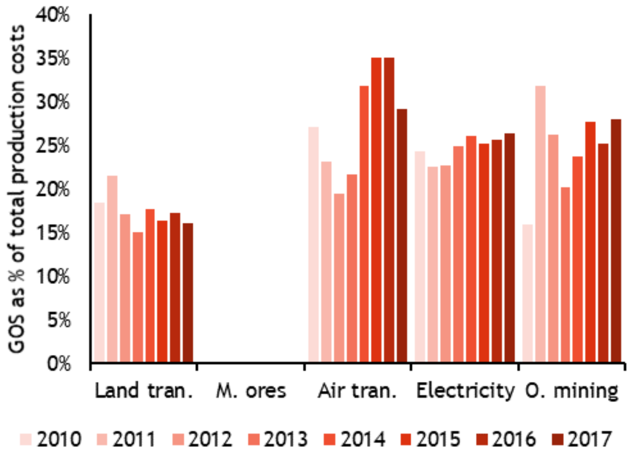
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Poland (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C241 - Iron and steel
3. C235 - Cement, lime and plaster
4. C231 - Glass
5. C244 - Non-ferrous metals
6. C222 - Plastics products
7. C29 - Motor vehicles
8. C25 - Fabricated metal products

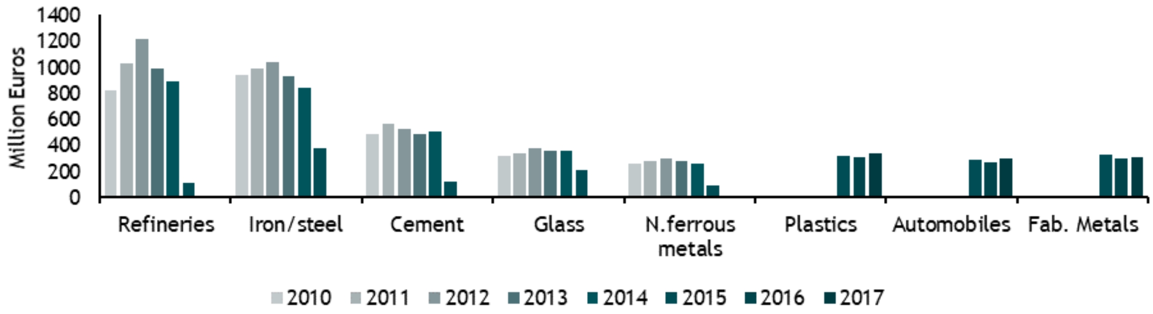
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. A - Agriculture
2. H51 - Air transport

Energy cost shares

Energy costs in value

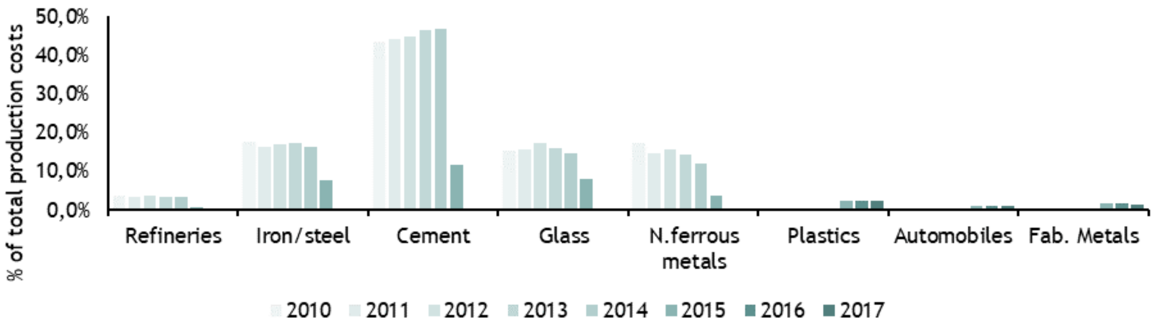
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

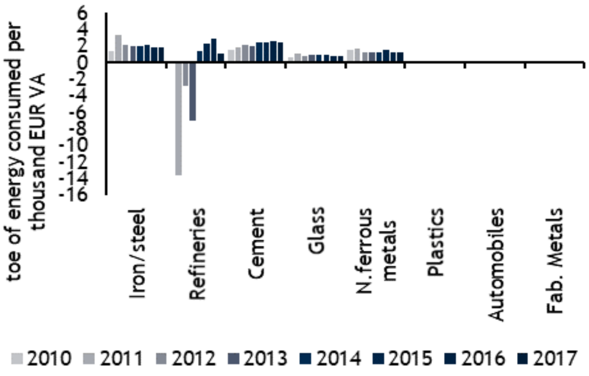
Manufacturing sectors



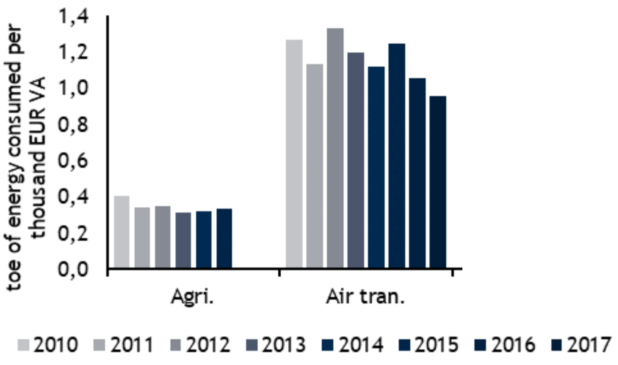
Energy intensity

Consumption of energy per value added

Manufacturing sectors



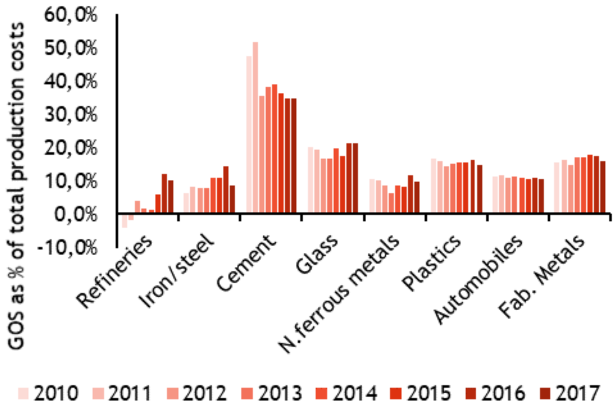
Non-manufacturing sectors



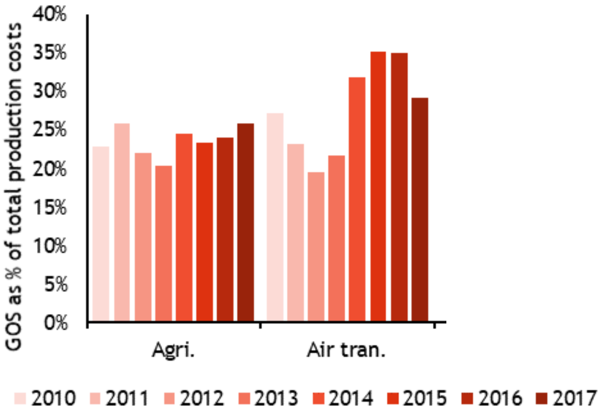
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Portugal (1/2)

Key – Top manufacturing sectors in terms of energy cost shares

1. C233 - Clay building materials
2. C235 - Cement, lime and plaster
3. C231 - Glass
4. C232 - Refractory products
5. C234 - Porcelain and ceramics
6. C171 - Pulp and paper
7. C239 - Abrasive products
8. C245 - Casting of metal
9. C161 - Sawmills
10. C201 - Basic chemicals

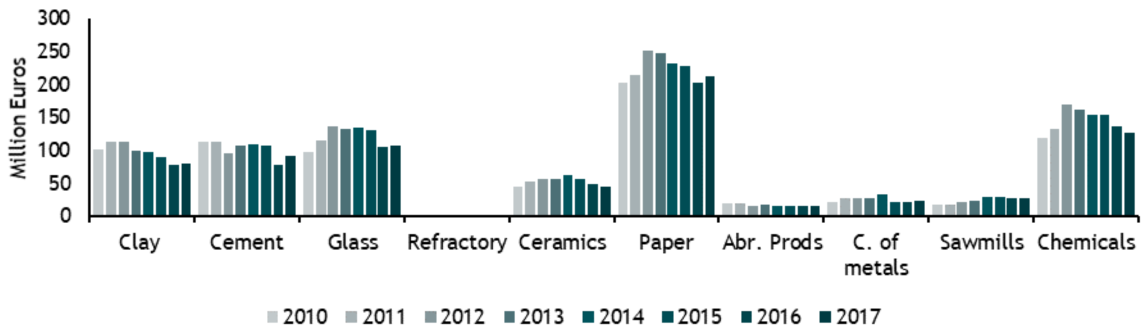
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

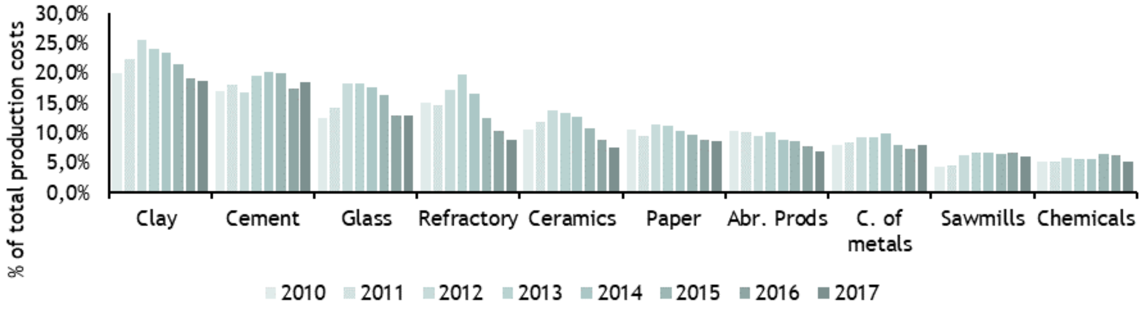
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

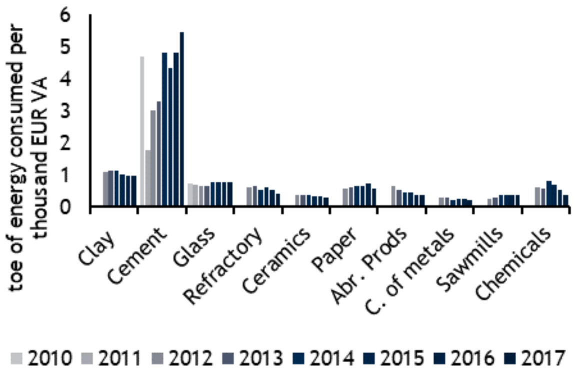
Manufacturing sectors



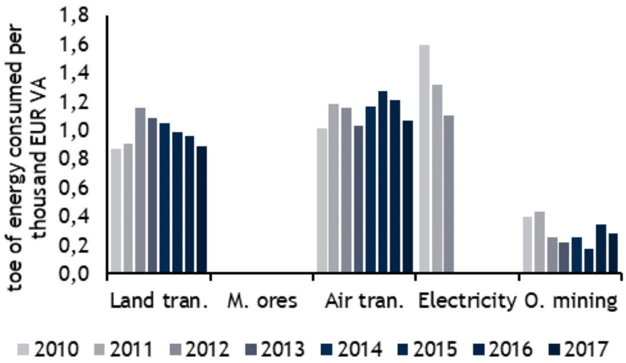
Energy intensity

Consumption of energy per value added

Manufacturing sectors



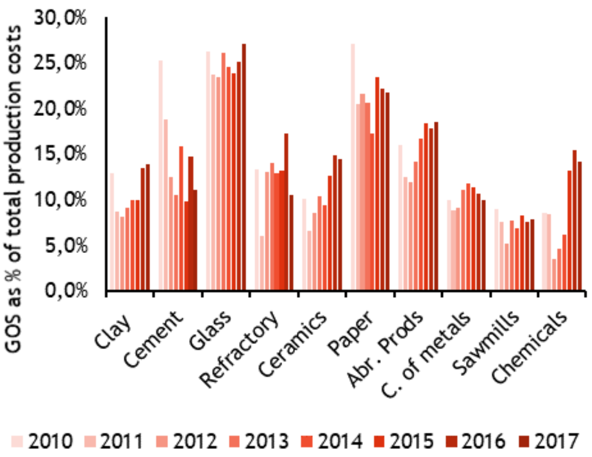
Non-manufacturing sectors



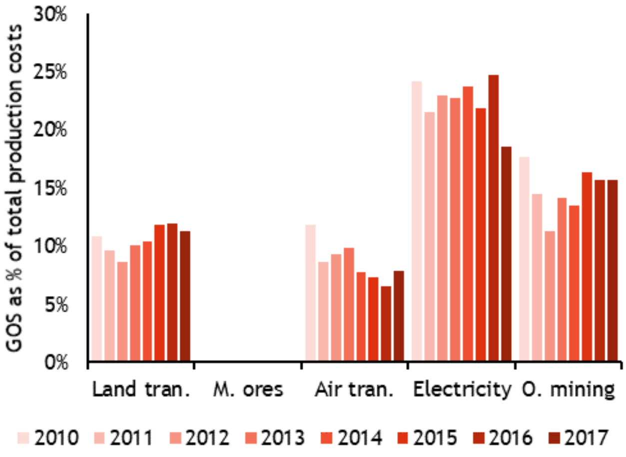
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Portugal (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C192 - Refineries
2. C235 - Cement, lime and plaster
3. C171 - Pulp and paper
4. C201 - Basic chemicals
5. C233 - Clay building materials
6. C241 - Iron and steel
7. C222 - Plastics products
8. C234 - Porcelain and ceramics

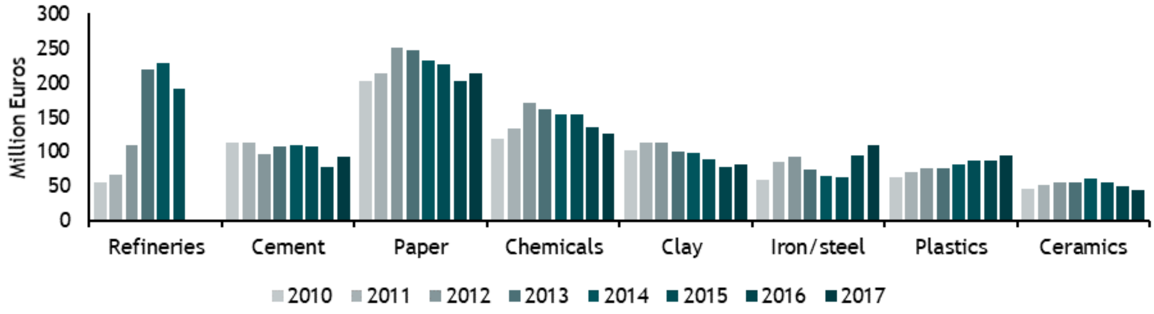
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H49 - Land transport
2. H51 - Air transport
3. A - Agriculture

Energy cost shares

Energy costs in value

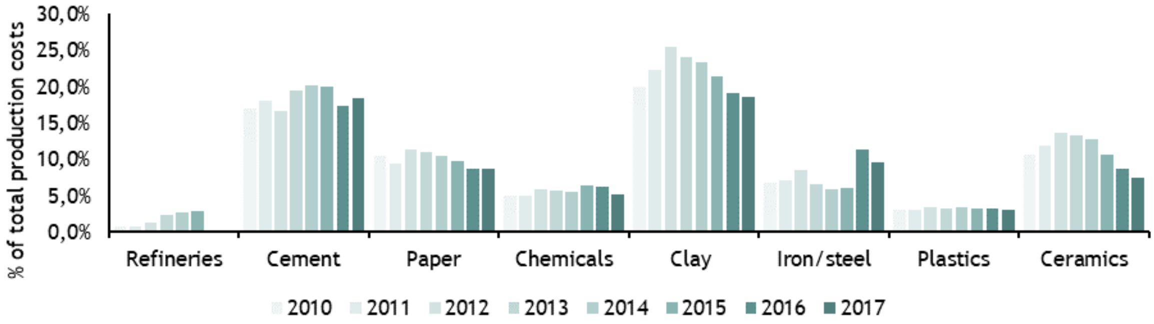
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

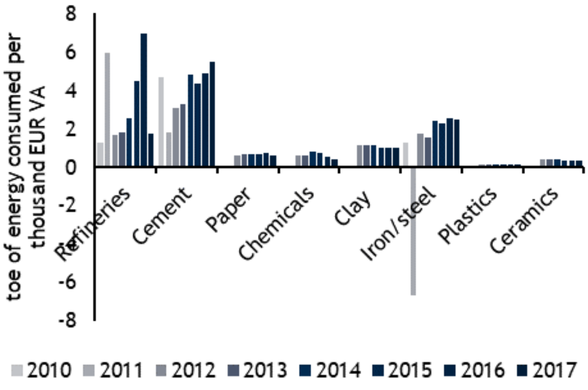
Manufacturing sectors



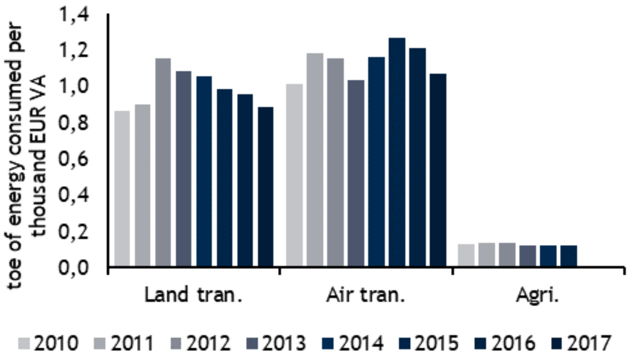
Energy intensity

Consumption of energy per value added

Manufacturing sectors



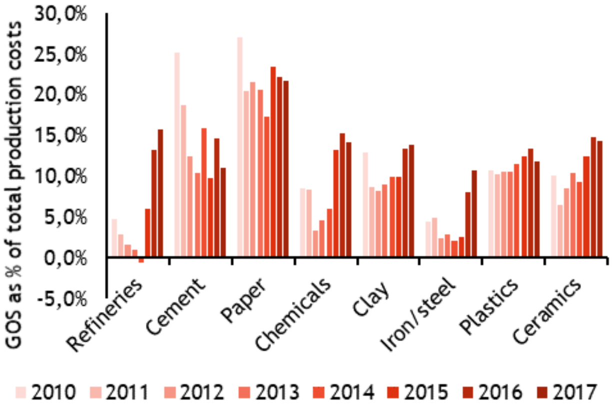
Non-manufacturing sectors



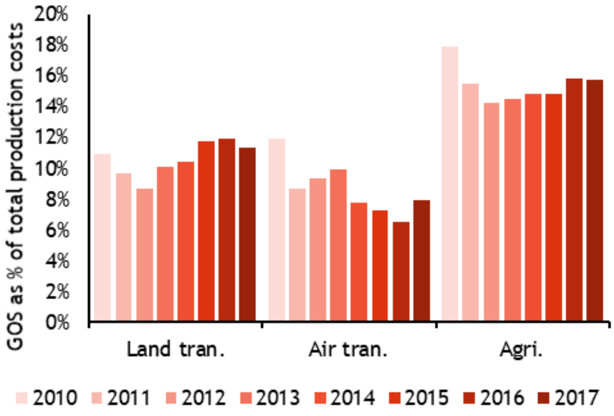
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Romania (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C244 - Non-ferrous metals
2. C241 - Iron and steel
3. C239 - Abrasive products
4. C235 - Cement, lime and plaster
5. C233 - Clay building materials
6. C232 - Refractory products
7. C171 - Pulp and paper
8. C231 - Glass
9. C234 - Porcelain and ceramics
10. C201 - Basic chemicals

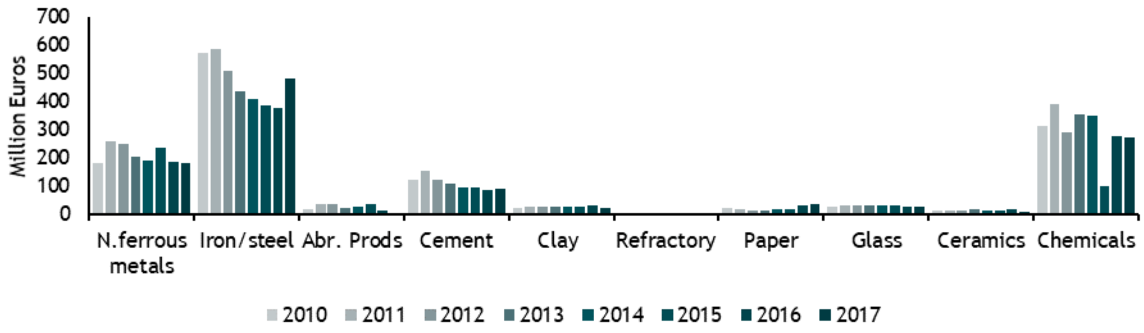
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

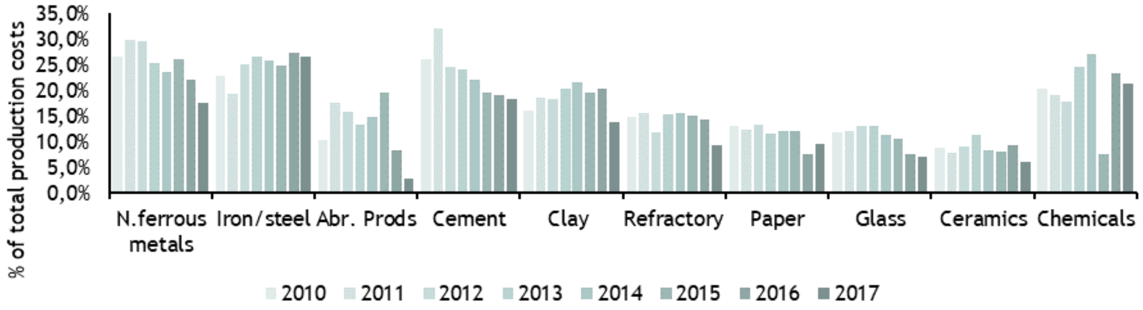
Energy costs in value

Manufacturing sectors



Energy costs as a share of total production costs

Manufacturing sectors

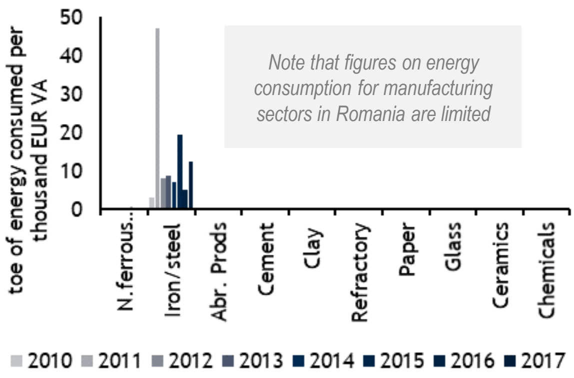


Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

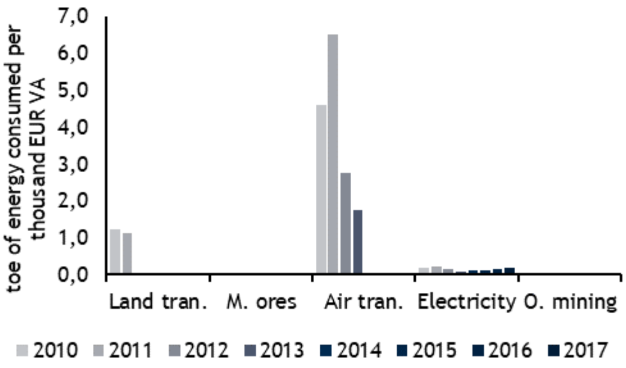
Energy intensity

Consumption of energy per value added

Manufacturing sectors



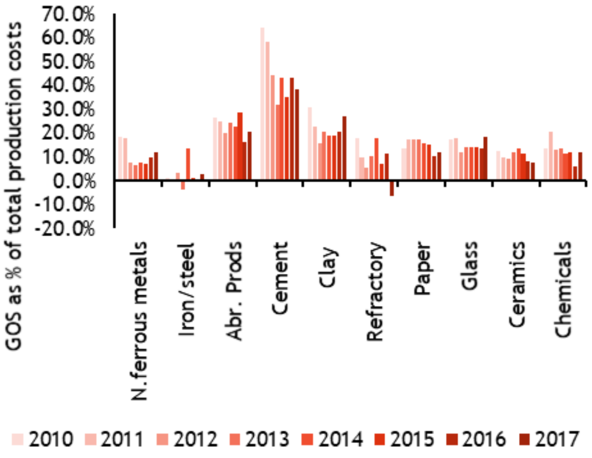
Non-manufacturing sectors



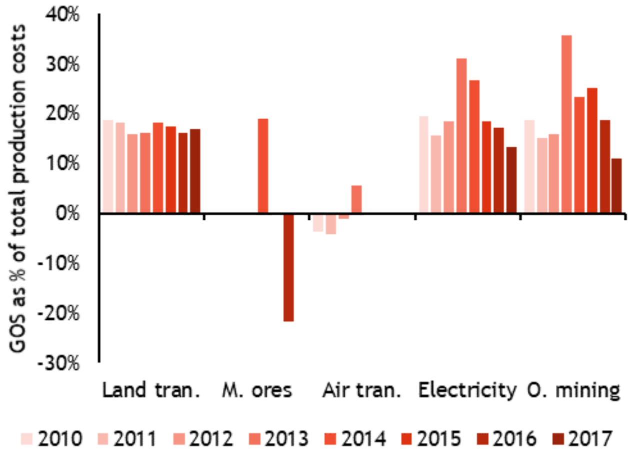
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Romania (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C192 - Refineries

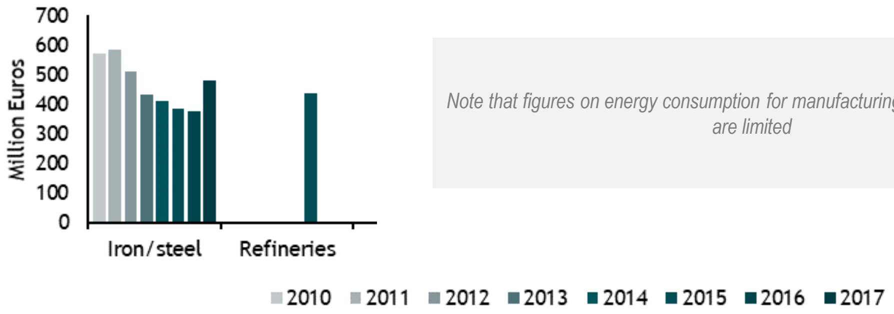
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. D35 - Electricity, gas and steam
2. A - Agriculture
3. F - Construction

Energy cost shares

Energy costs in value

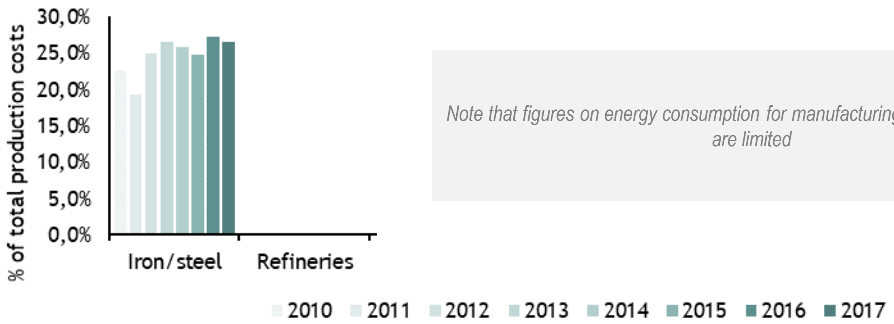
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Romania are limited

Energy costs as a share of total production costs

Manufacturing sectors



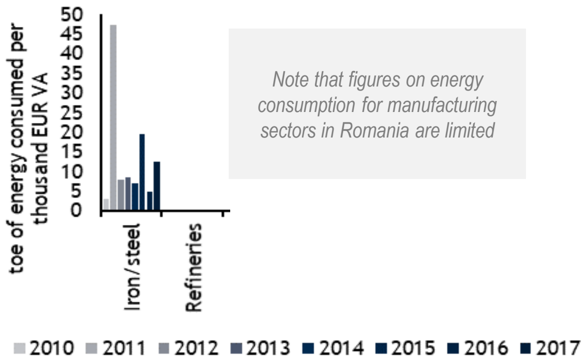
Note that figures on energy consumption for manufacturing sectors in Romania are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

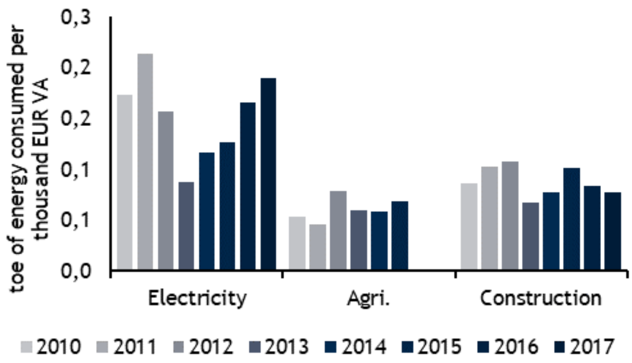
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Romania are limited

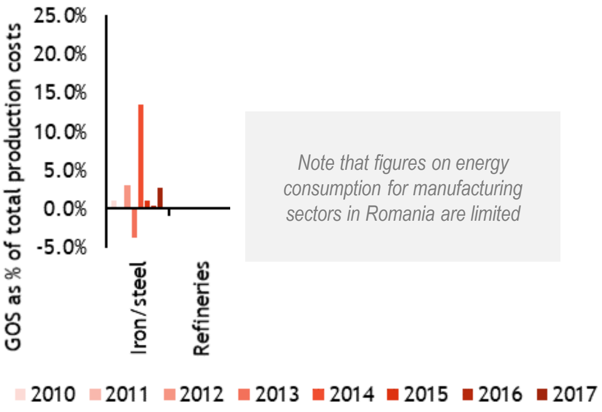
Non-manufacturing sectors



Profitability

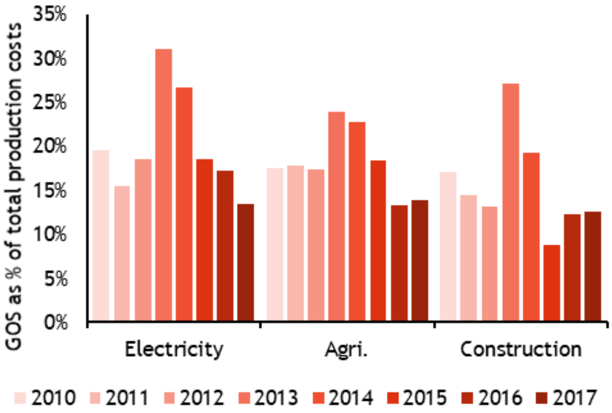
Gross operating surplus as a share of production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Romania are limited

Non-manufacturing sectors



Cost dynamics of energy intensive industries in Sweden (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C171 - Pulp and paper
3. C245 - Casting of metal
4. C132 - Textiles
5. C201 - Basic chemicals
6. C241 - Iron and steel
7. C106 - Grain products
8. C239 - Abrasive products
9. C237 - Stone
10. C222 - Plastics products

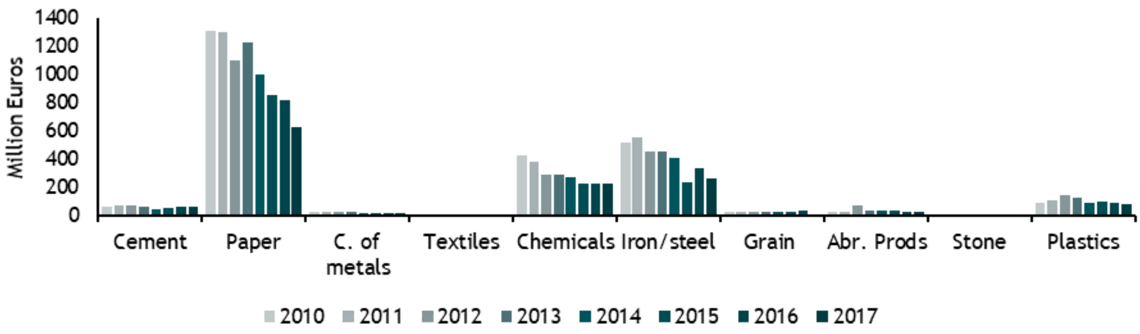
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

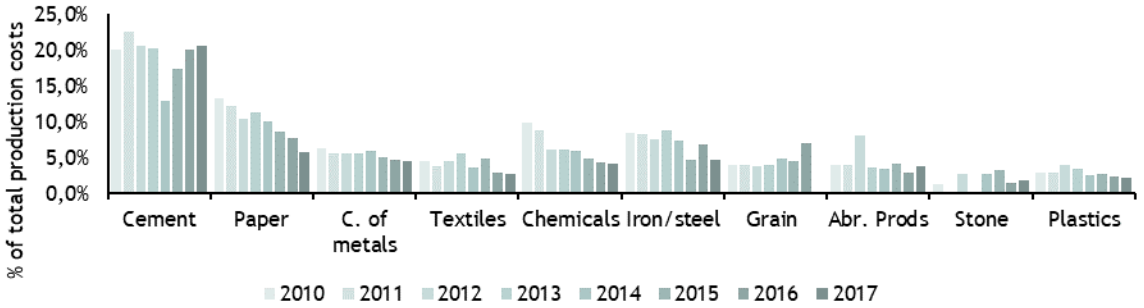
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

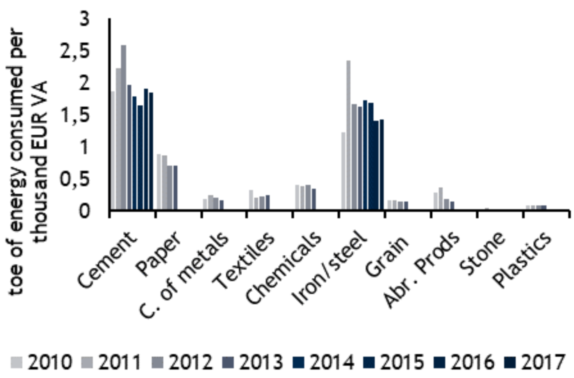
Manufacturing sectors



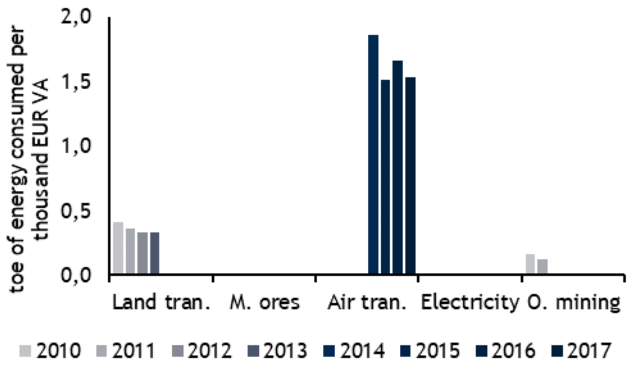
Energy intensity

Consumption of energy per value added

Manufacturing sectors



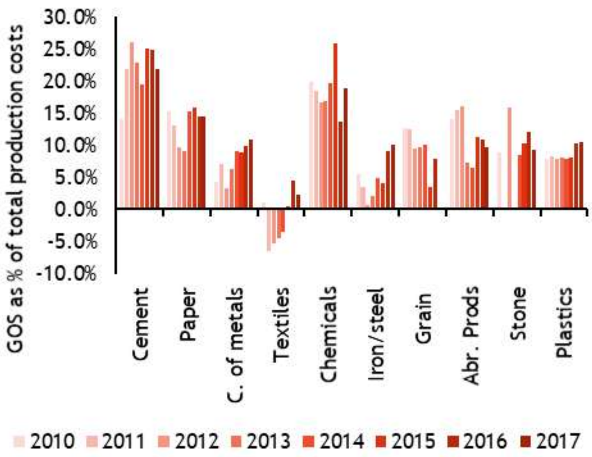
Non-manufacturing sectors



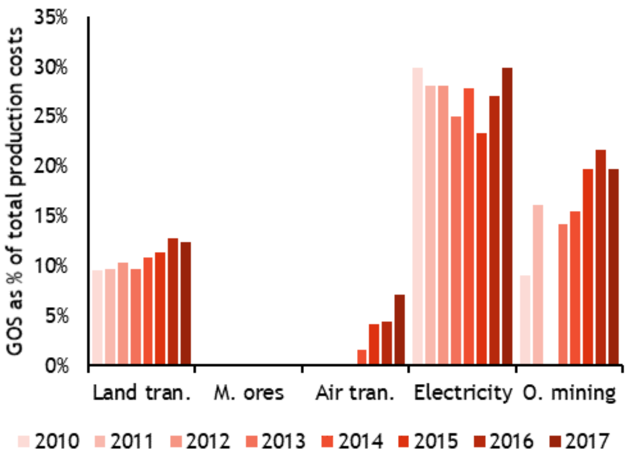
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Sweden (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C171 - Pulp and paper
2. C241 - Iron and steel
3. C192 - Refineries
4. C244 - Non-ferrous metals
5. C161 - Sawmills
6. C235 - Cement, lime and plaster
7. C29 - Motor vehicles
8. C28 - Machinery and equipment

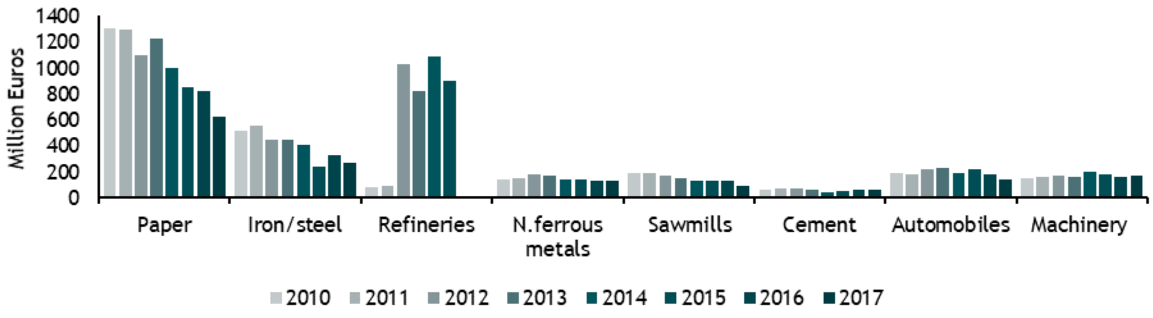
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H51 - Air transport
2. G - Wholesale and retail trade
3. A - Agriculture

Energy cost shares

Energy costs in value

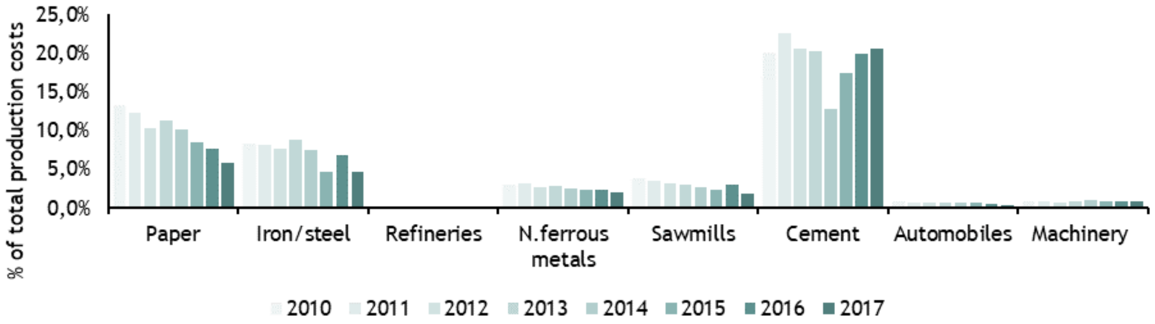
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

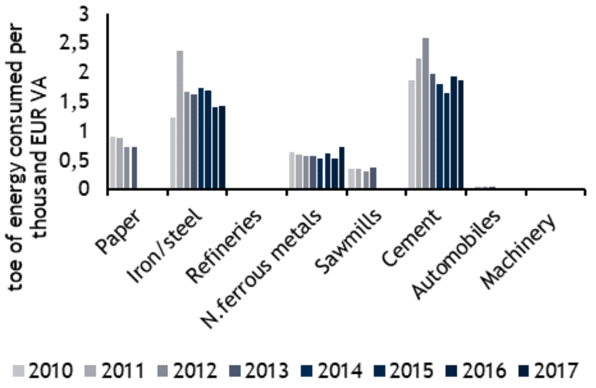
Manufacturing sectors



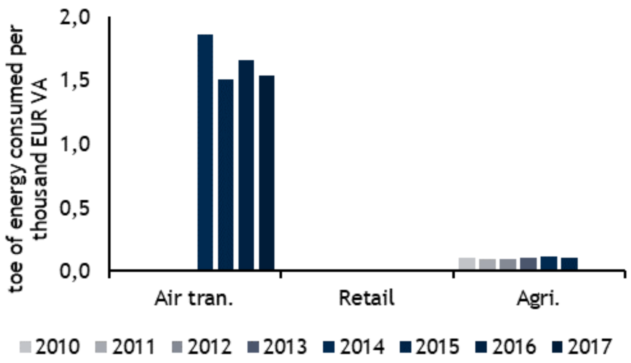
Energy intensity

Consumption of energy per value added

Manufacturing sectors



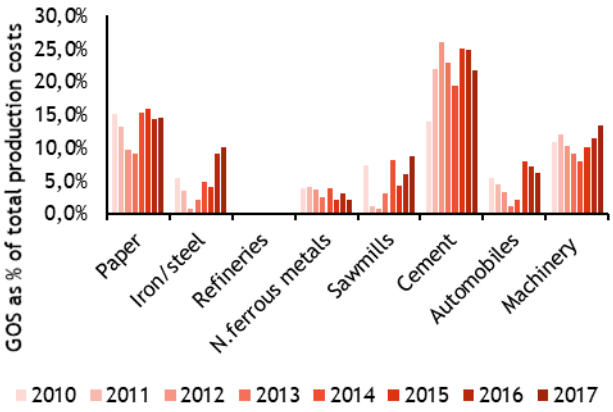
Non-manufacturing sectors



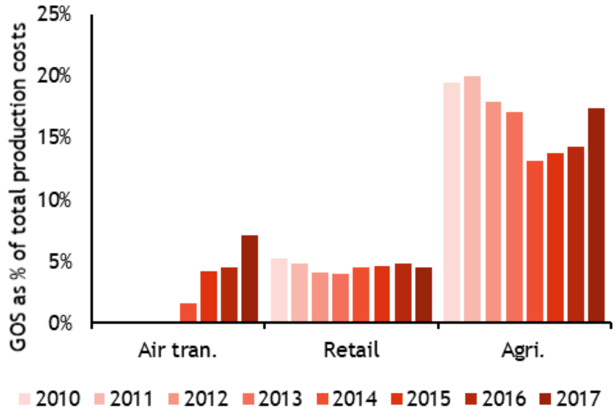
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Slovenia (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C244 - Non-ferrous metals
3. C233 - Clay building materials
4. C171 - Pulp and paper
5. C231 - Glass
6. C241 - Iron and steel
7. C201 - Basic chemicals
8. C239 - Abrasive products
9. C161 - Sawmills
10. C172 - Articles of paper

Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

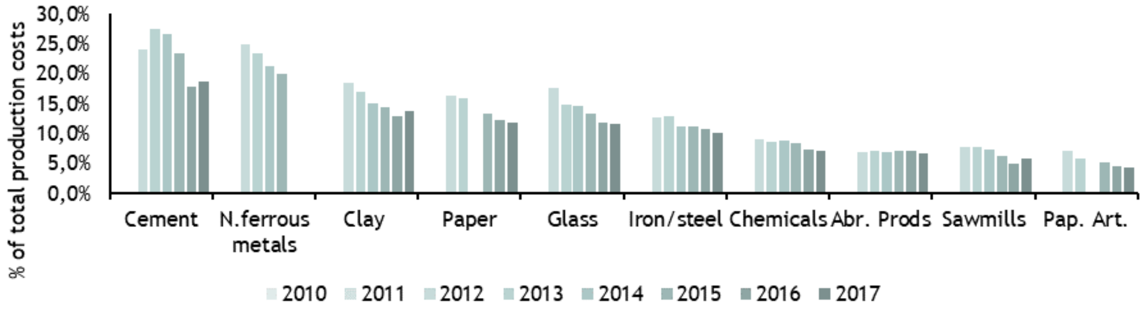
Energy costs in value

Manufacturing sectors

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

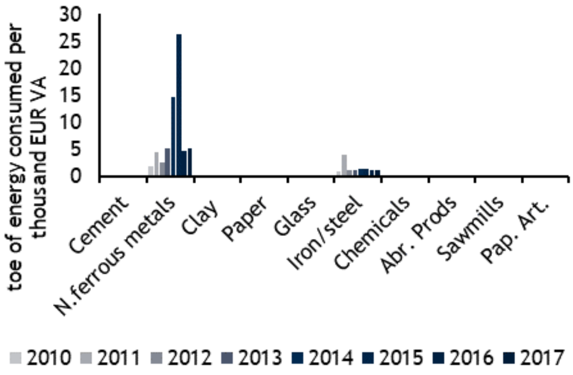
Manufacturing sectors



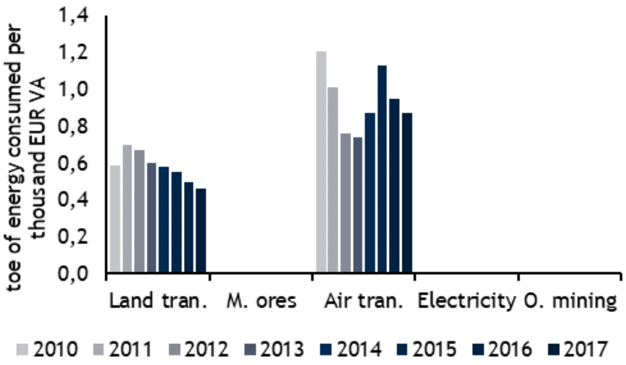
Energy intensity

Consumption of energy per value added

Manufacturing sectors



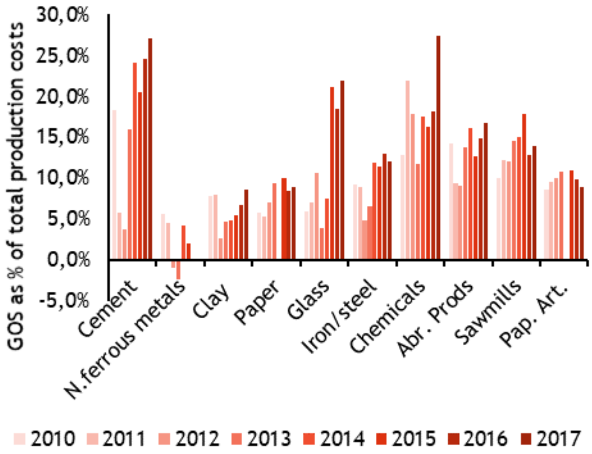
Non-manufacturing sectors



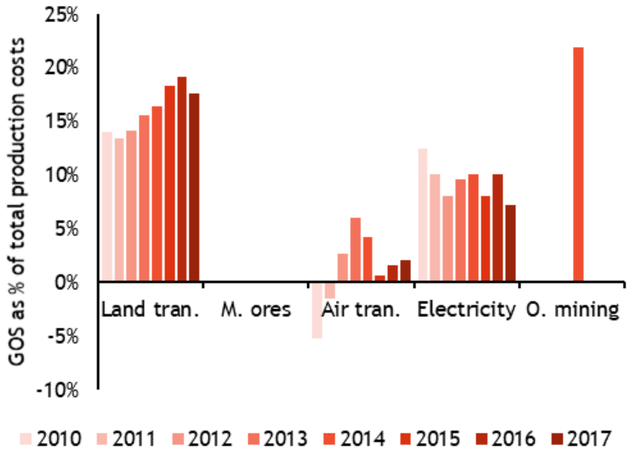
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Slovenia (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C244 - Non-ferrous metals
3. C25 - Fabricated metal products
4. C27 - Electrical equipment
5. C29 - Motor vehicles
6. C28 - Machinery and equipment
7. C11 - Beverages
8. C26 - Computer and electronics

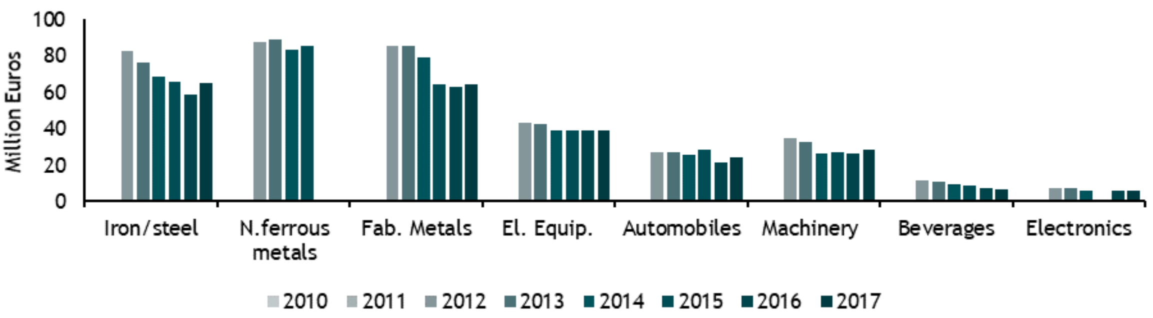
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. H49 - Land transport
2. A - Agriculture

Energy cost shares

Energy costs in value

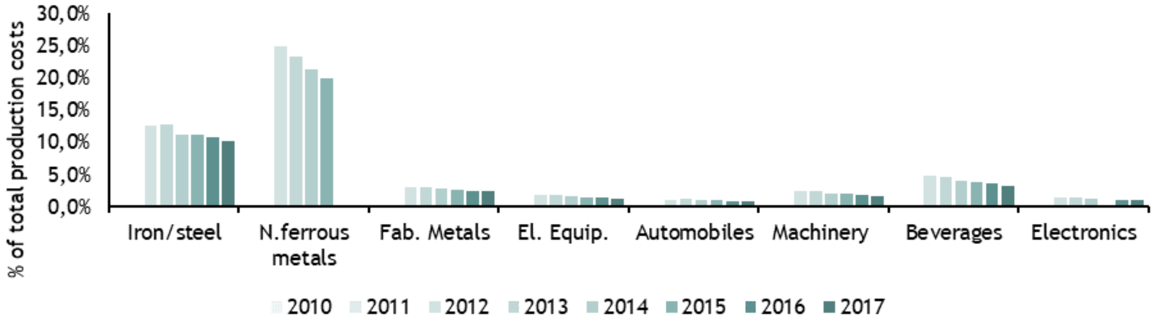
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

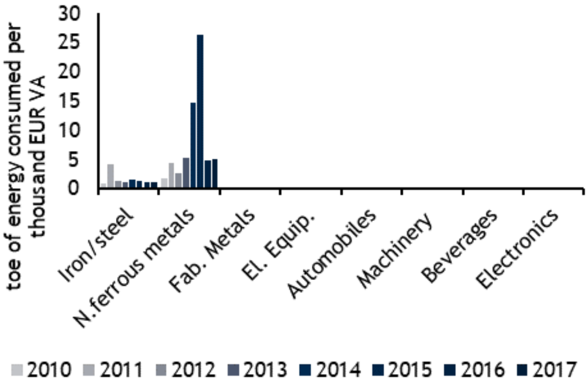
Manufacturing sectors



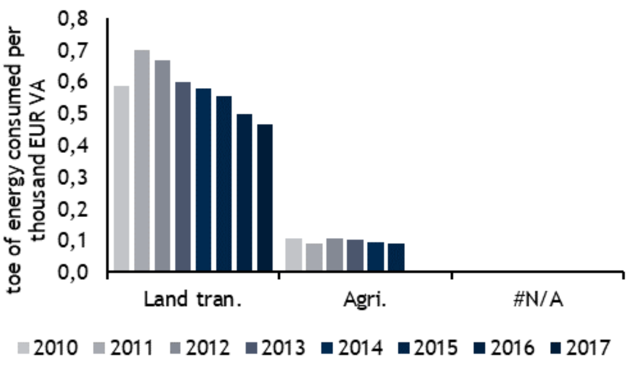
Energy intensity

Consumption of energy per value added

Manufacturing sectors



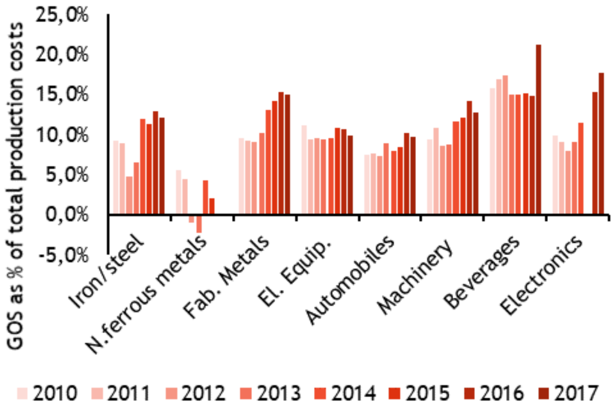
Non-manufacturing sectors



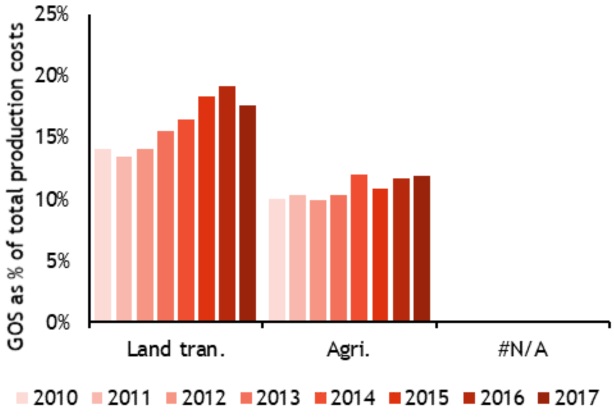
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Slovakia (1/2)

Cost shares

Key – Top manufacturing sectors in terms of energy cost shares

1. C235 - Cement, lime and plaster
2. C232 - Refractory products
3. C233 - Clay building materials
4. C231 - Glass
5. C171 - Pulp and paper
6. C201 - Basic chemicals
7. C234 - Porcelain and ceramics
8. C106 - Grain products
9. C245 - Casting of metal
10. C239 - Abrasive products

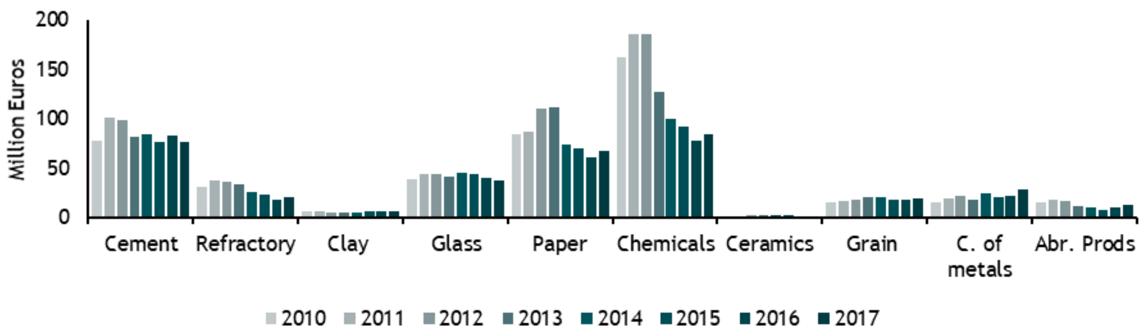
Key – Top non-manufacturing sectors in terms of energy cost shares

1. H49 - Land transport
2. B07 - Mining of metal ores
3. H51 - Air transport
4. D35 - Electricity, gas and steam
5. B08 - Other mining

Energy cost shares

Energy costs in value

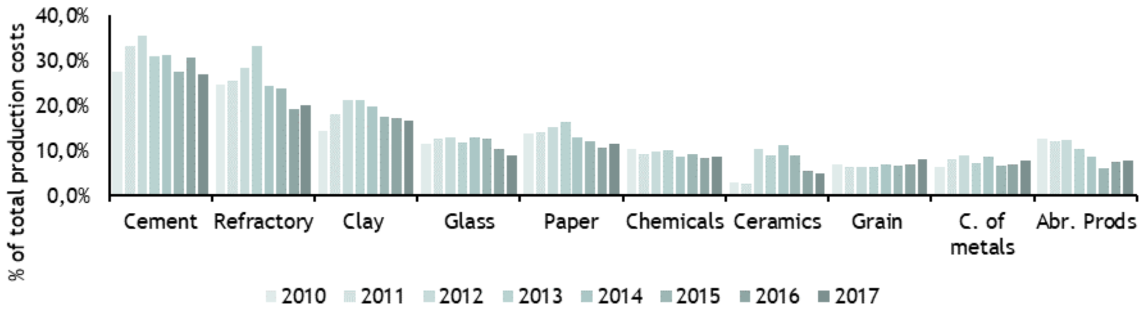
Manufacturing sectors



Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy costs as a share of total production costs

Manufacturing sectors



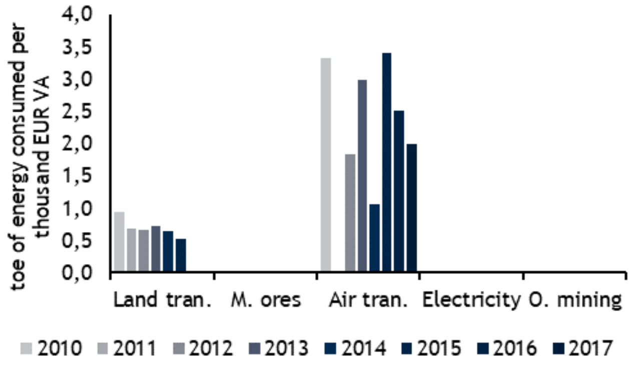
Energy intensity

Consumption of energy per value added

Manufacturing sectors

Note that figures on energy consumption for manufacturing sectors in Slovakia are limited

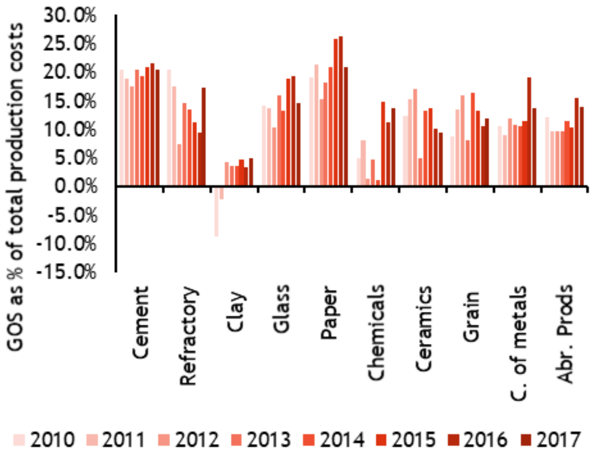
Non-manufacturing sectors



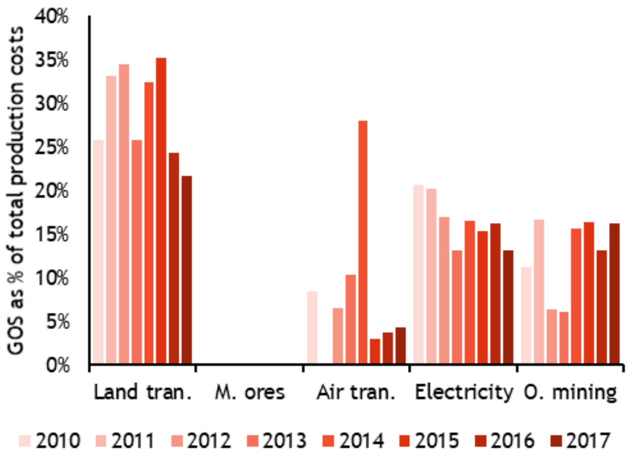
Profitability

Gross operating surplus as a share of production costs

Manufacturing sectors



Non-manufacturing sectors



Cost dynamics of energy intensive industries in Slovakia (2/2)

Consumption levels

Key – Top manufacturing sectors in terms of energy consumption levels

1. C241 - Iron and steel
2. C192 - Refineries
3. C244 - Non-ferrous metals

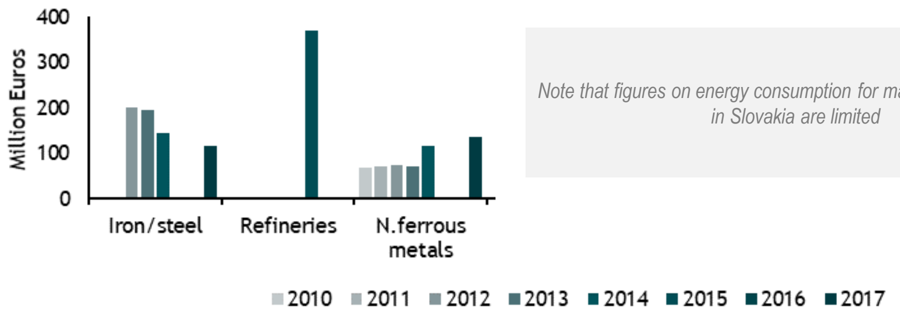
Key – Top non-manufacturing sectors In terms of energy consumption levels

1. A - Agriculture
2. H51 - Air transport

Energy cost shares

Energy costs in value

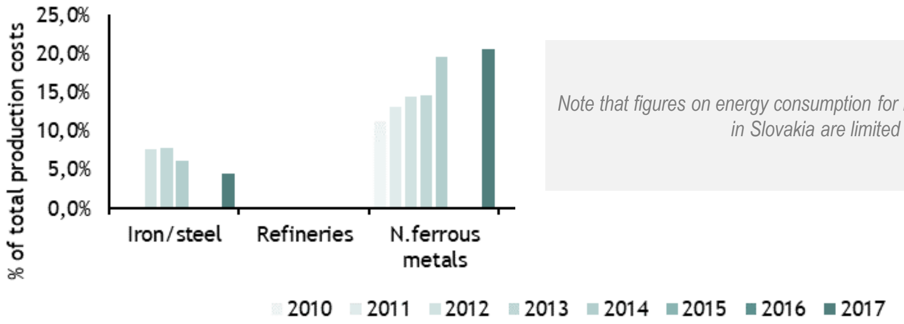
Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Slovakia are limited

Energy costs as a share of total production costs

Manufacturing sectors



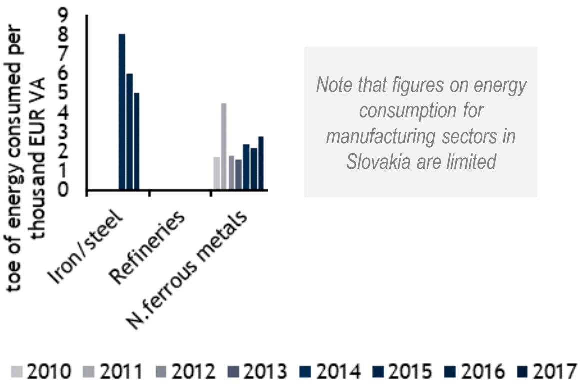
Note that figures on energy consumption for manufacturing sectors in Slovakia are limited

Note that figures on energy costs for non-manufacturing sectors are not presented due to very limited data availability

Energy intensity

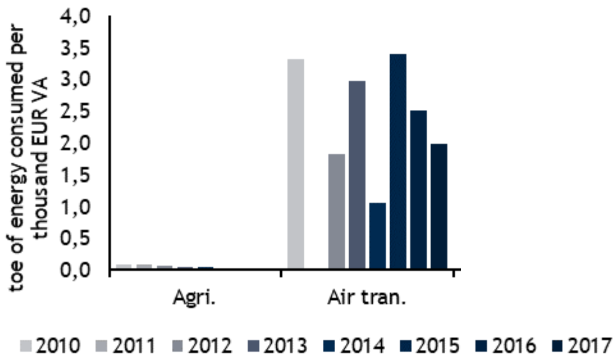
Consumption of energy per value added

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Slovakia are limited

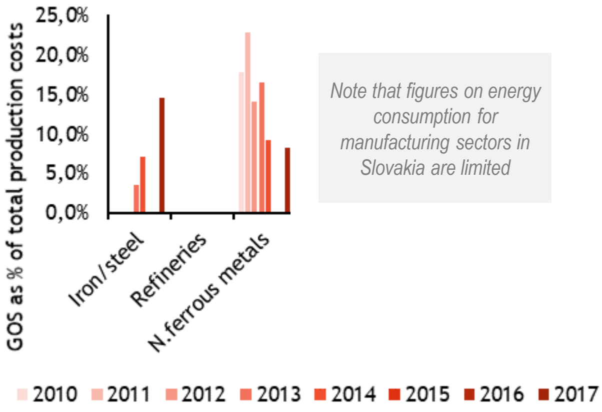
Non-manufacturing sectors



Profitability

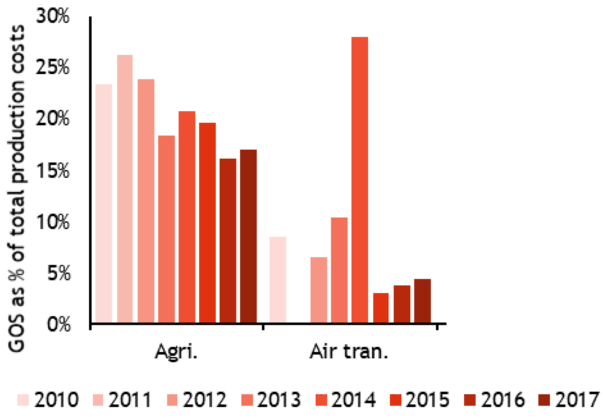
Gross operating surplus as a share of production costs

Manufacturing sectors



Note that figures on energy consumption for manufacturing sectors in Slovakia are limited

Non-manufacturing sectors



Study on energy prices, costs and their impact on industry and households

Final report
Annex E - Task 2 Sector Factsheets

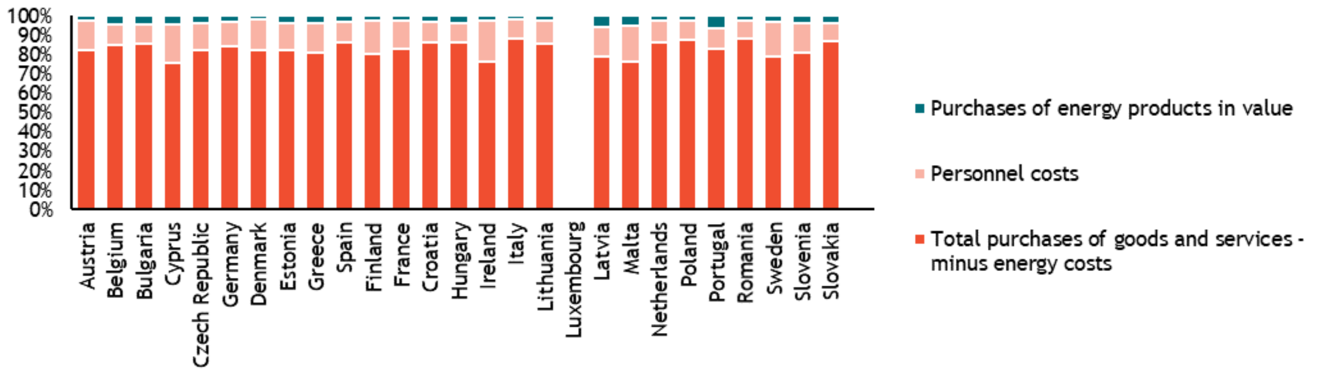
Trinomics

Cost dynamics for Sector C103 – Processing and preserving of fruits and vegetables

Breakdown of production costs

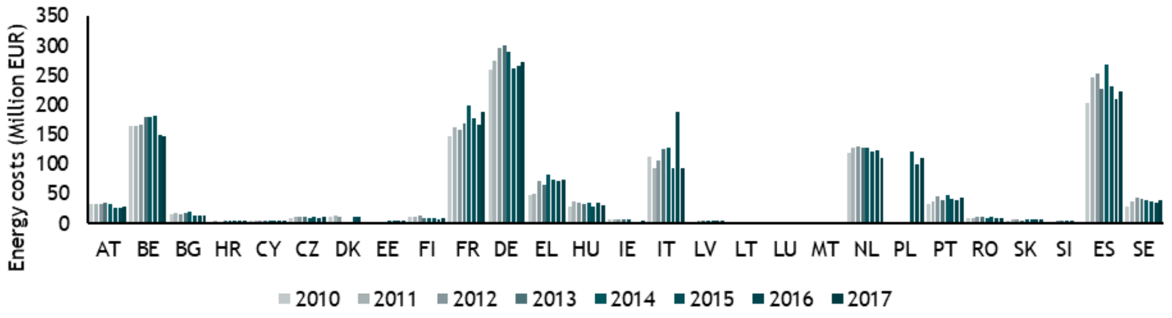
Distribution of costs per Member State in the EU27

Average 2010-2017

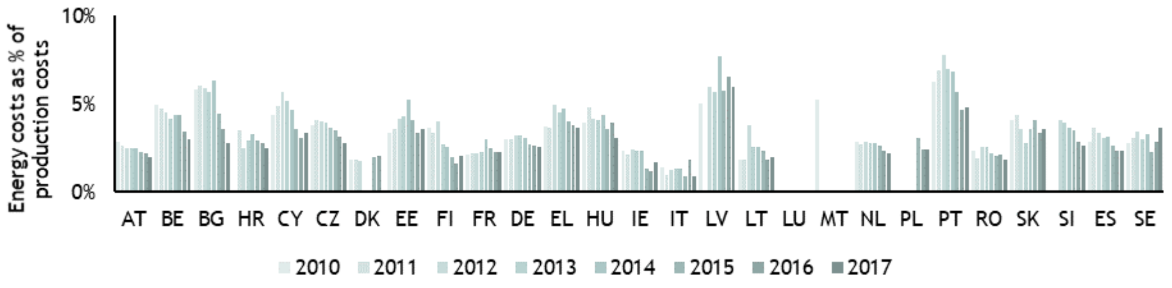


Energy cost shares

Energy costs in value

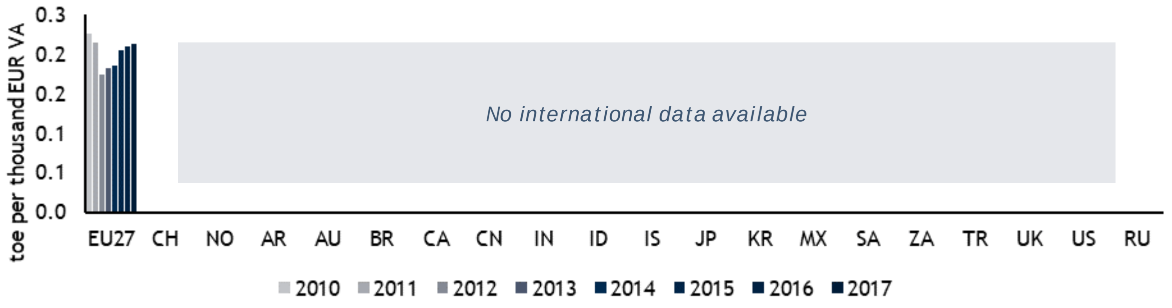


Energy costs as a share of total production costs



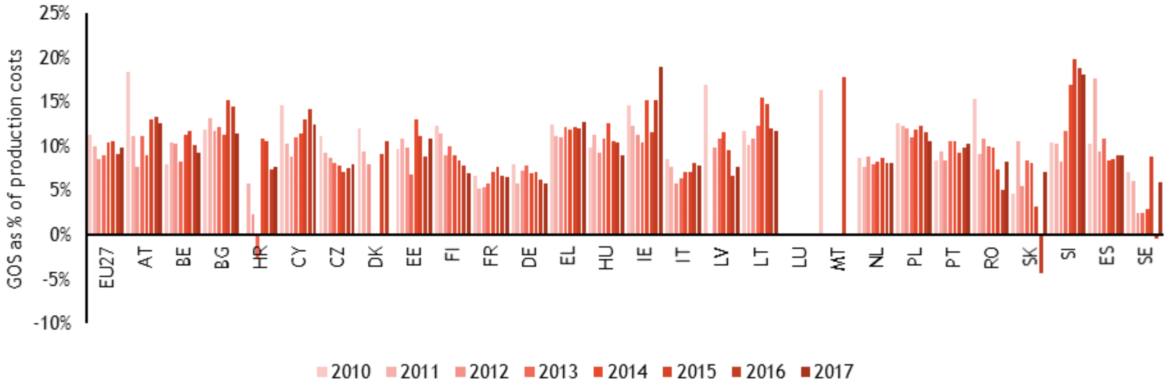
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

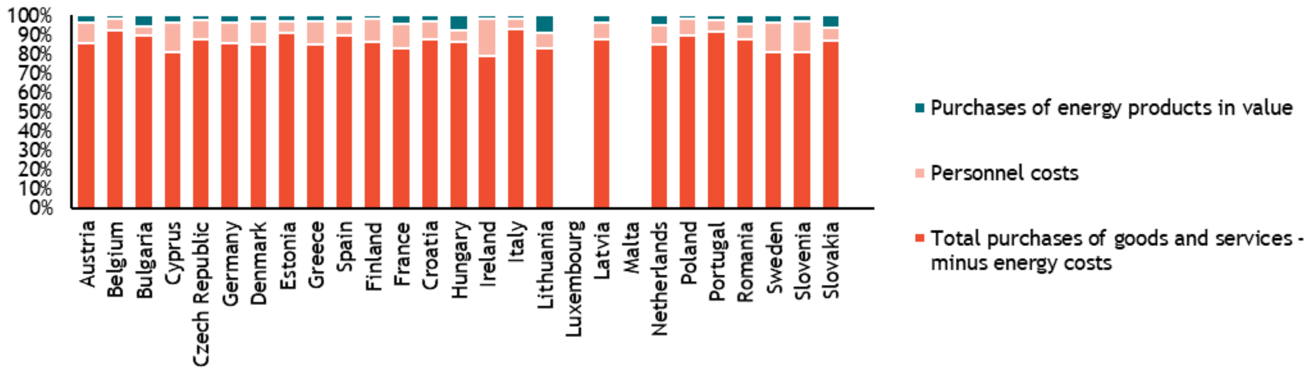


Cost dynamics for Sector C106 – Manufacture of grain mill products and starches

Breakdown of production costs

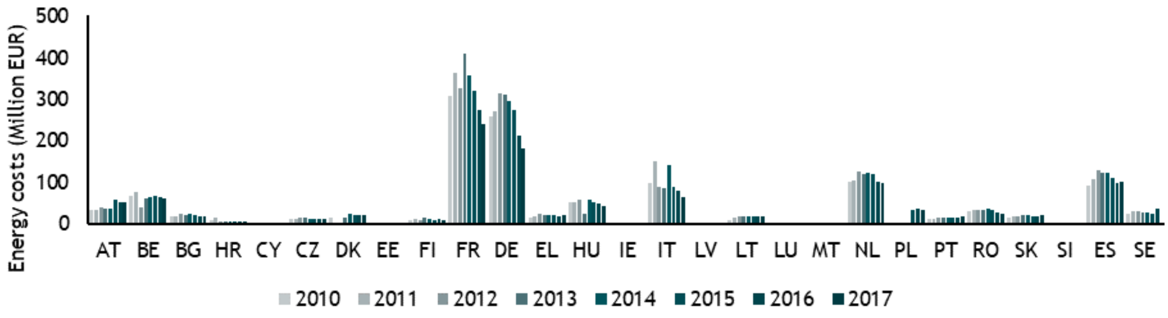
Distribution of costs per Member State in the EU27

Average 2010-2017

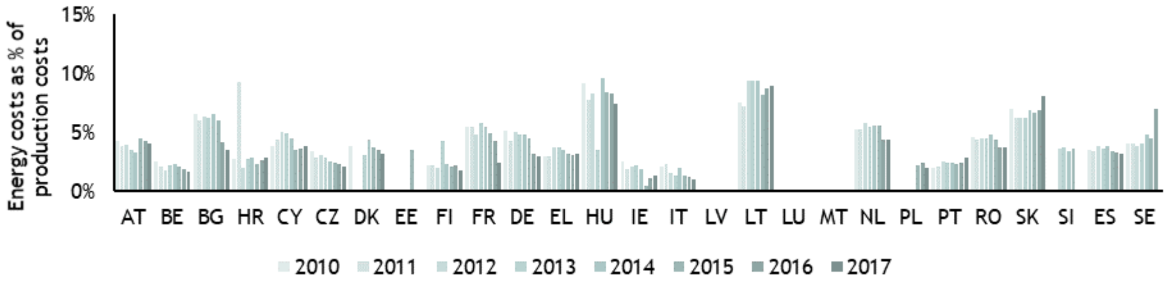


Energy cost shares

Energy costs in value

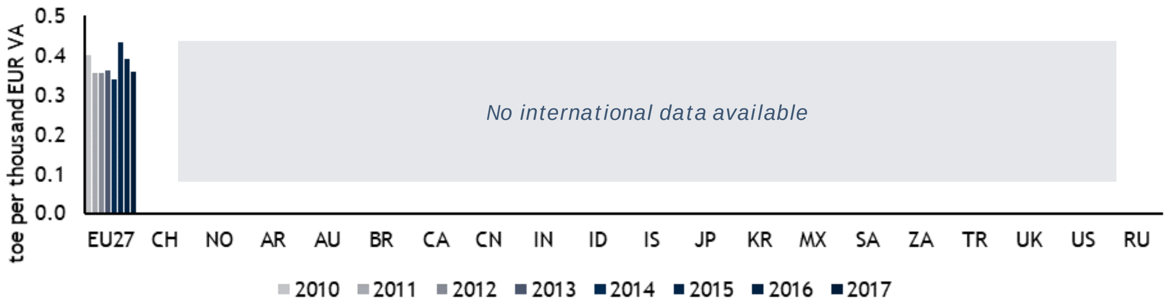


Energy costs as a share of total production costs



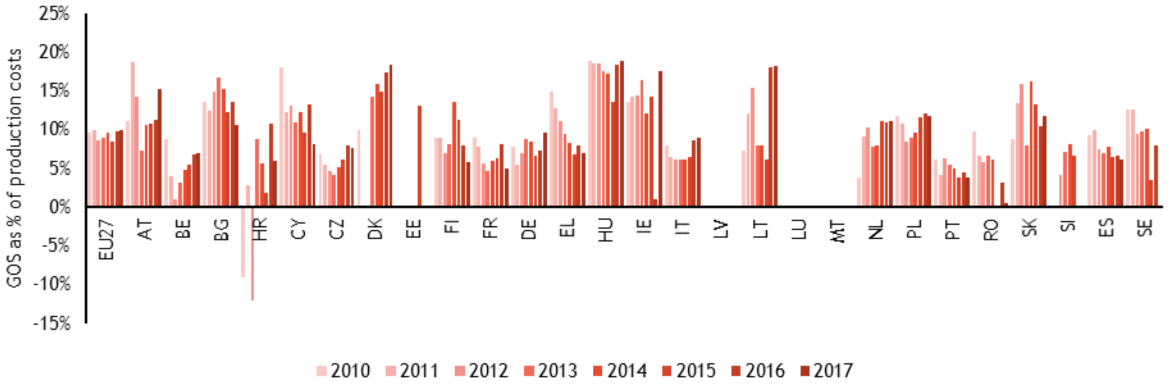
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

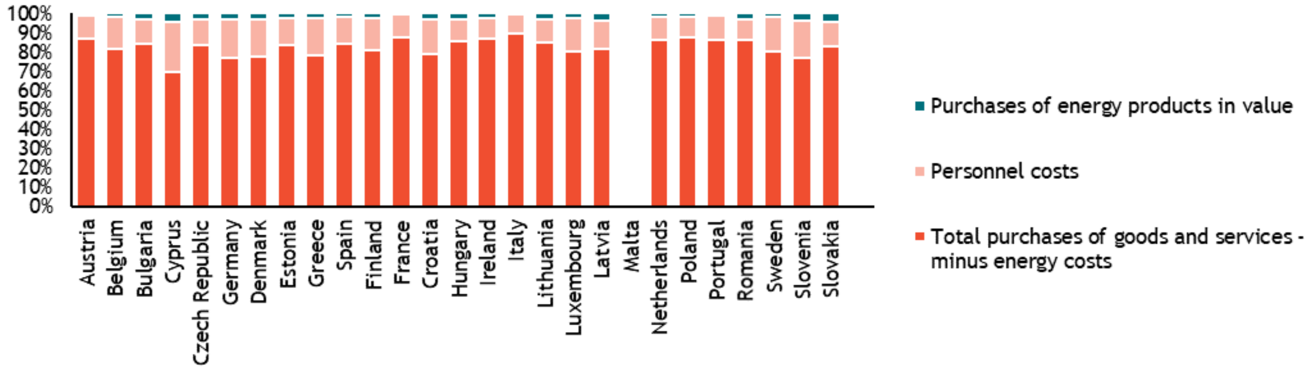


Cost dynamics for Sector C11 – Manufacture of beverages

Breakdown of production costs

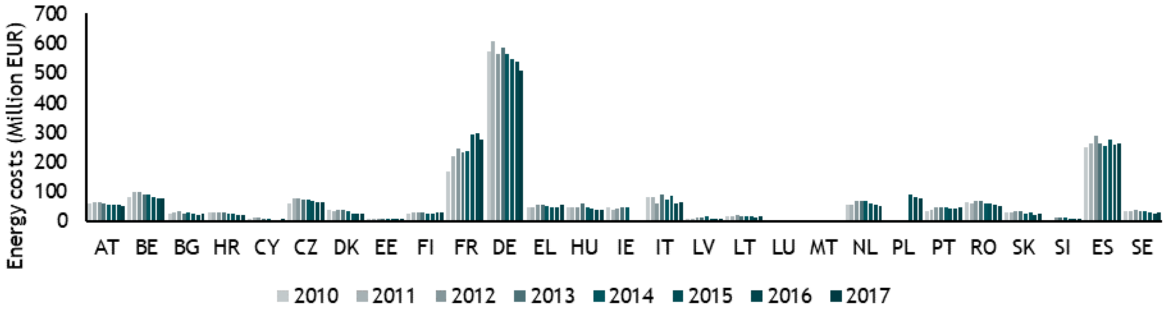
Distribution of costs per Member State in the EU27

Average 2010-2017

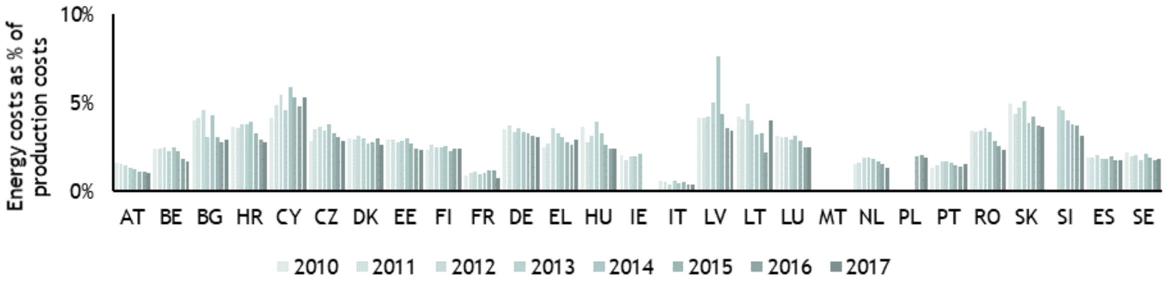


Energy cost shares

Energy costs in value

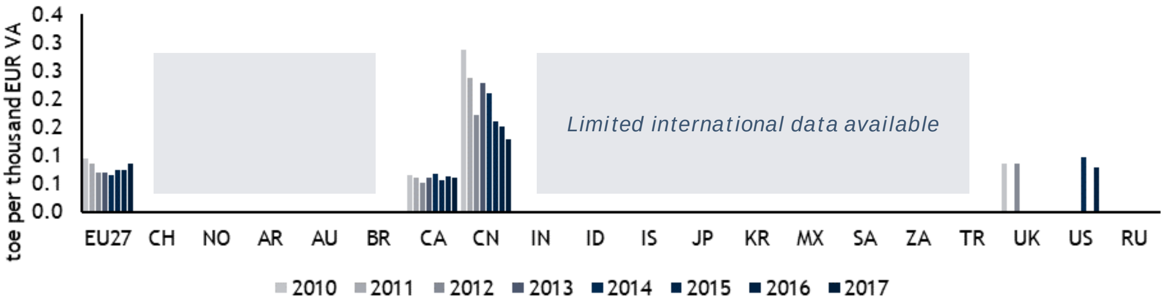


Energy costs as a share of total production costs



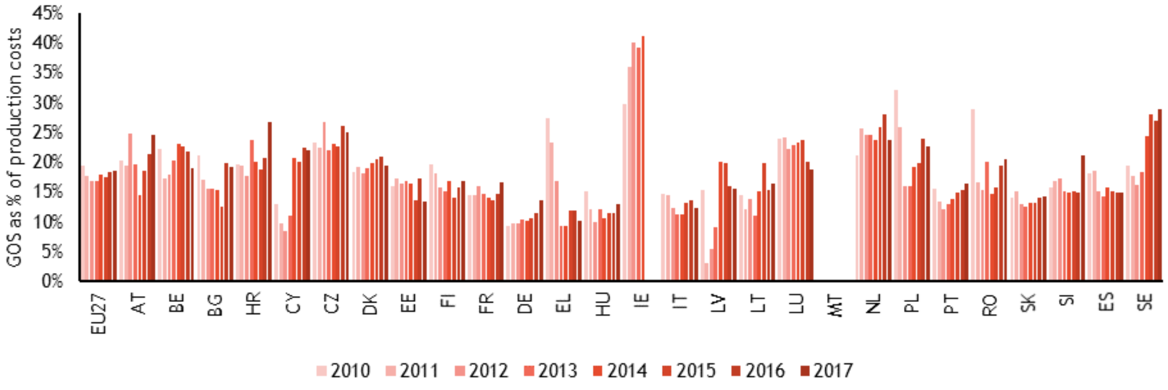
Energy intensity

Consumption of energy per value added



Profitability

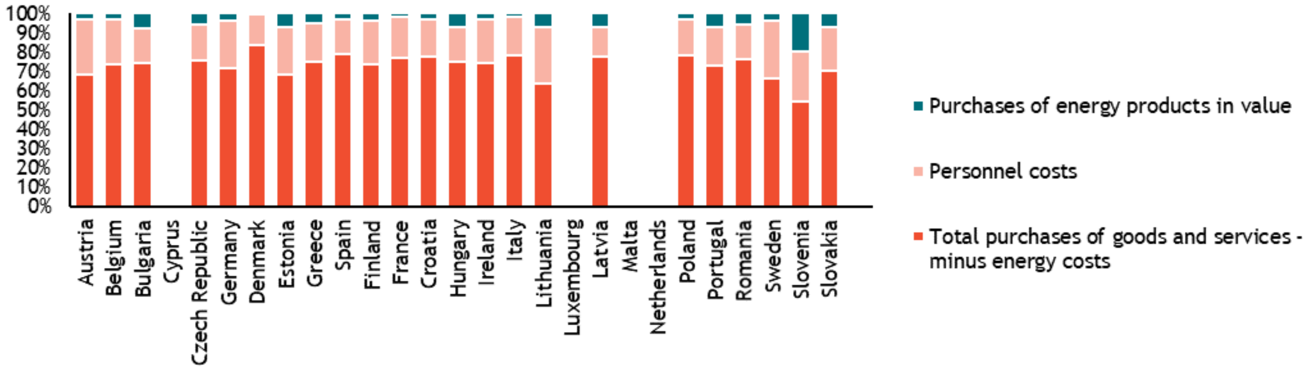
Gross operating surplus as a share of production costs



Cost dynamics for Sector 132 – Weaving of textiles

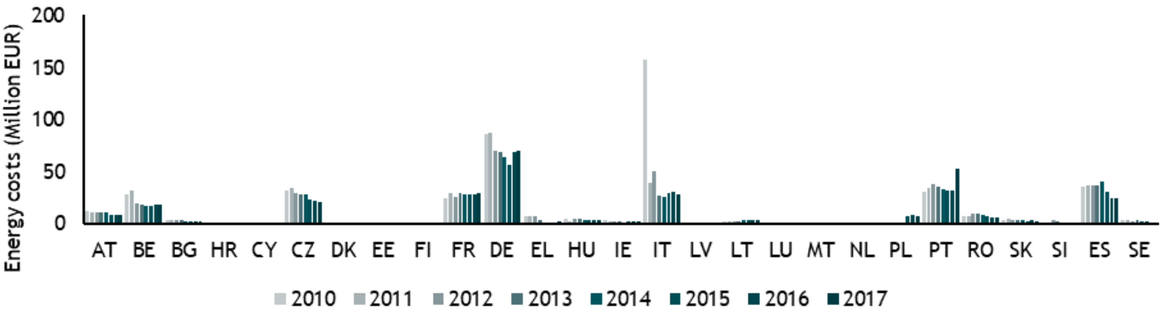
Breakdown of production costs

Distribution of costs per Member State in the EU27
Average 2010-2017

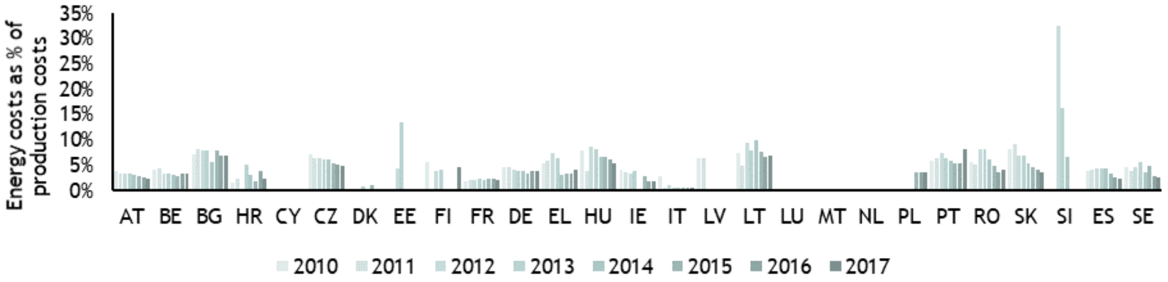


Energy cost shares

Energy costs in value

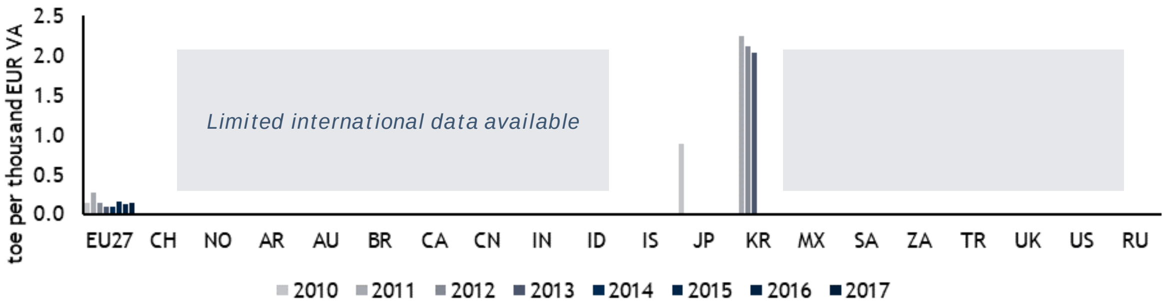


Energy costs as a share of total production costs



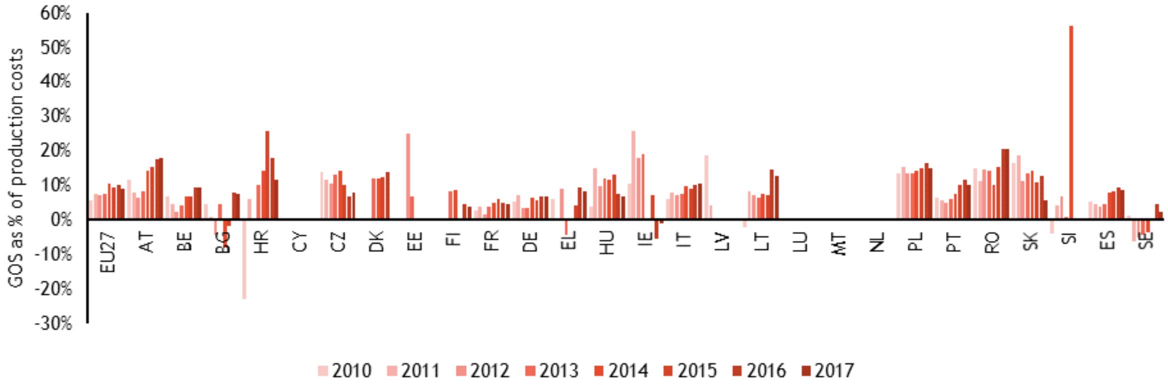
Energy intensity

Consumption of energy per value added



Profitability

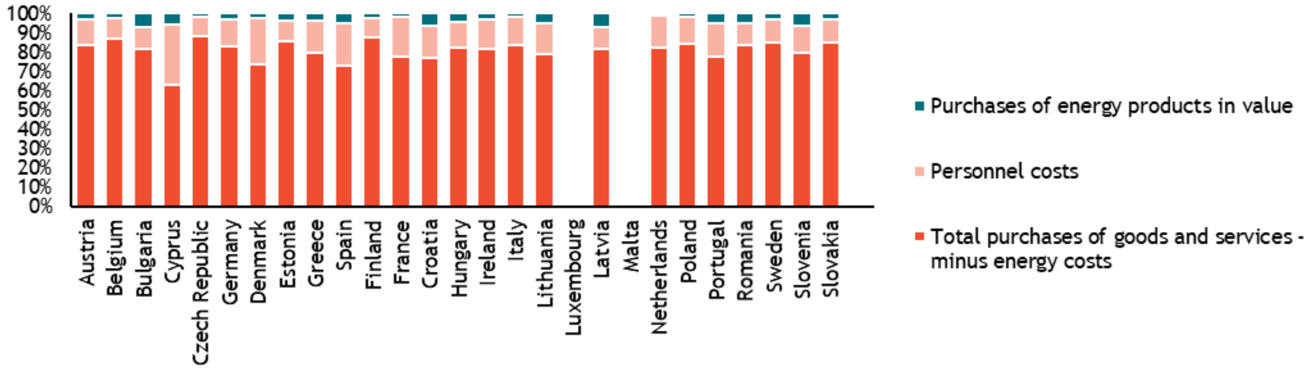
Gross operating surplus as a share of production costs



Cost dynamics for Sector 161 – Sawmilling and planning of wood

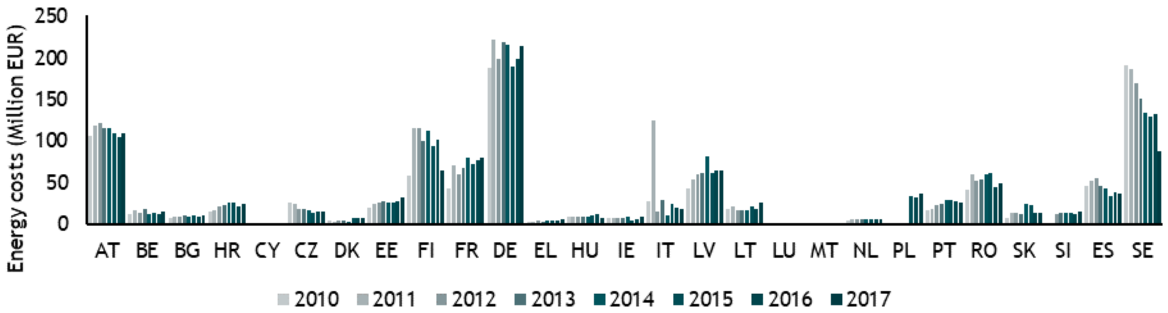
Breakdown of production costs

Distribution of costs per Member State in the EU27
Average 2010-2017

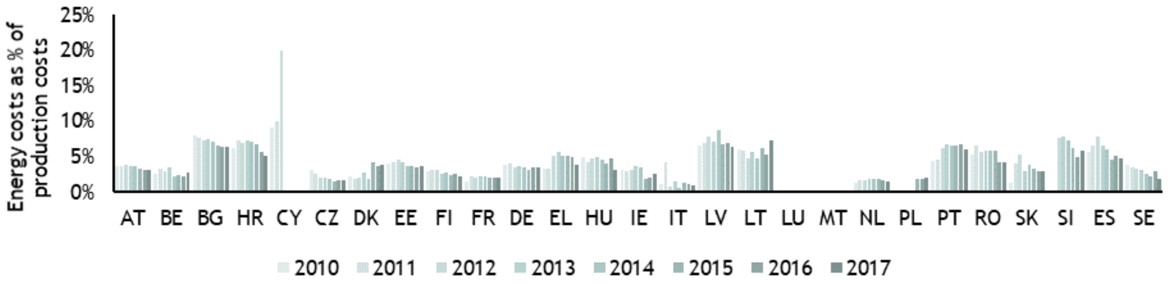


Energy cost shares

Energy costs in value

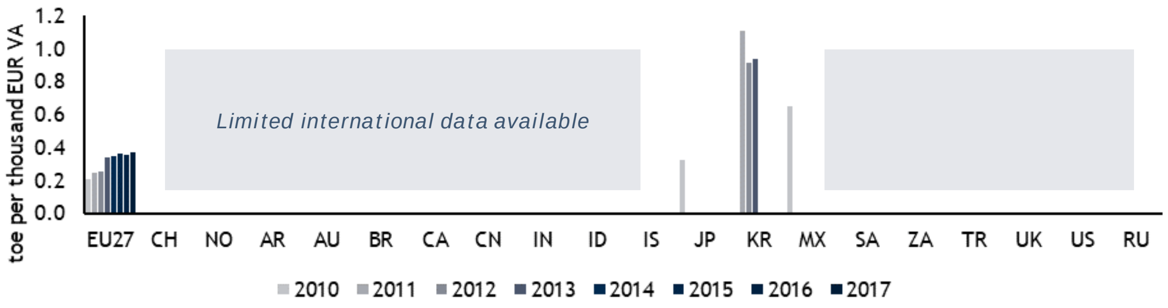


Energy costs as a share of total production costs



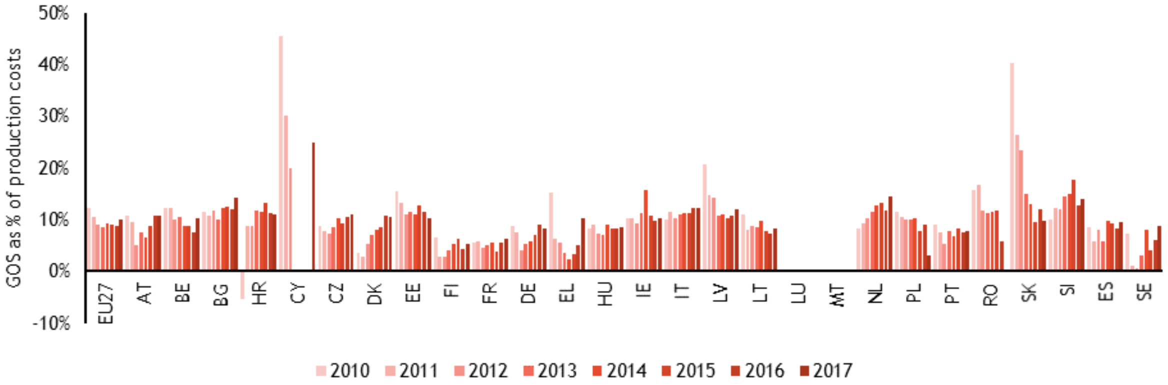
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

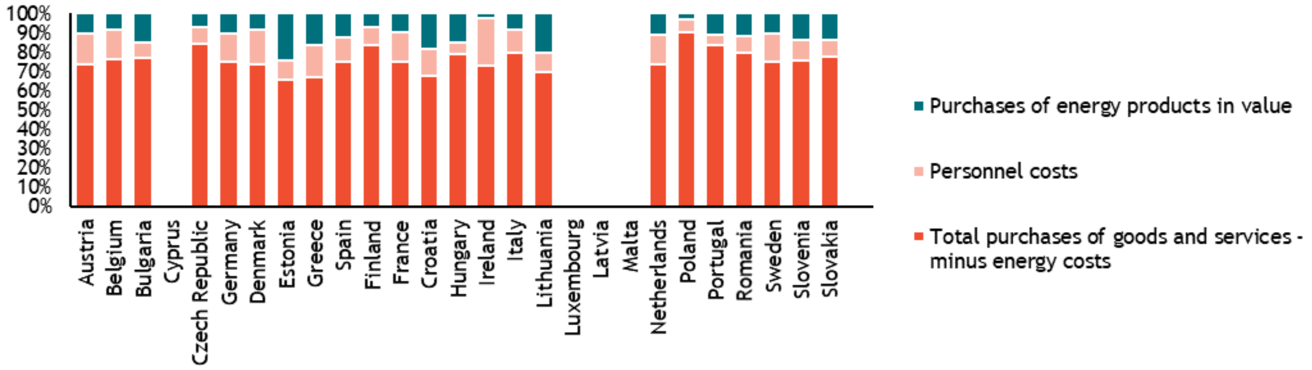


Cost dynamics for Sector C171 – Manufacture of pulp, paper and paperboard

Breakdown of production costs

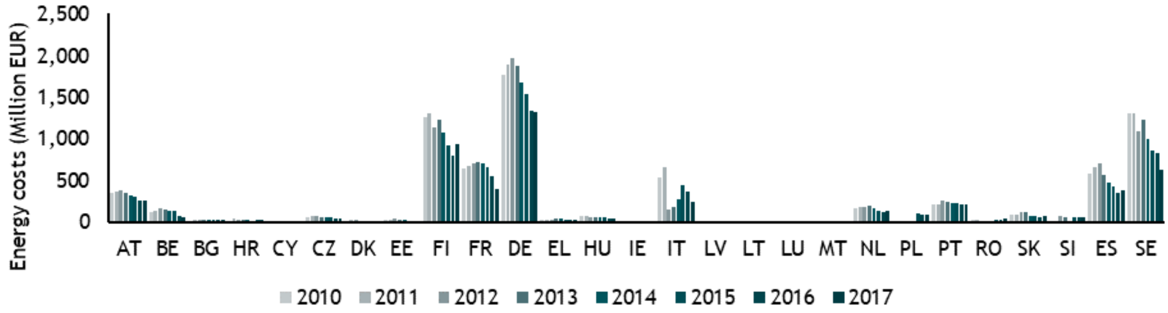
Distribution of costs per Member State in the EU27

Average 2010-2017

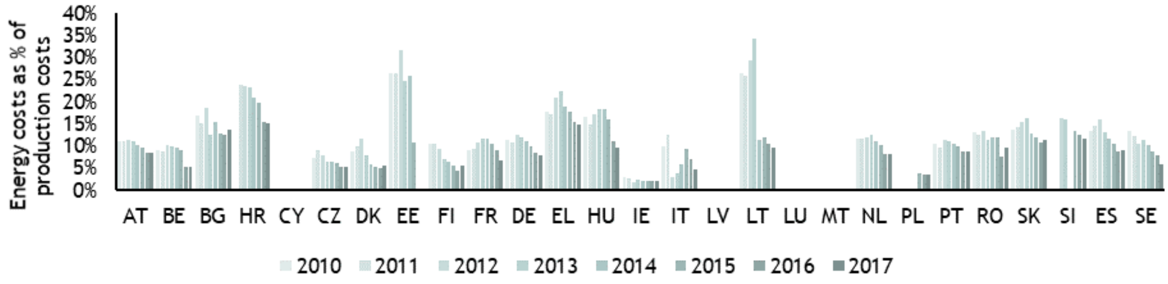


Energy cost shares

Energy costs in value

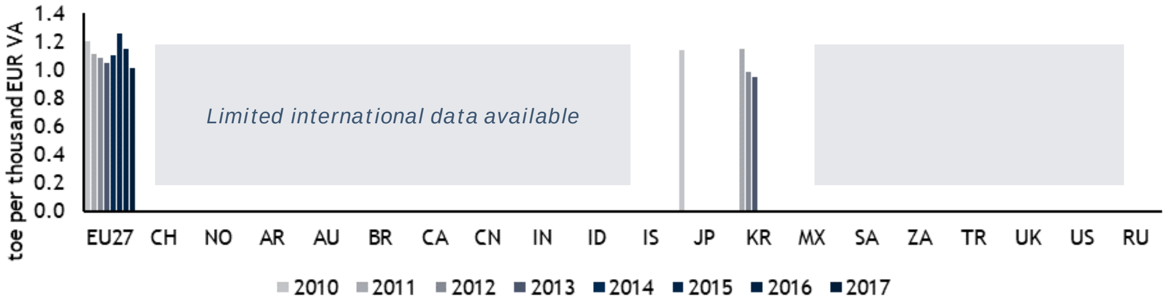


Energy costs as a share of total production costs



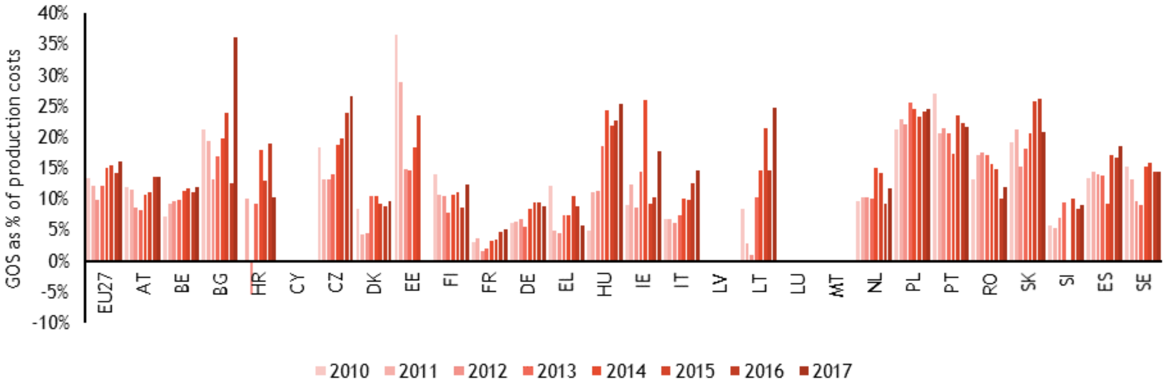
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

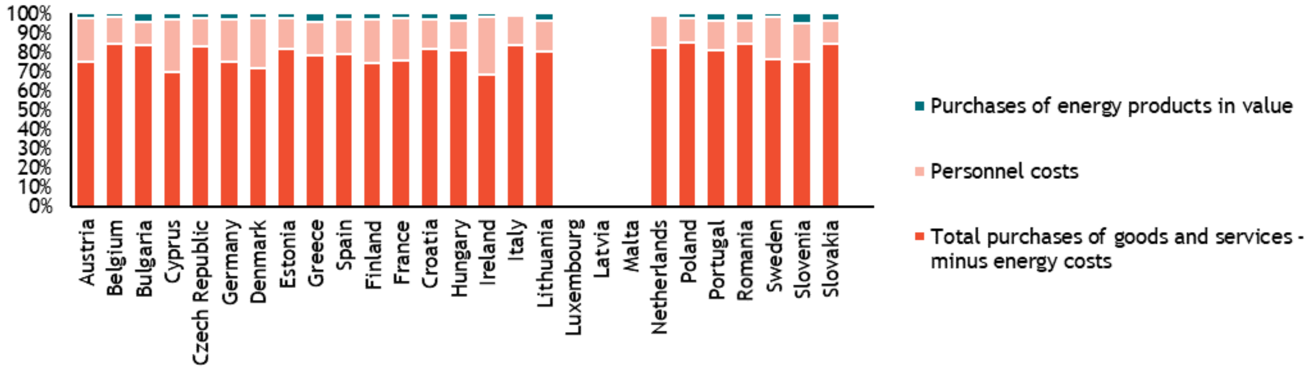


Cost dynamics for Sector C172 – Manufacture of articles of paper and paperboard

Breakdown of production costs

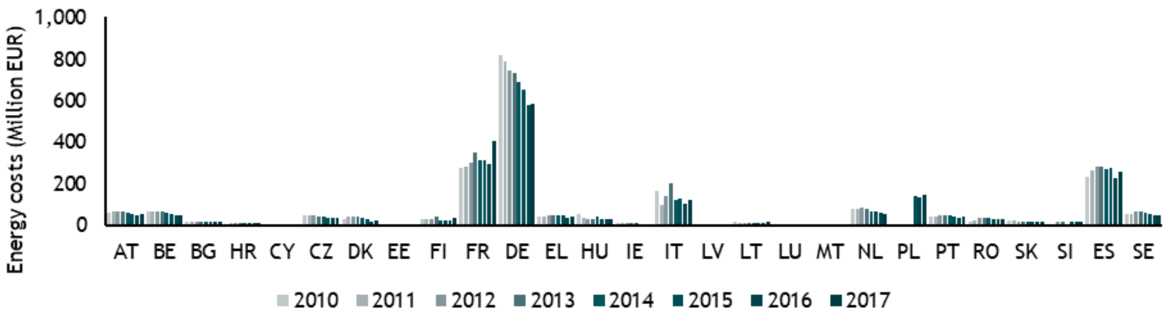
Distribution of costs per Member State in the EU27

Average 2010-2017

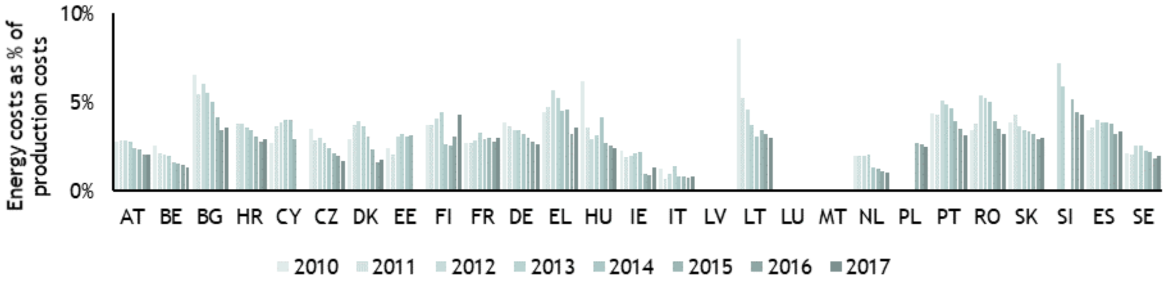


Energy cost shares

Energy costs in value

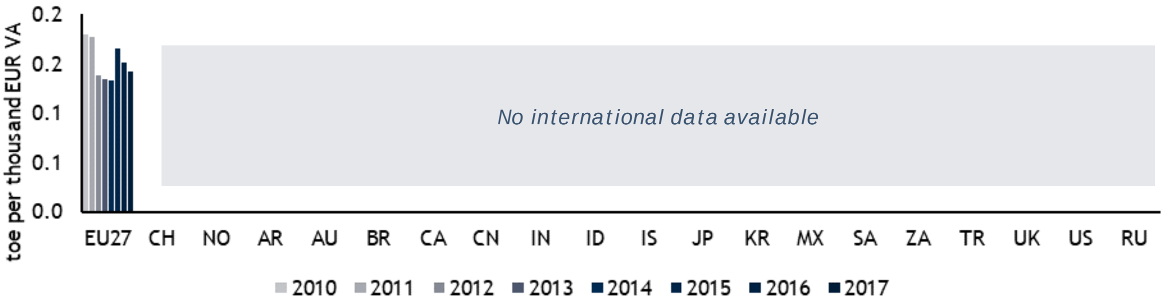


Energy costs as a share of total production costs



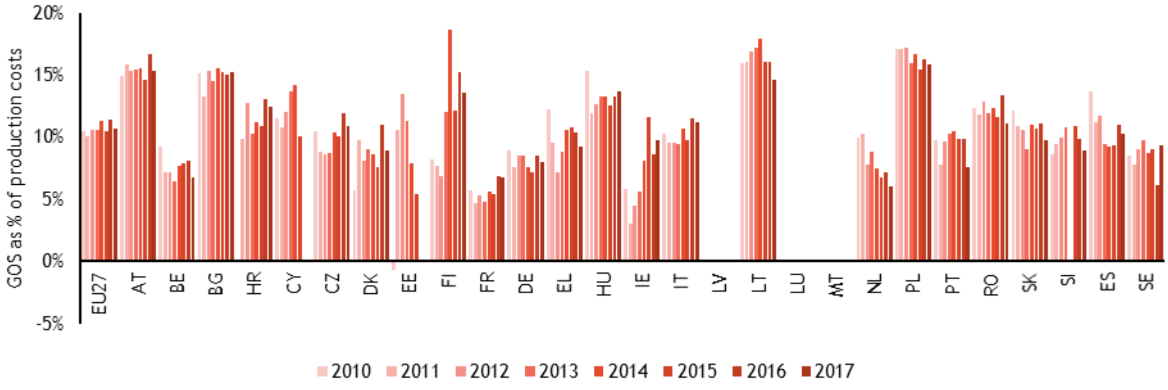
Energy intensity

Consumption of energy per value added



Profitability

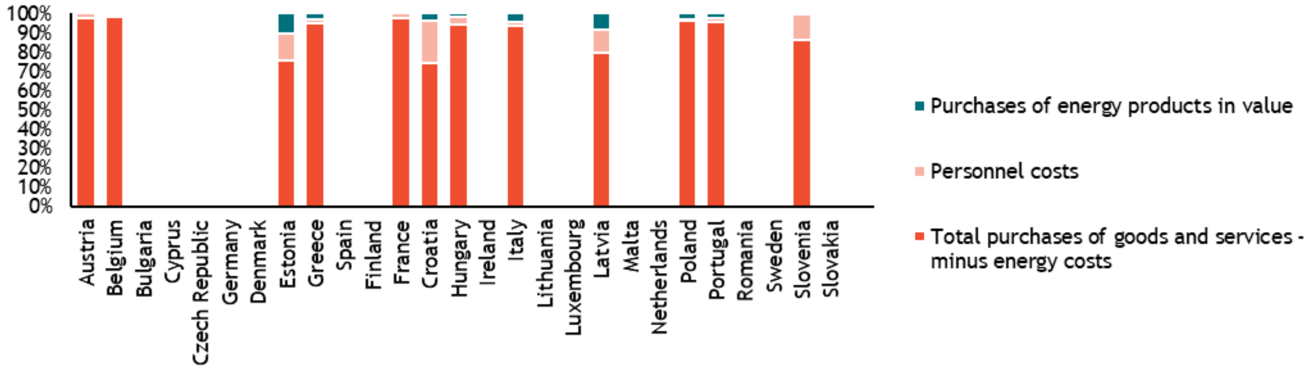
Gross operating surplus as a share of production costs



Cost dynamics for Sector C192 – Manufacture of refined petroleum products

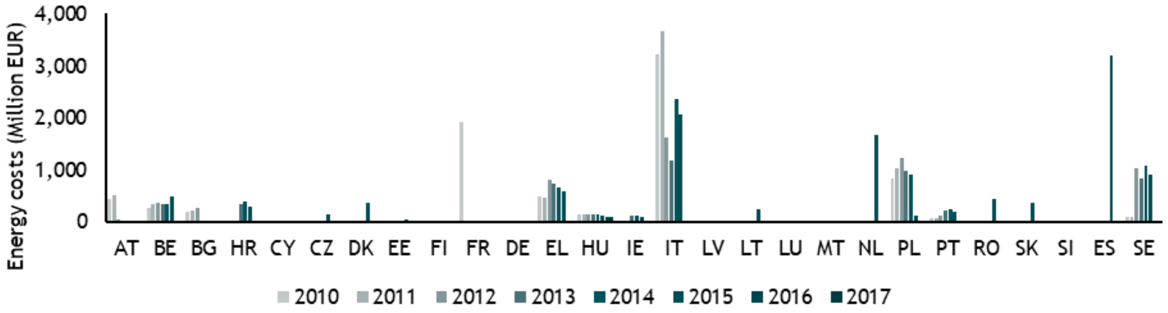
Breakdown of production costs

Distribution of costs per Member State in the EU27
Average 2010-2017

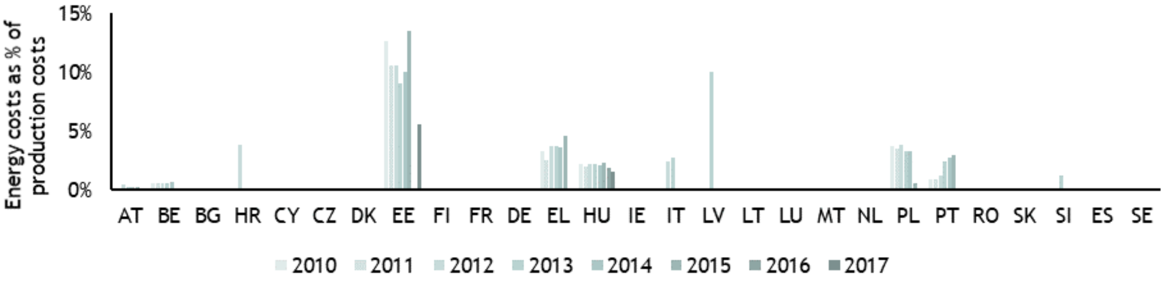


Energy cost shares

Energy costs in value

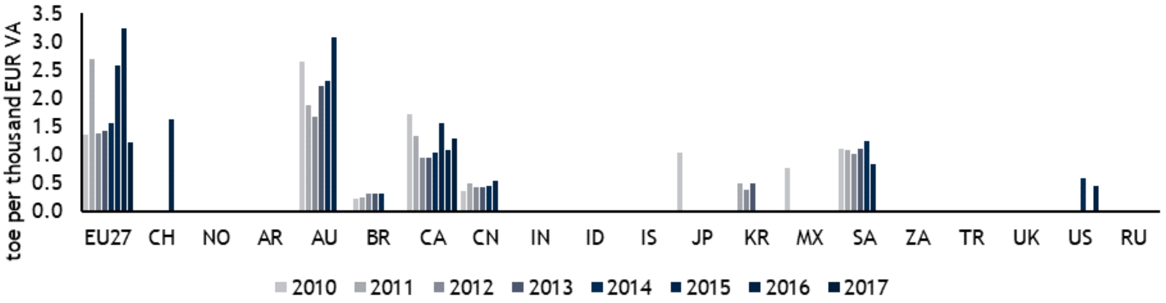


Energy costs as a share of total production costs



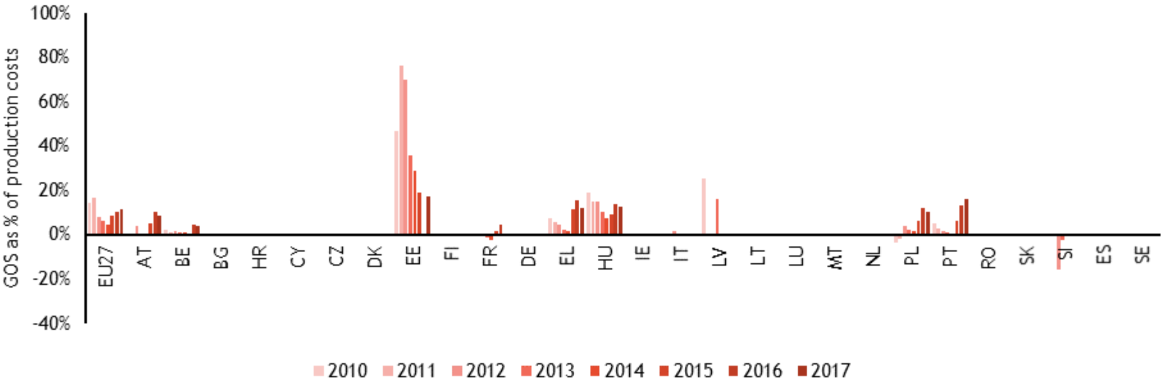
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

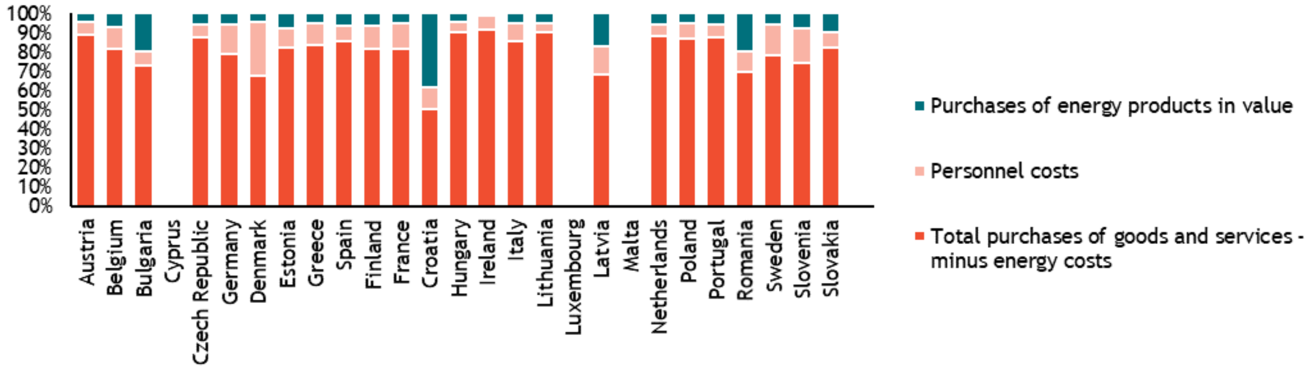


Cost dynamics for Sector C201 – Manufacture of basic chemicals, fertilisers, and nitrogen compounds, plastics, and synthetic rubber in primary forms

Breakdown of production costs

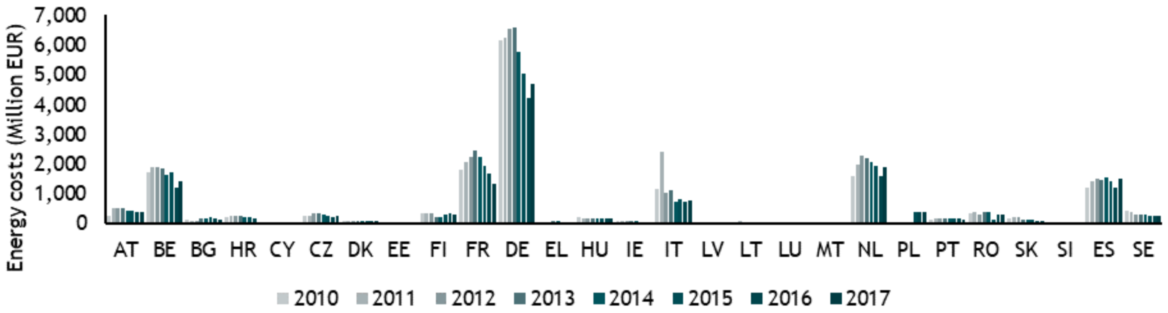
Distribution of costs per Member State in the EU27

Average 2010-2017

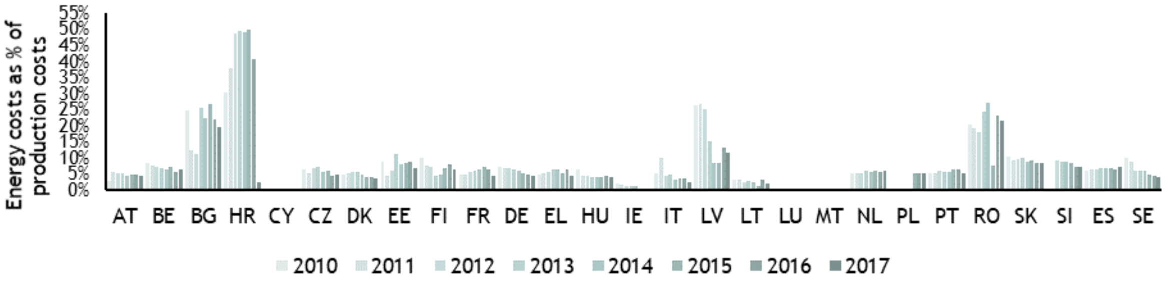


Energy cost shares

Energy costs in value

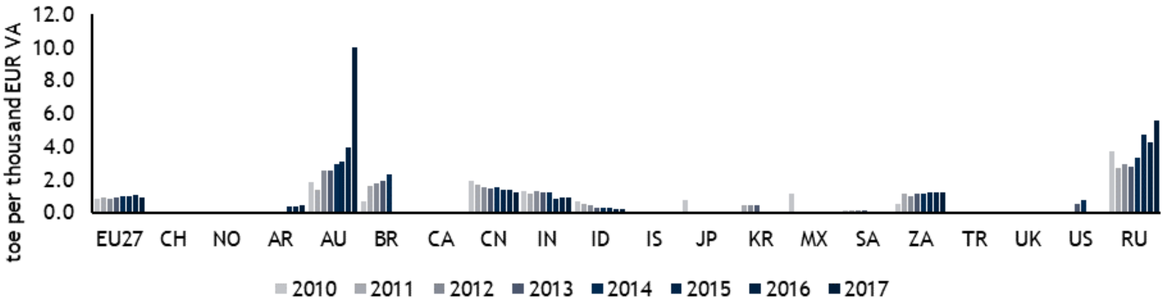


Energy costs as a share of total production costs



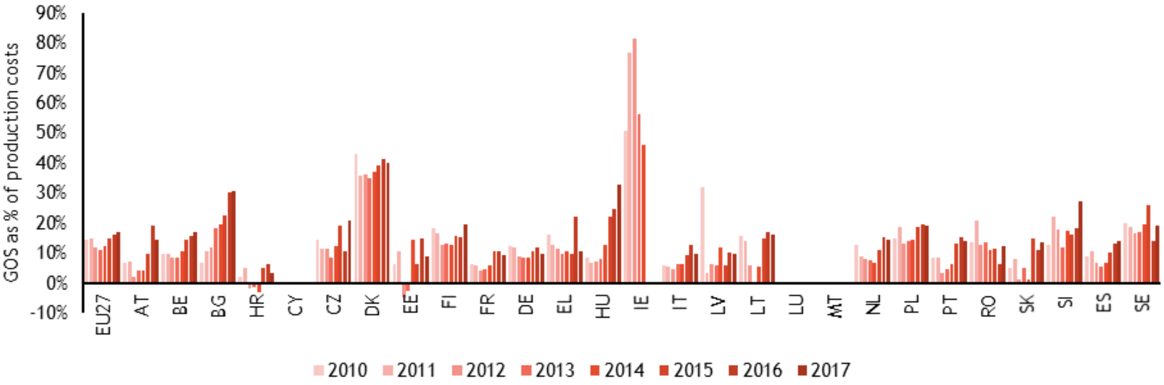
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

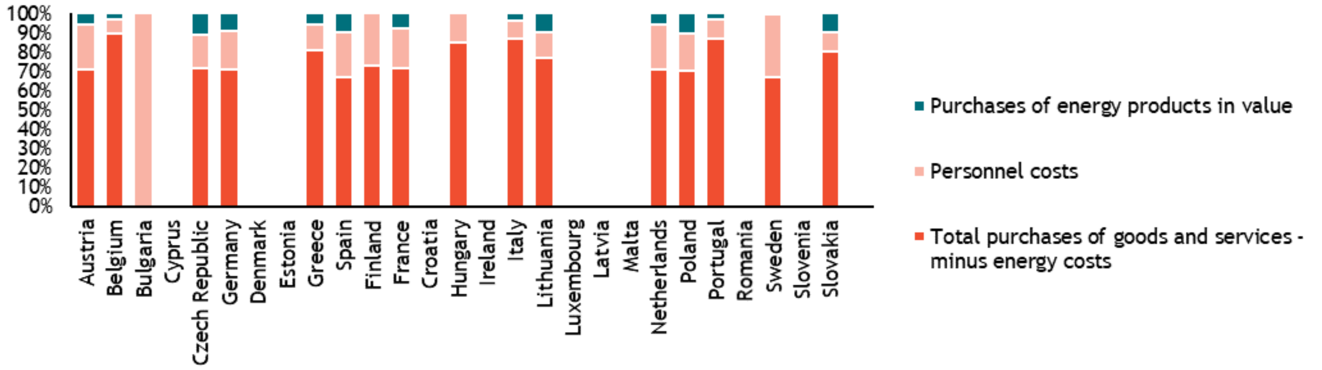


Cost dynamics for Sector C206 – Manufacture of man-made fibres

Breakdown of production costs

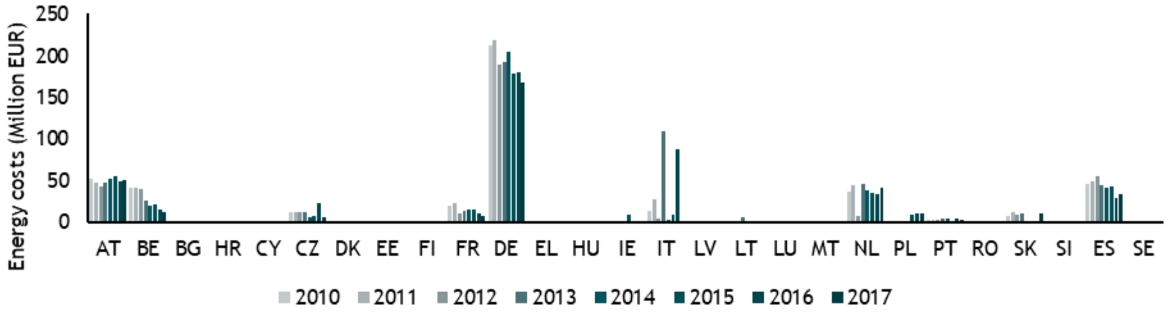
Distribution of costs per Member State in the EU27

Average 2010-2017

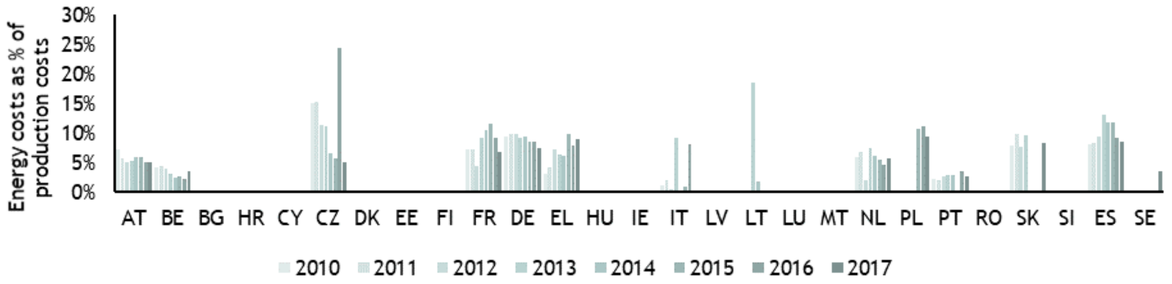


Energy cost shares

Energy costs in value

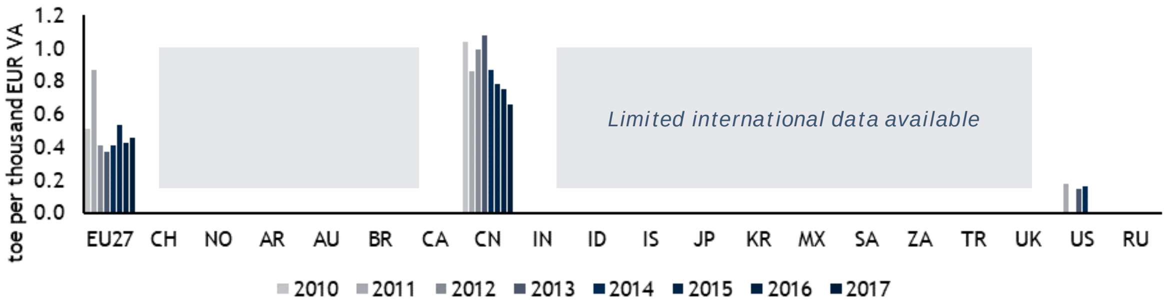


Energy costs as a share of total production costs



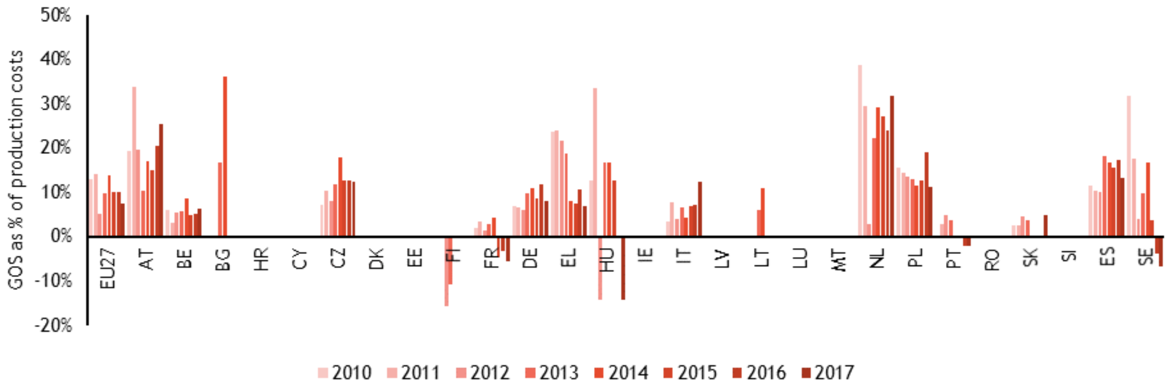
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

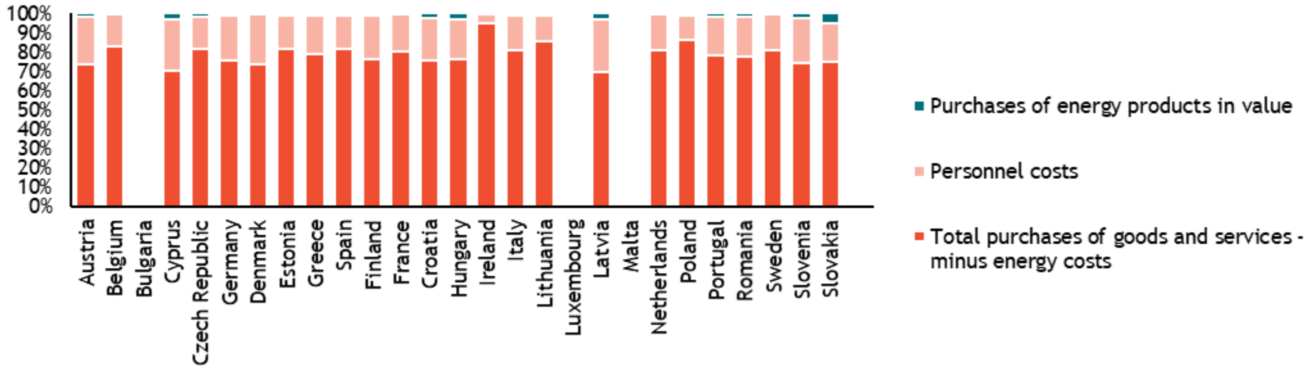


Cost dynamics for Sector C21 – Manufacture of basic pharmaceutical products

Breakdown of production costs

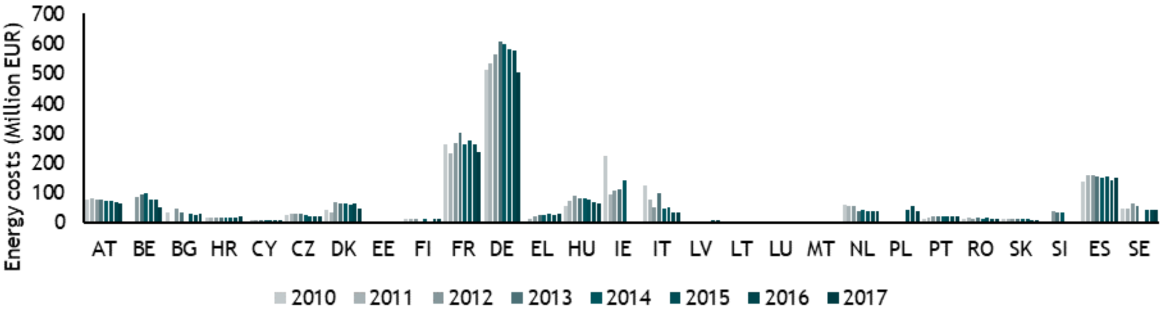
Distribution of costs per Member State in the EU27

Average 2010-2017

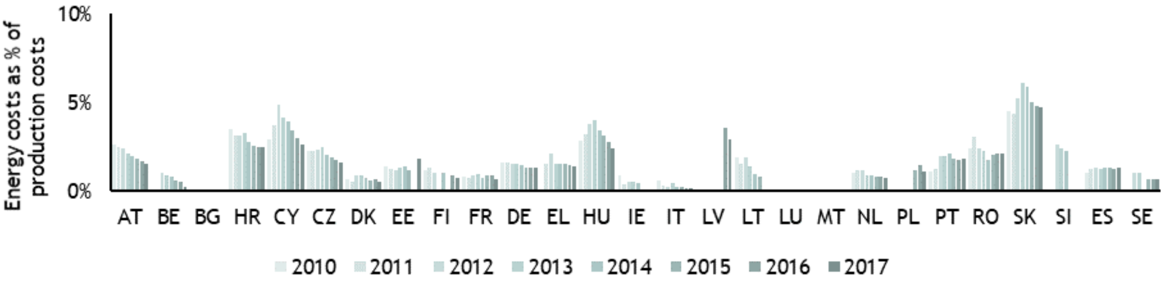


Energy cost shares

Energy costs in value

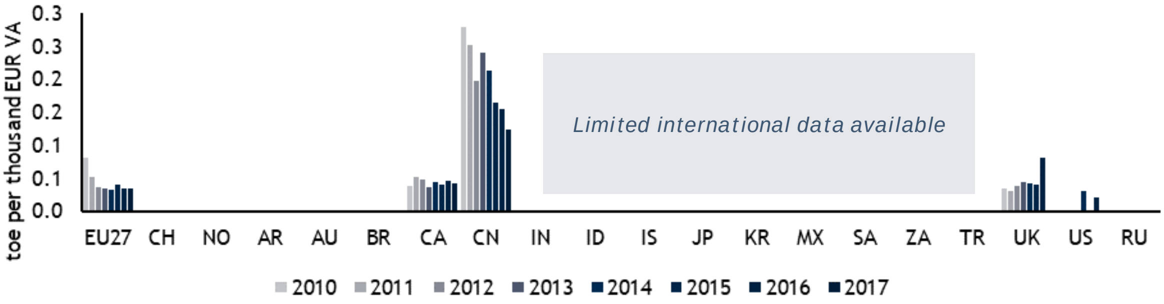


Energy costs as a share of total production costs



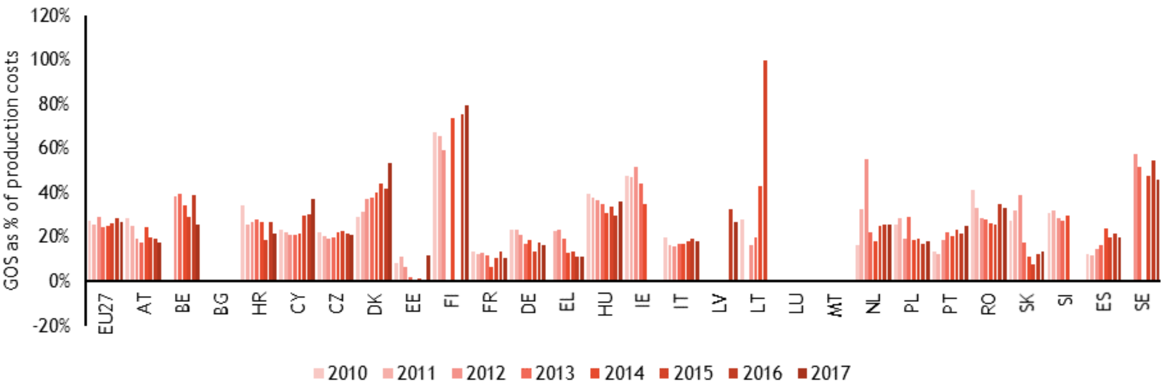
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

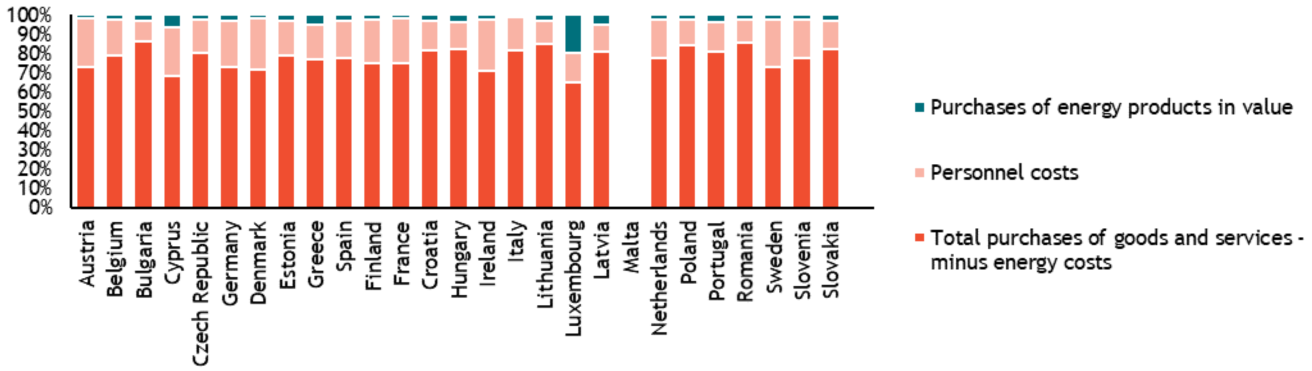


Cost dynamics for Sector C222 – Manufacture of plastics products

Breakdown of production costs

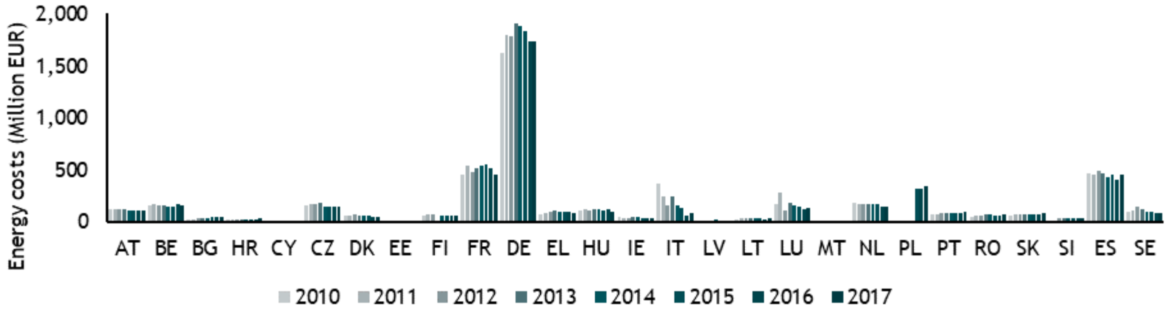
Distribution of costs per Member State in the EU27

Average 2010-2017

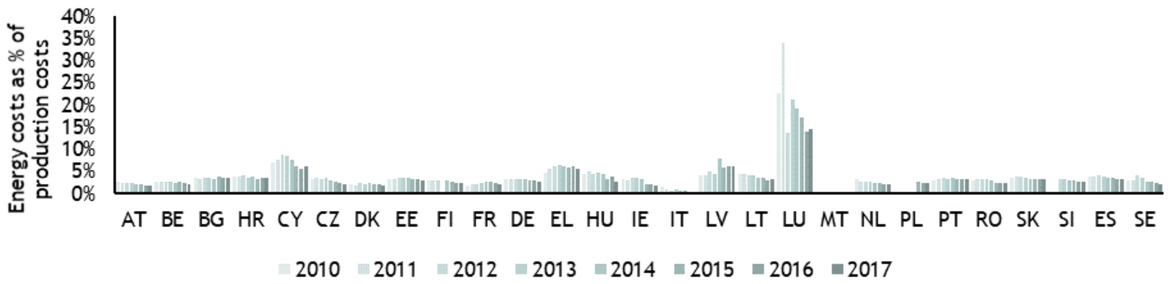


Energy cost shares

Energy costs in value

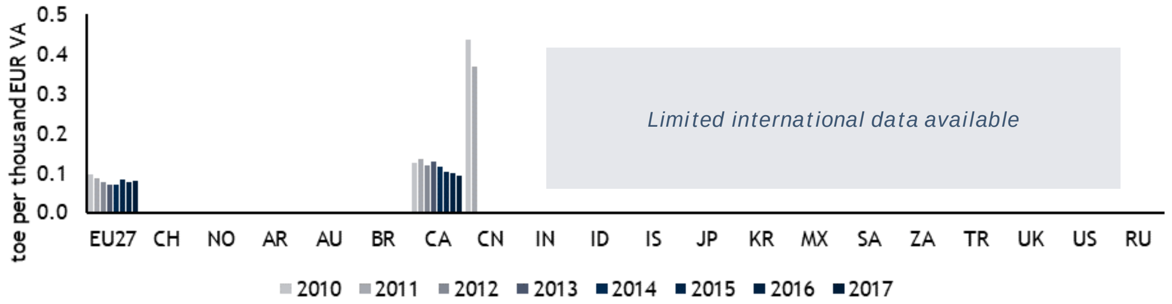


Energy costs as a share of total production costs



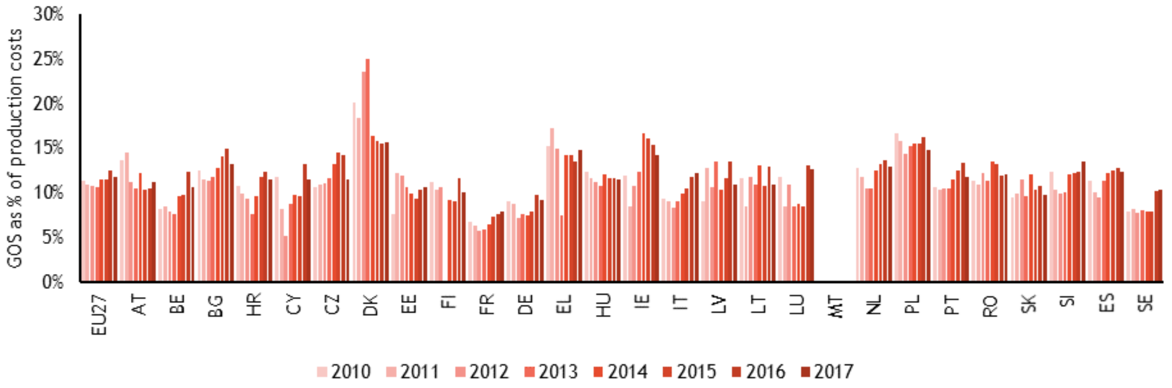
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

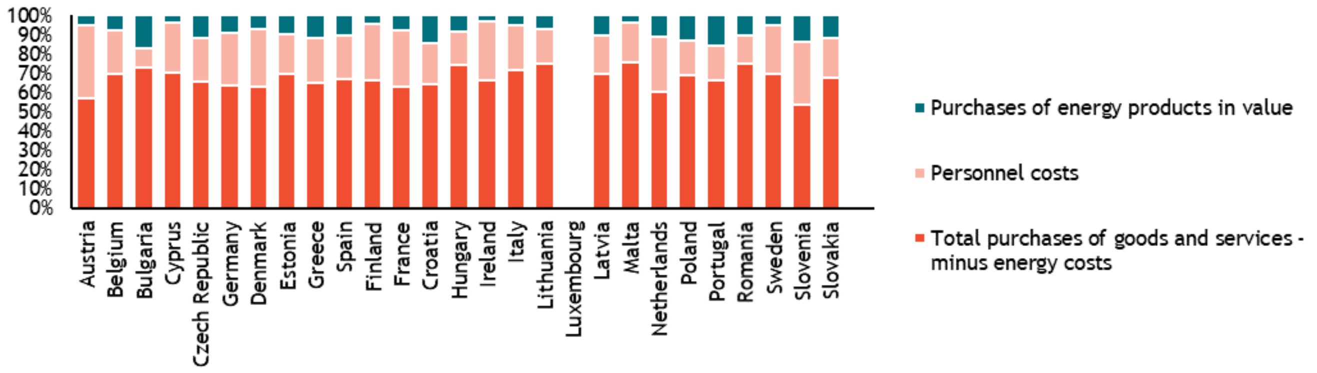


Cost dynamics for Sector 231 – Manufacture of glass and glass products

Breakdown of production costs

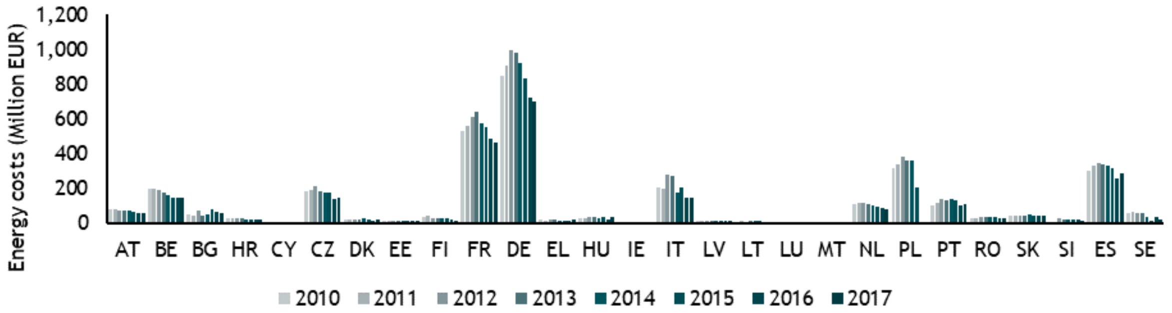
Distribution of costs per Member State in the EU27

Average 2010-2017

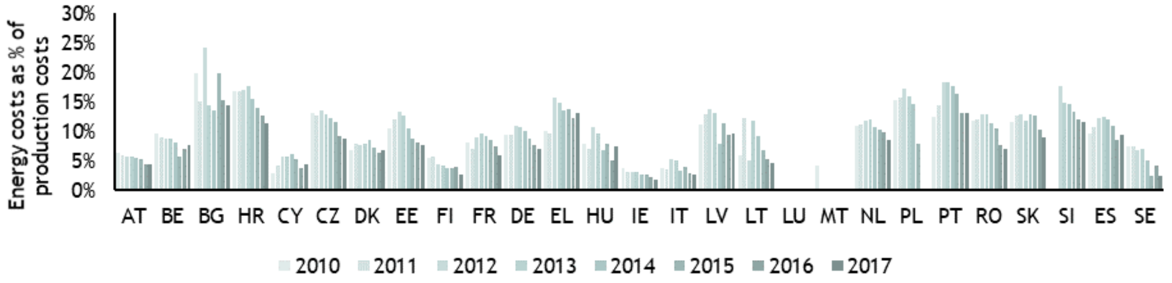


Energy cost shares

Energy costs in value

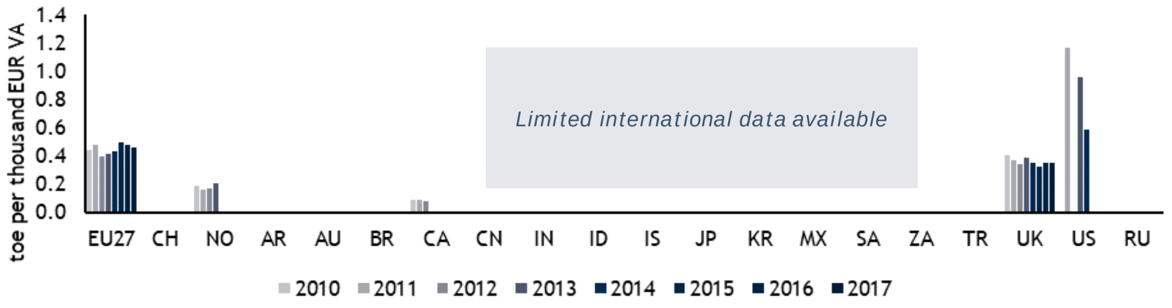


Energy costs as a share of total production costs



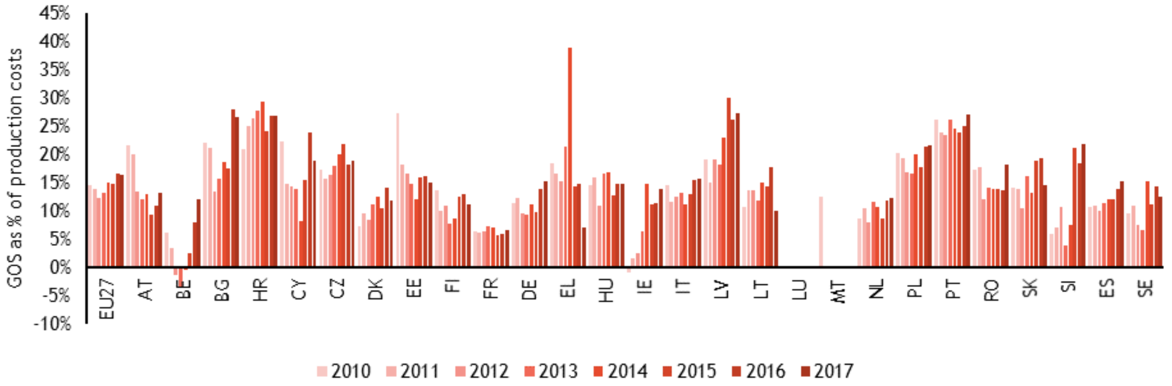
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

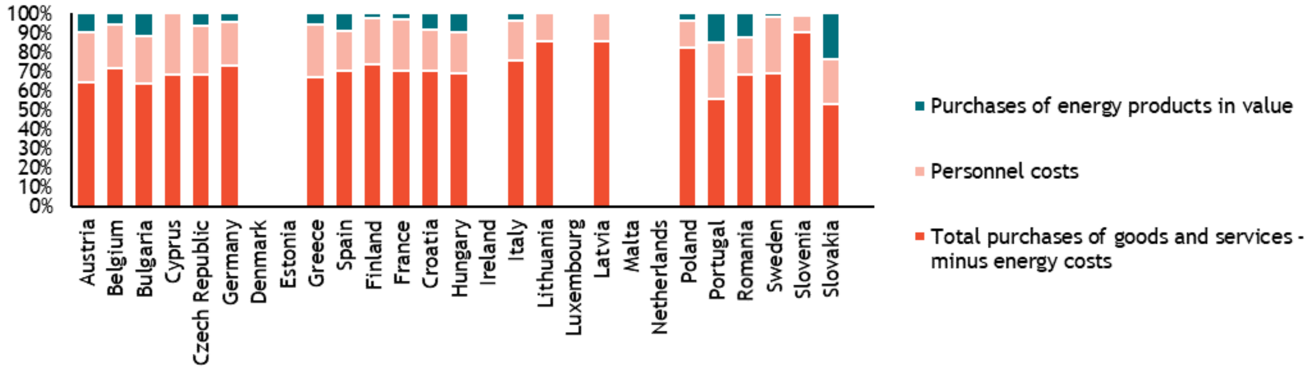


Cost dynamics for Sector C232 – Manufacture of refractory products

Breakdown of production costs

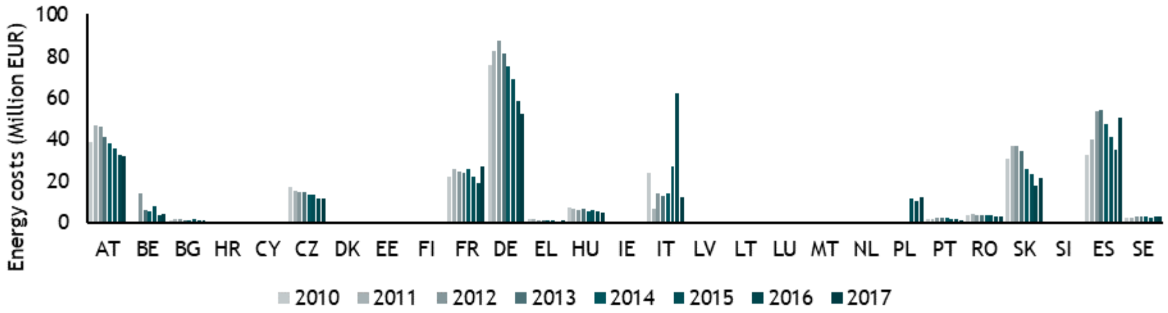
Distribution of costs per Member State in the EU27

Average 2010-2017

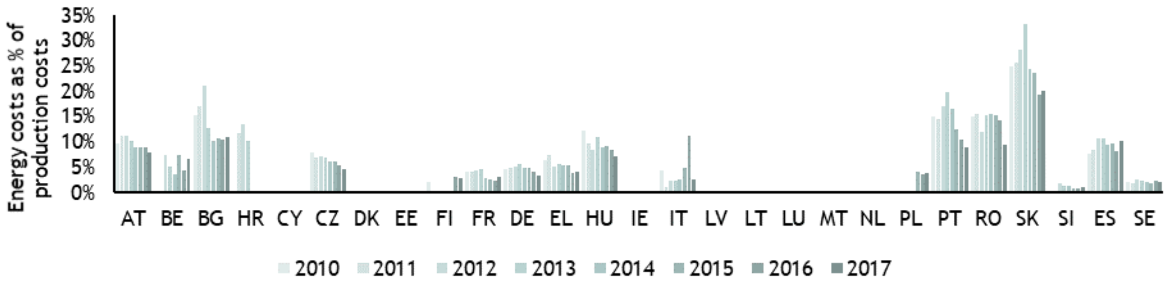


Energy cost shares

Energy costs in value

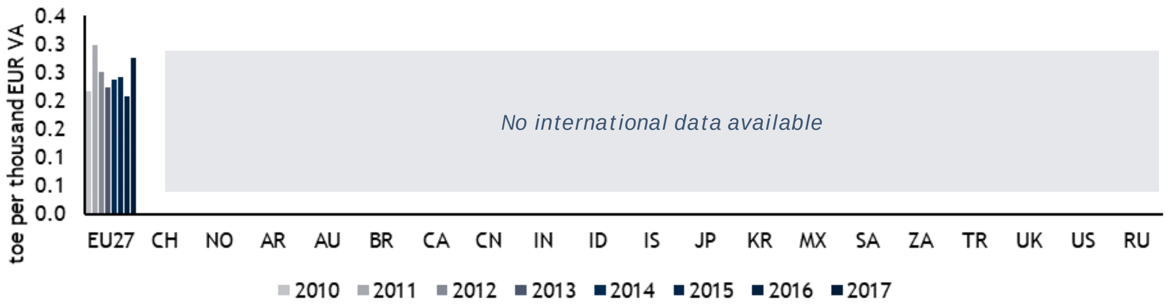


Energy costs as a share of total production costs



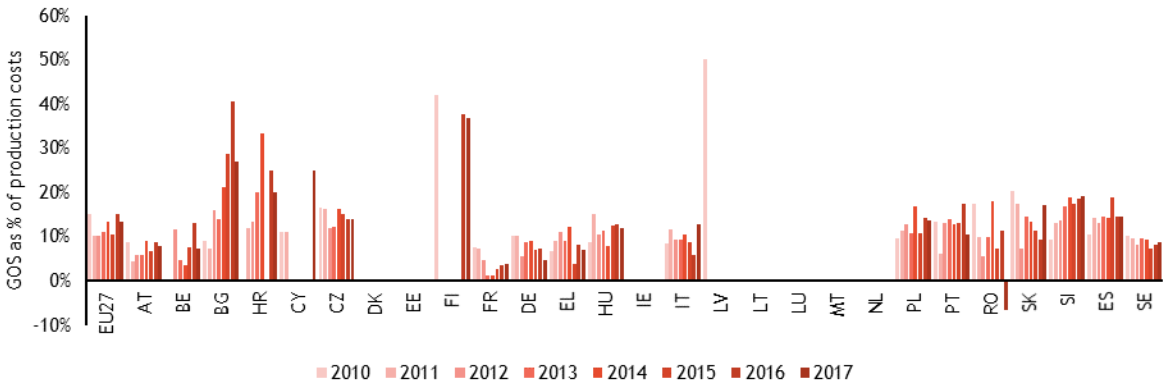
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

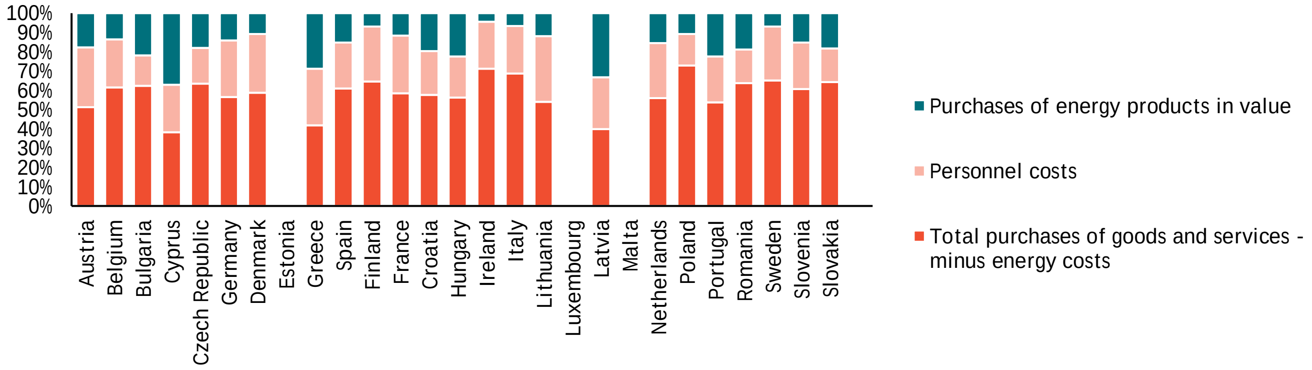


Cost dynamics for Sector 233 – Manufacture of clay building materials

Breakdown of production costs

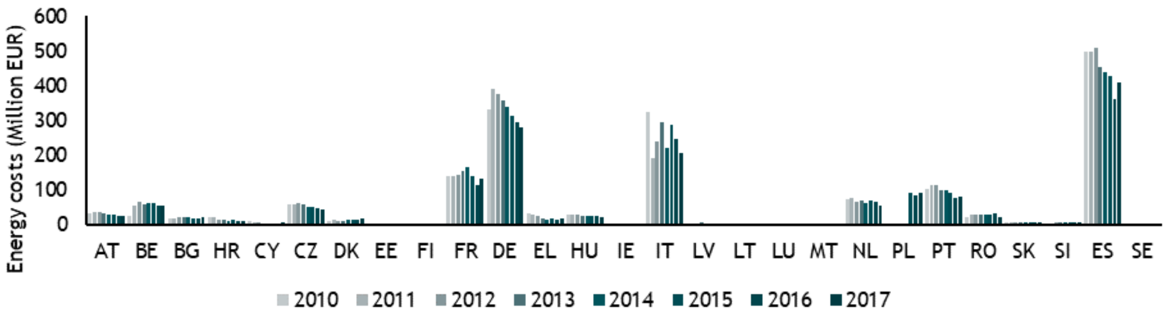
Distribution of costs per Member State in the EU27

Average 2010-2017

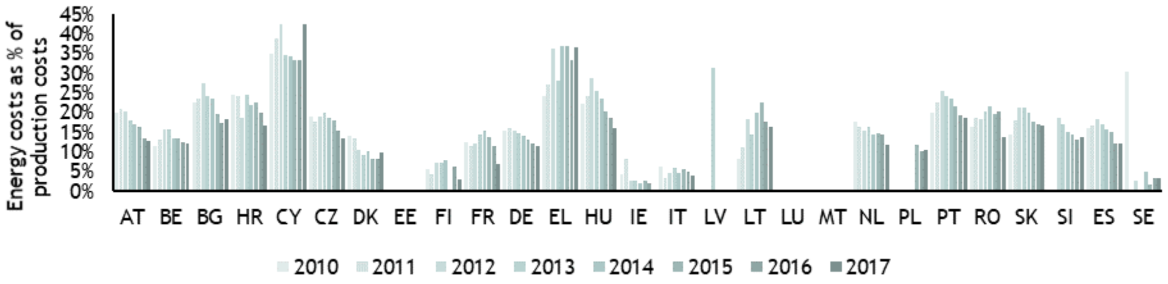


Energy cost shares

Energy costs in value

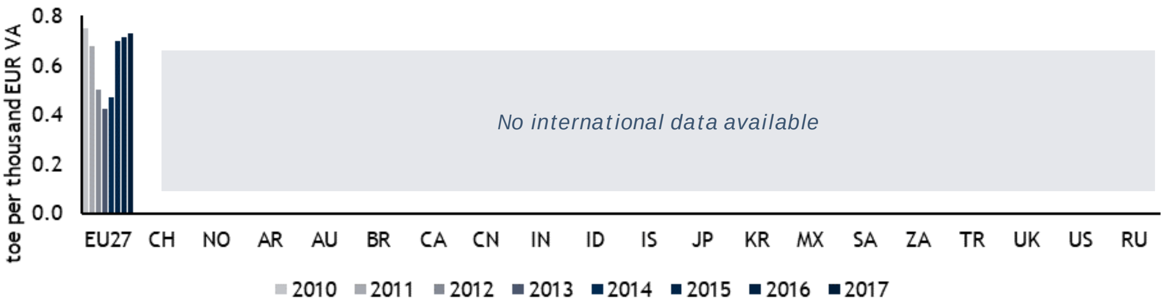


Energy costs as a share of total production costs



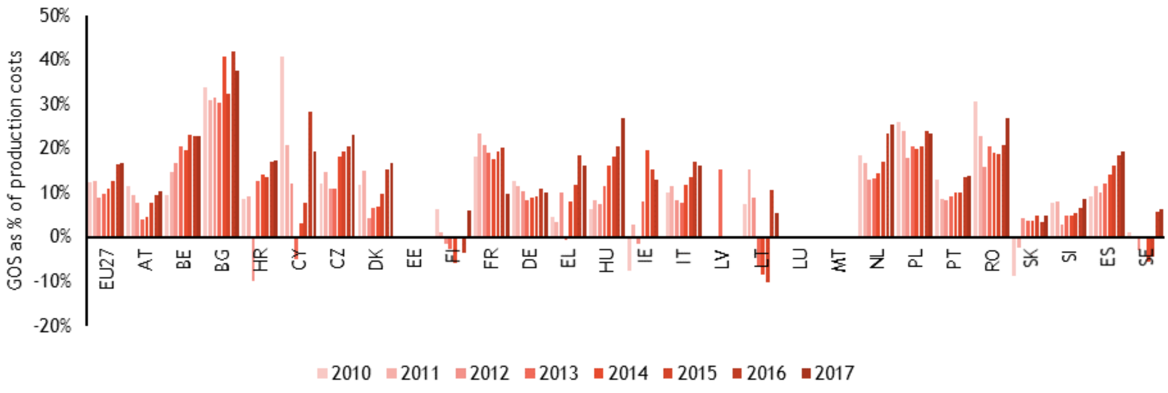
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

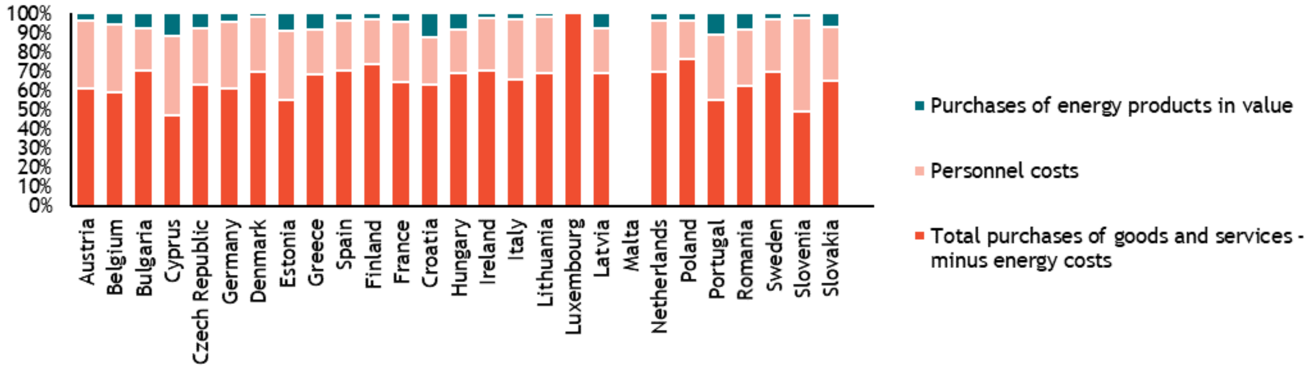


Cost dynamics for Sector C234 - Manufacture of other porcelain and ceramic products

Breakdown of production costs

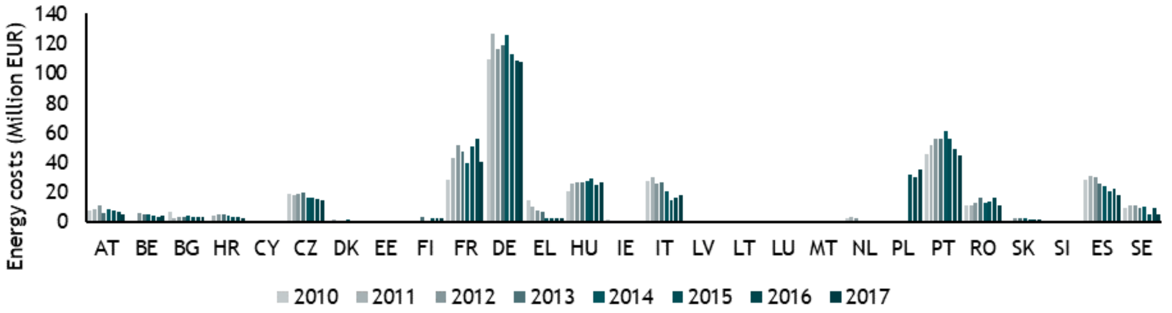
Distribution of costs per Member State in the EU27

Average 2010-2017

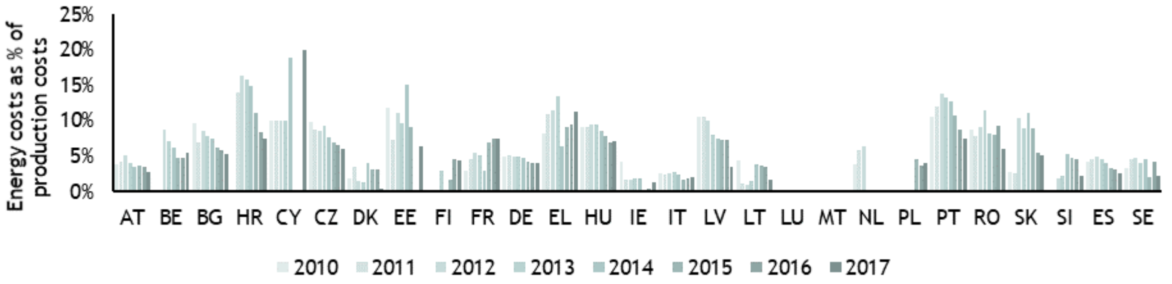


Energy cost shares

Energy costs in value

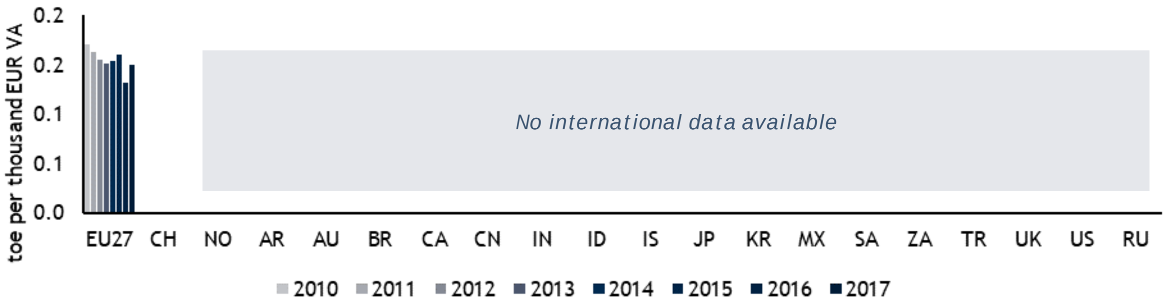


Energy costs as a share of total production costs



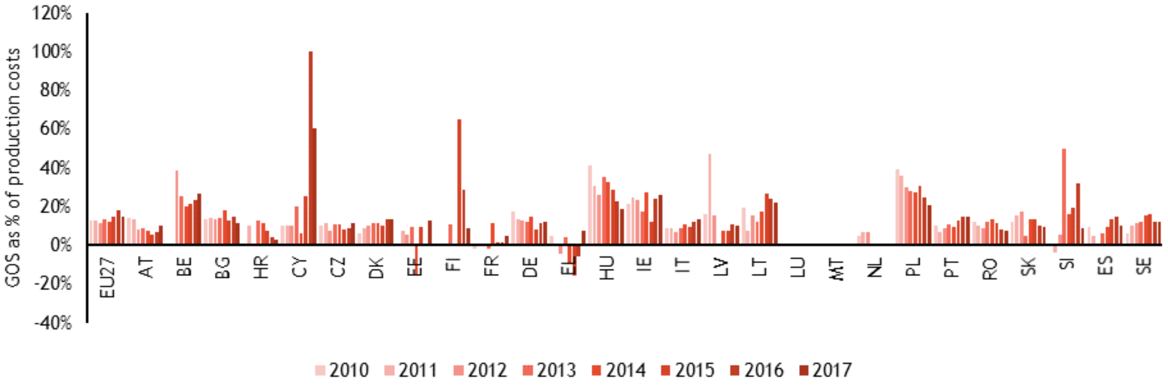
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

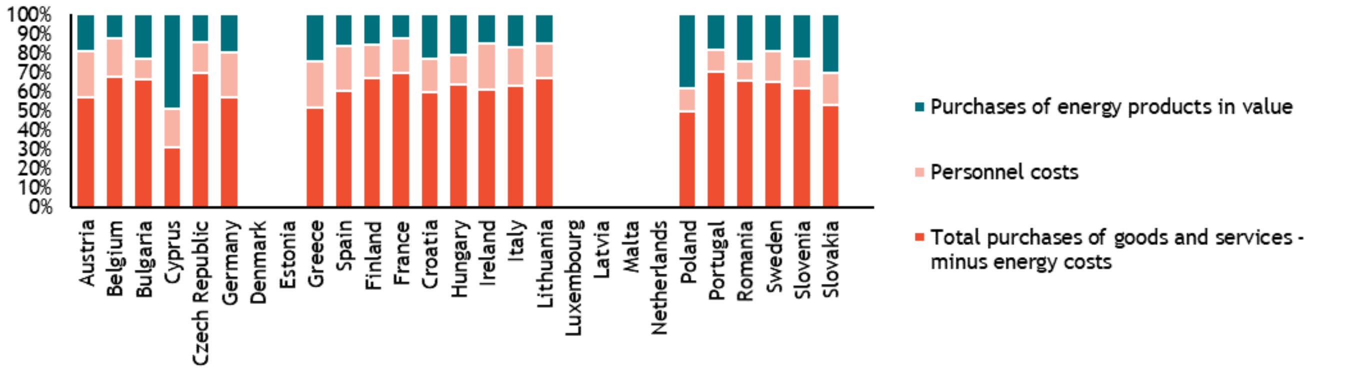


Cost dynamics for Sector C235 - Manufacture of cement, lime and plaster

Breakdown of production costs

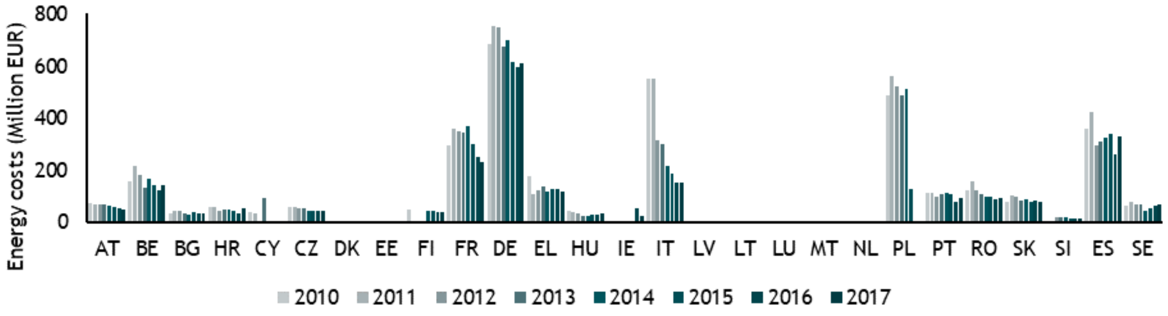
Distribution of costs per Member State in the EU27

Average 2010-2017

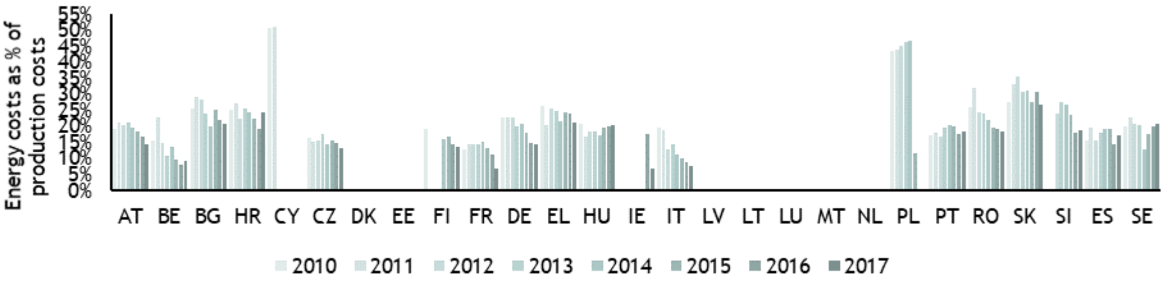


Energy cost shares

Energy costs in value

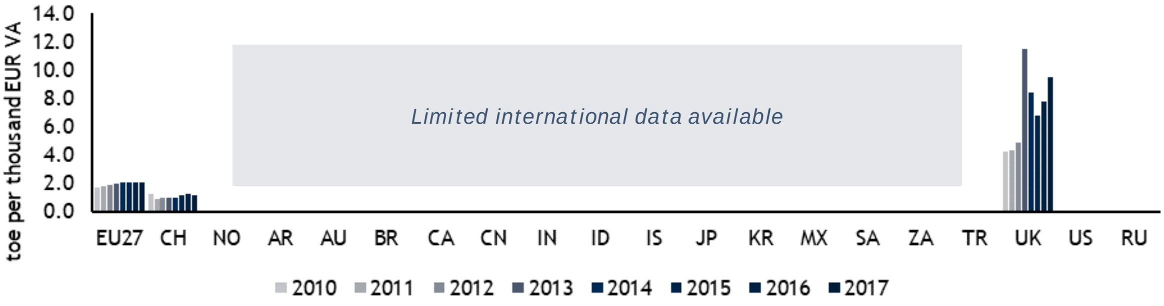


Energy costs as a share of total production costs



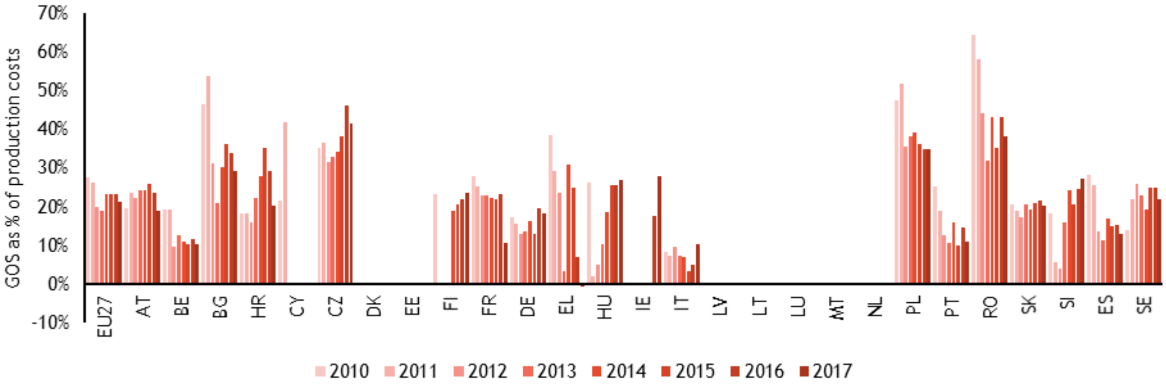
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

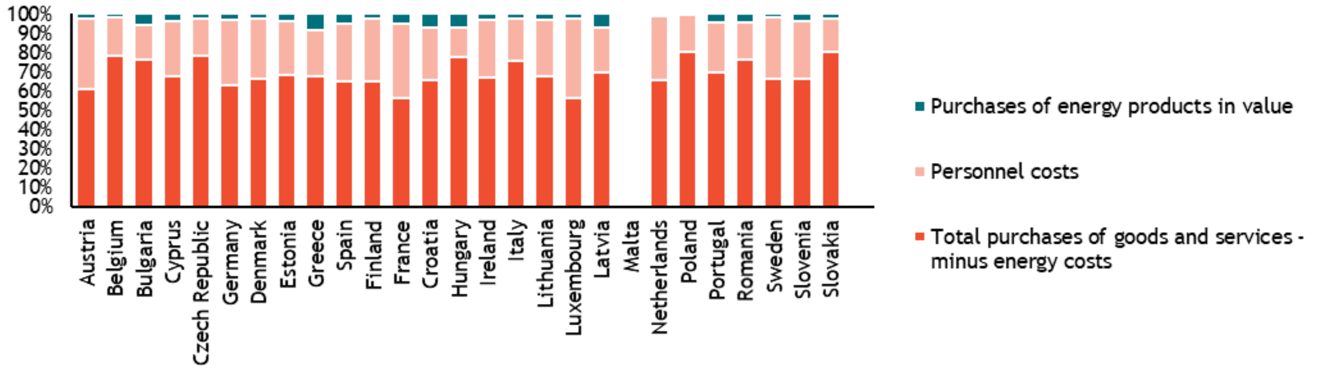


Cost dynamics for Sector C237 - Cutting, shaping and finishing of stone

Breakdown of production costs

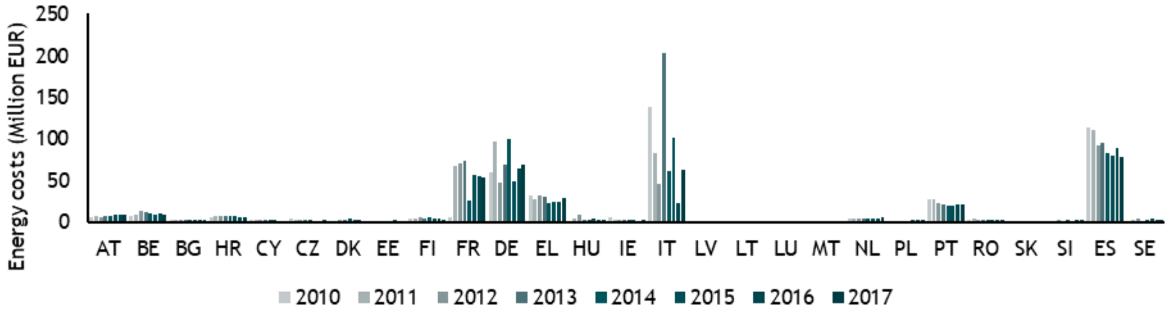
Distribution of costs per Member State in the EU27

Average 2010-2017

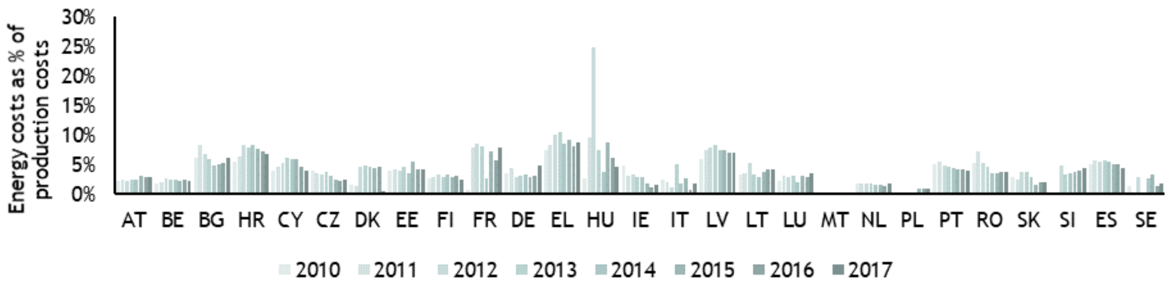


Energy cost shares

Energy costs in value

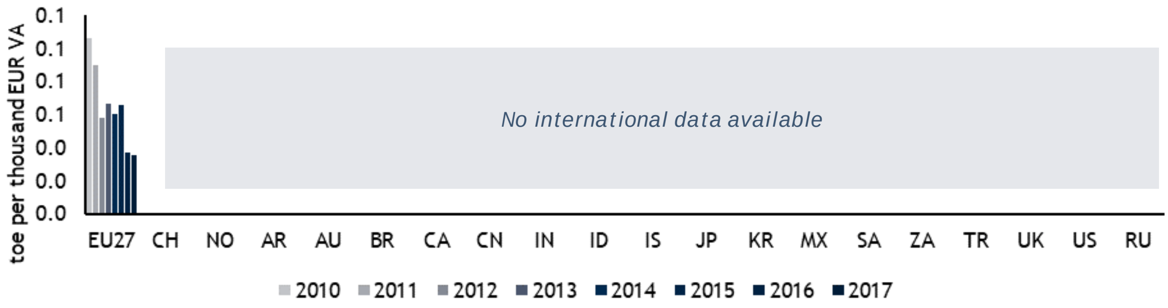


Energy costs as a share of total production costs



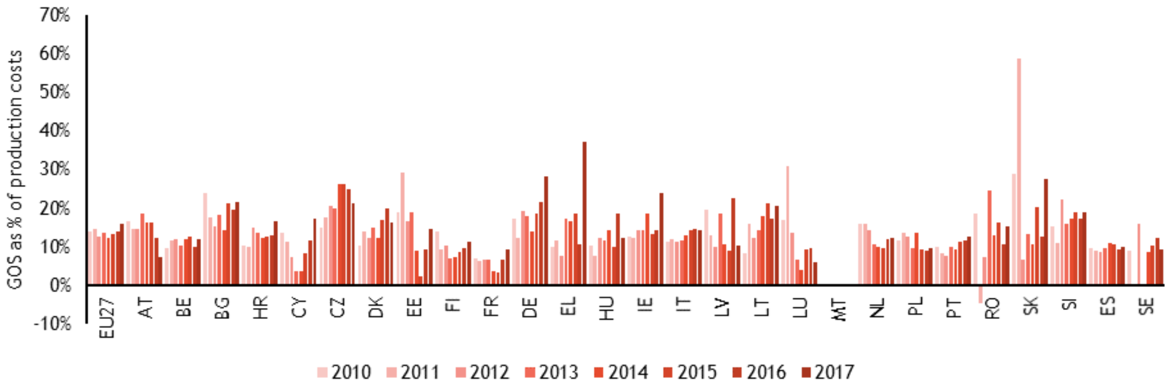
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

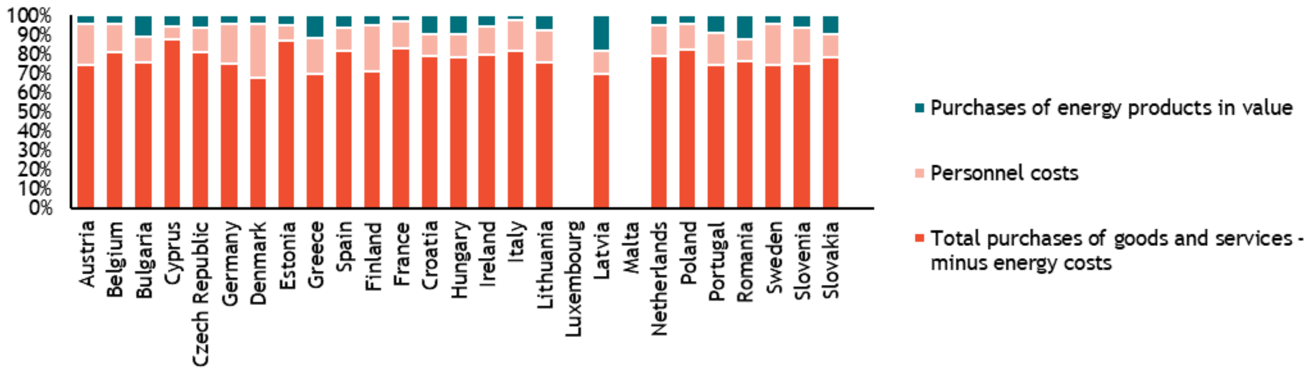


Cost dynamics for Sector C239 - Manufacture of abrasive products and non-metallic mineral products

Breakdown of production costs

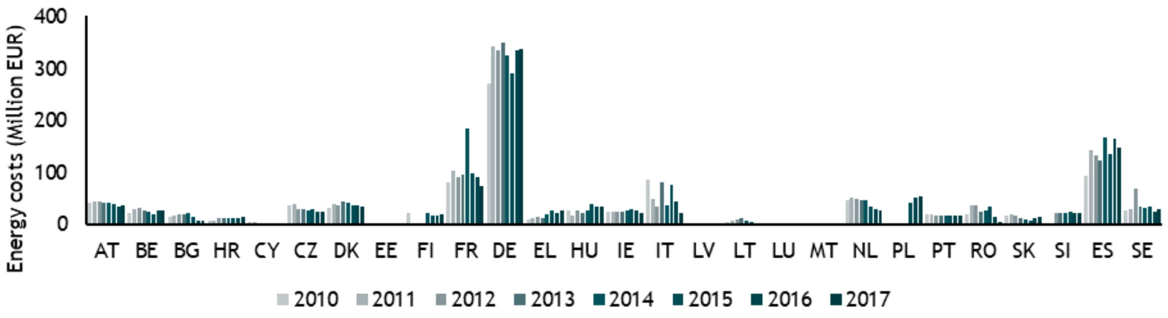
Distribution of costs per Member State in the EU27

Average 2010-2017

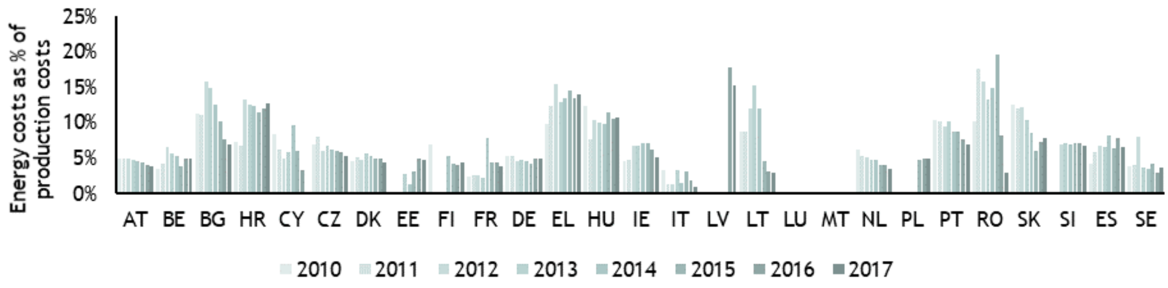


Energy cost shares

Energy costs in value

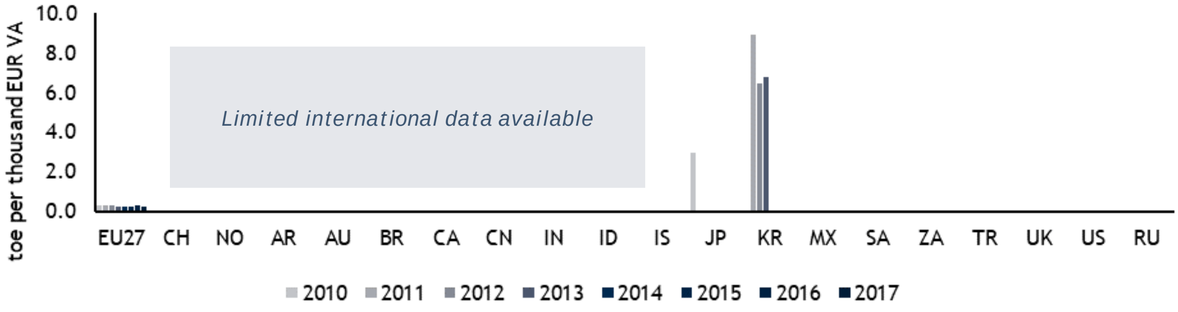


Energy costs as a share of total production costs



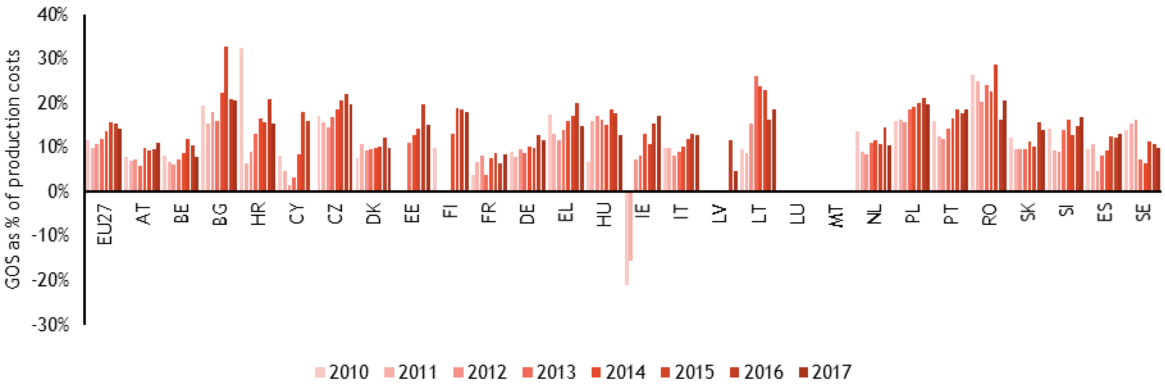
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

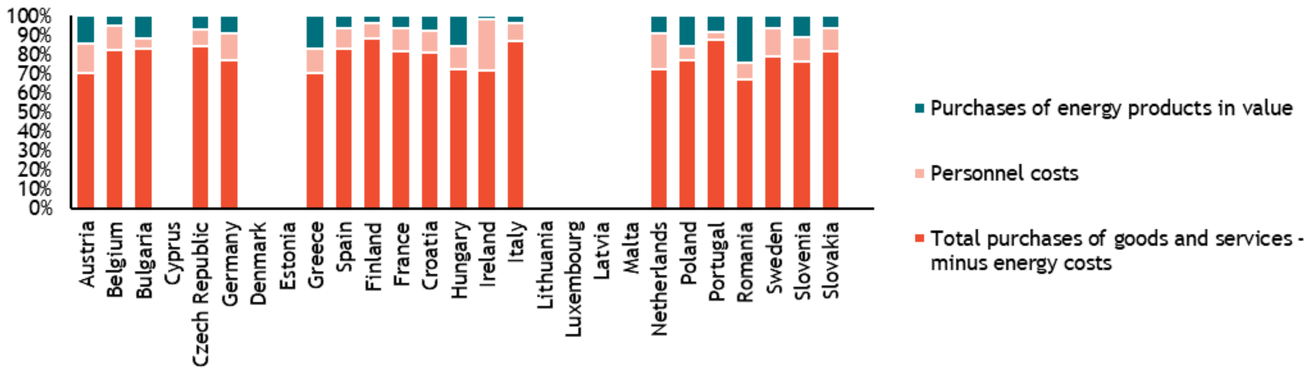


Cost dynamics for Sector C241 – Manufacture of basic iron and steel and of ferro-alloys

Breakdown of production costs

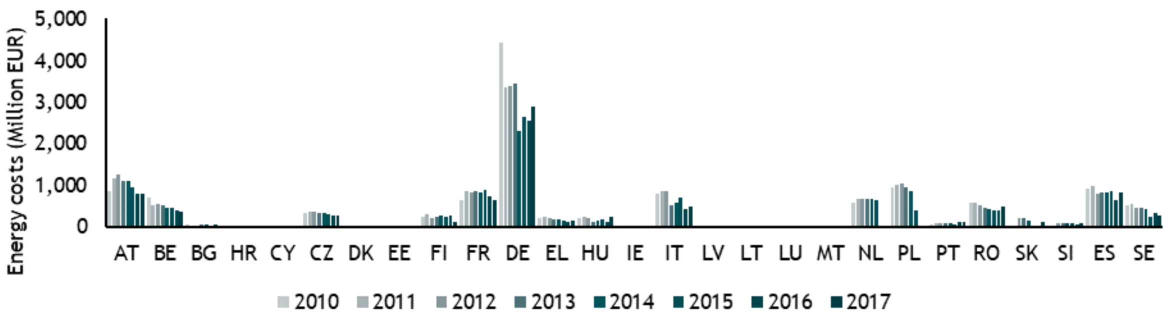
Distribution of costs per Member State in the EU27

Average 2010-2017

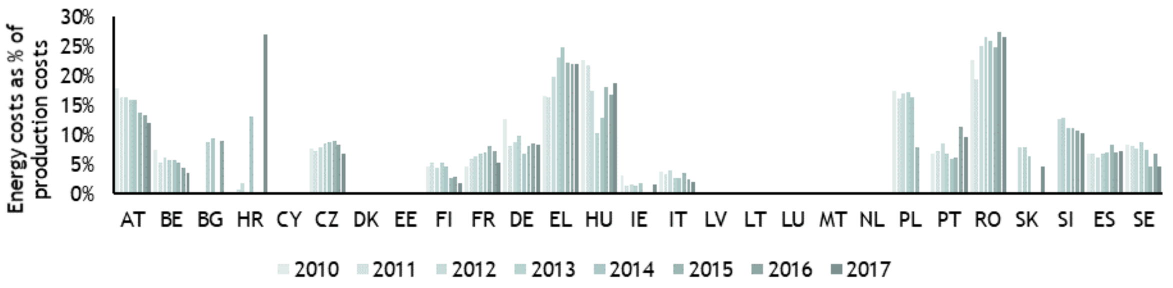


Energy cost shares

Energy costs in value

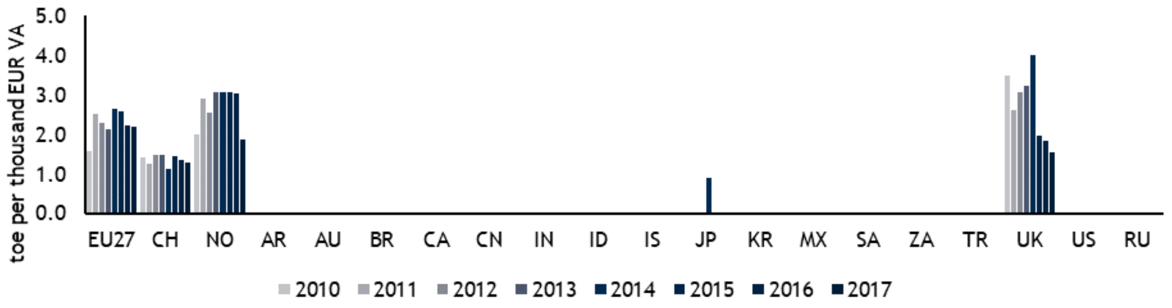


Energy costs as a share of total production costs



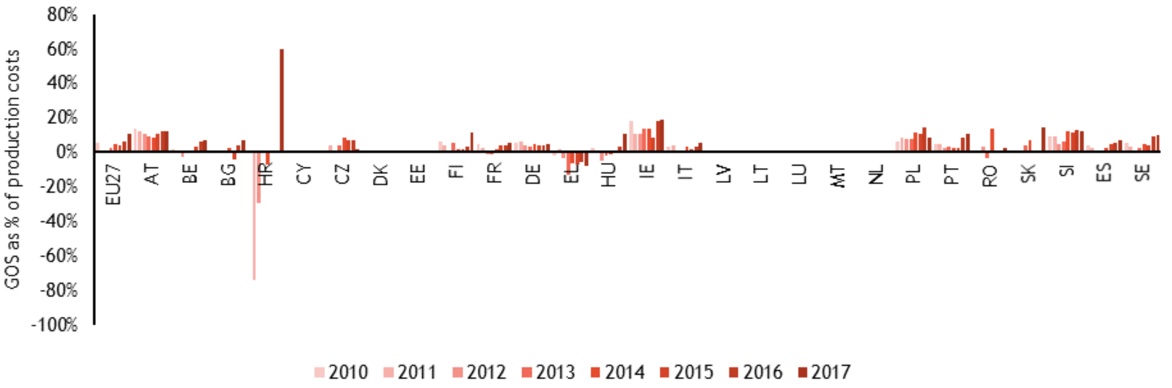
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

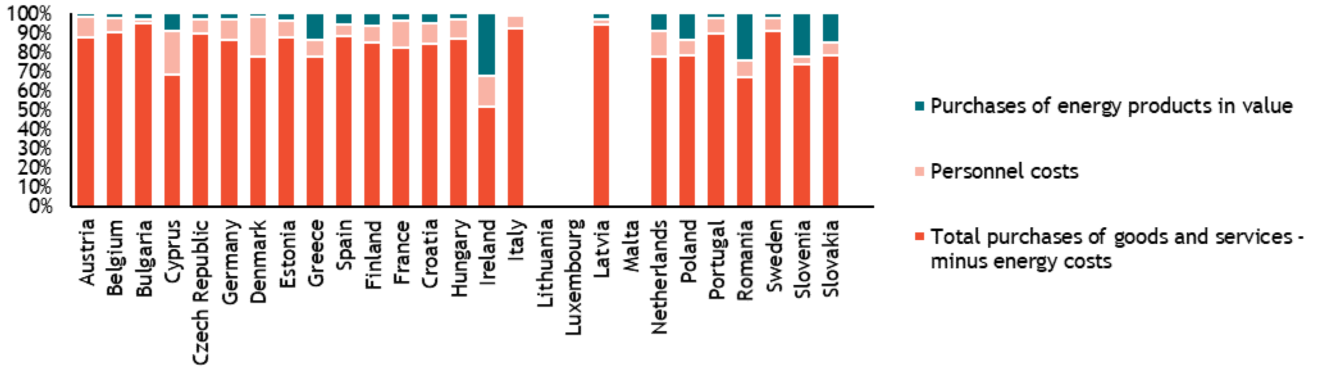


Cost dynamics for Sector C244 - Manufacture of basic precious and other non-ferrous metals

Breakdown of production costs

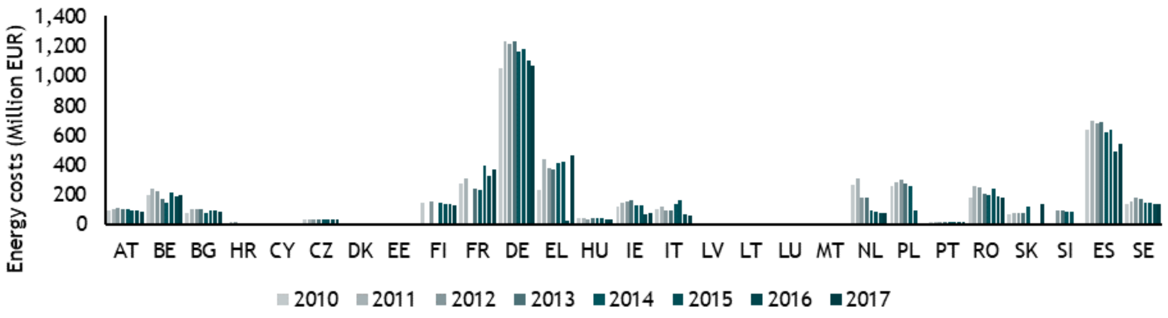
Distribution of costs per Member State in the EU27

Average 2010-2017

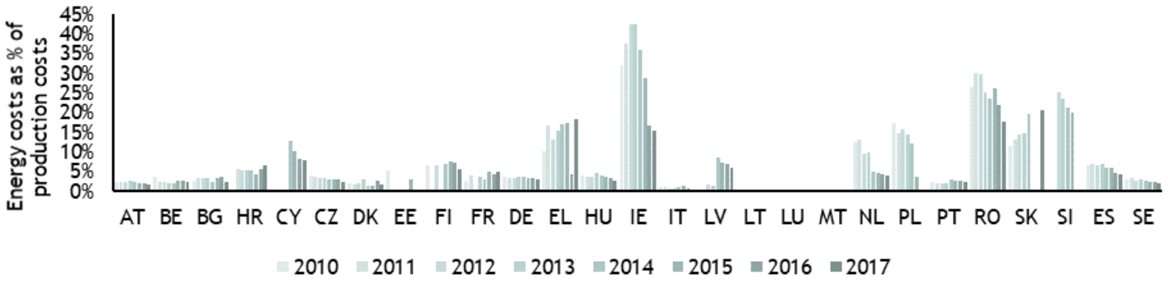


Energy cost shares

Energy costs in value

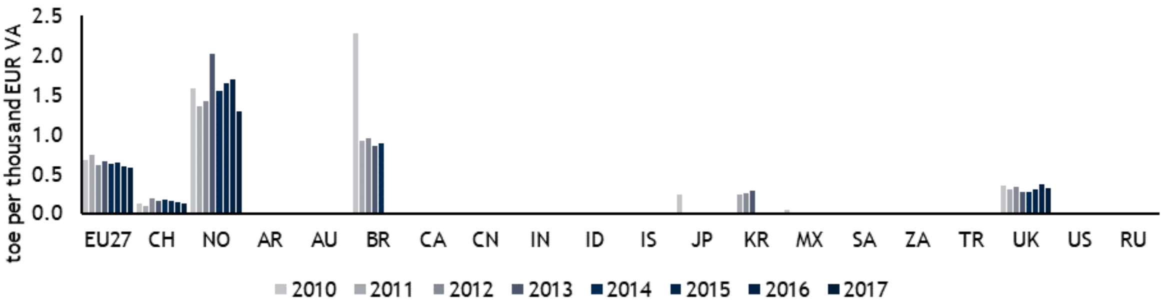


Energy costs as a share of total production costs



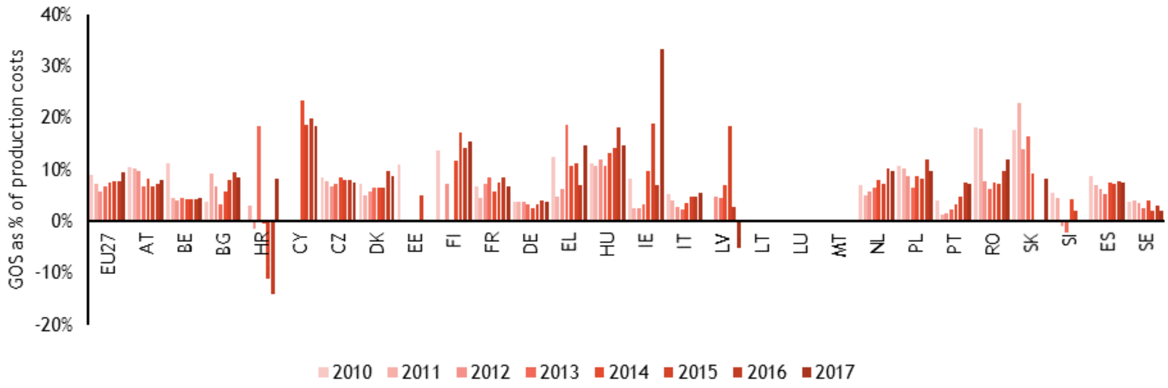
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

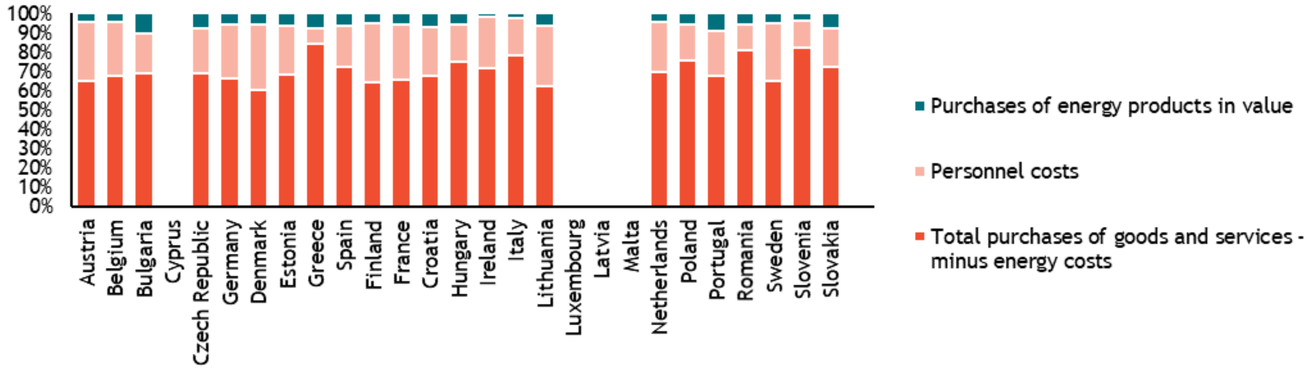


Cost dynamics for Sector C245 - Casting of metals

Breakdown of production costs

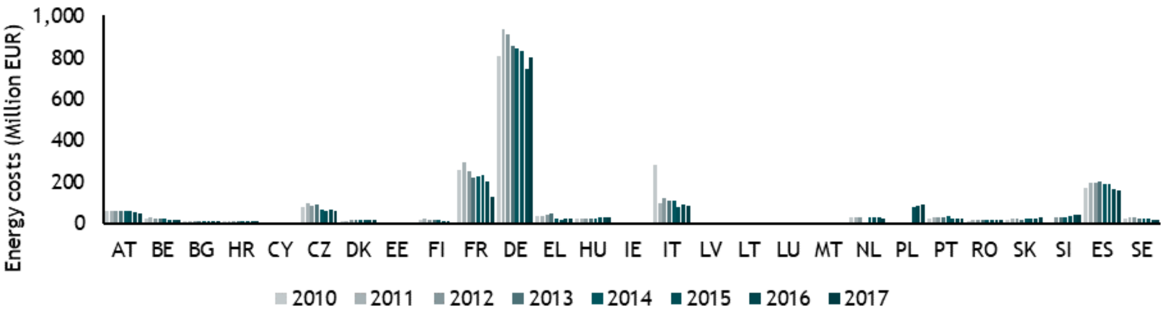
Distribution of costs per Member State in the EU27

Average 2010-2017

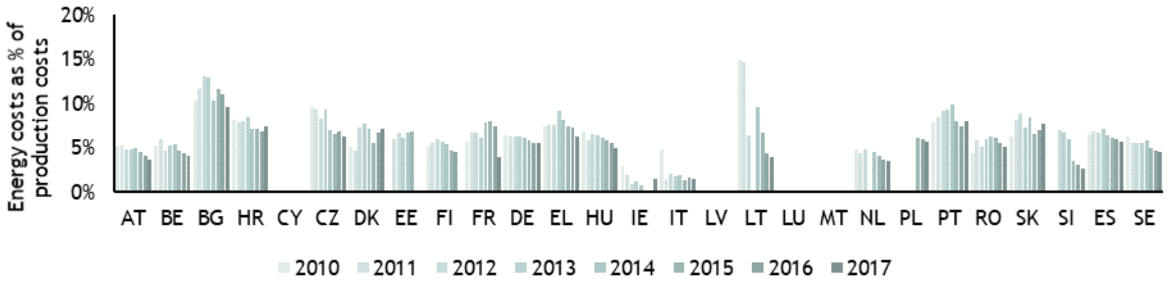


Energy cost shares

Energy costs in value

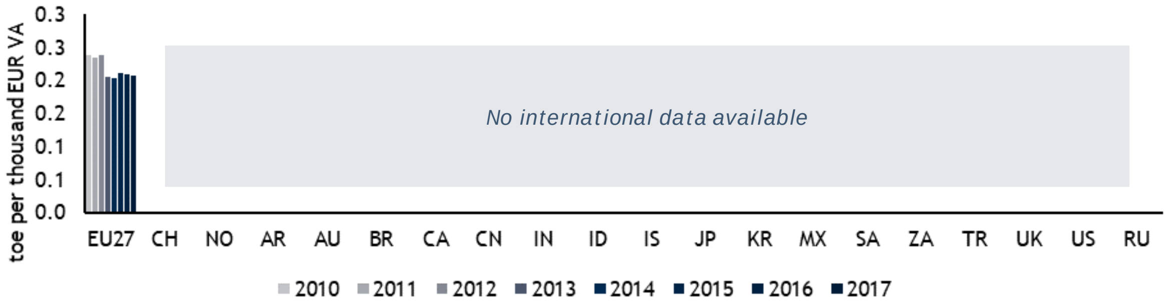


Energy costs as a share of total production costs



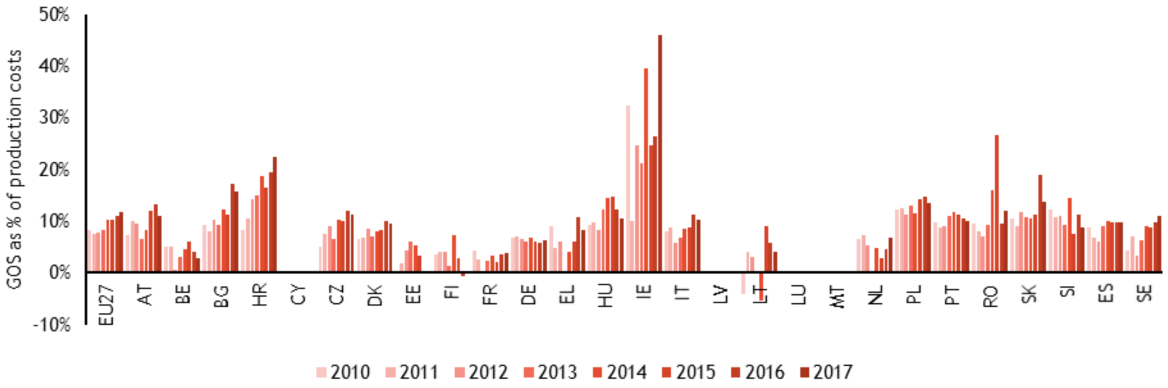
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

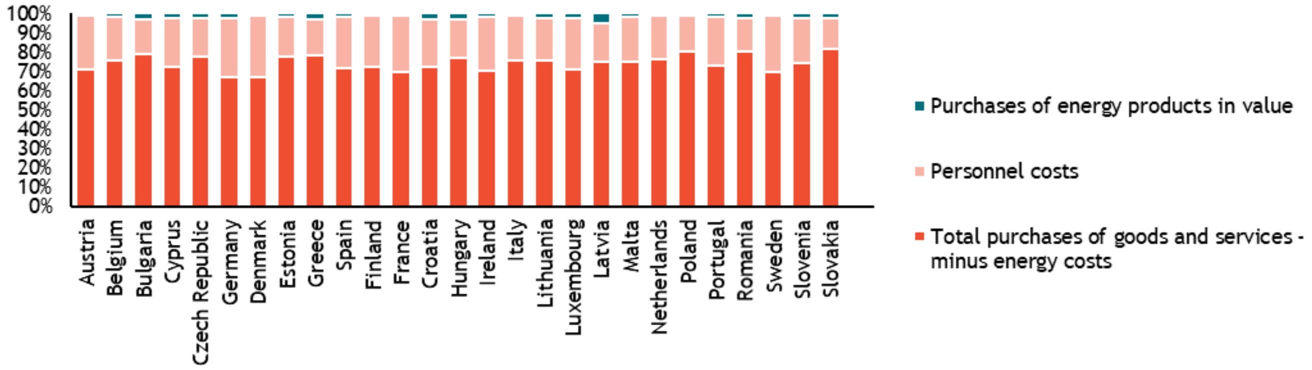


Cost dynamics for Sector C25 - Manufacture of fabricated metal products, except machinery and equipment

Breakdown of production costs

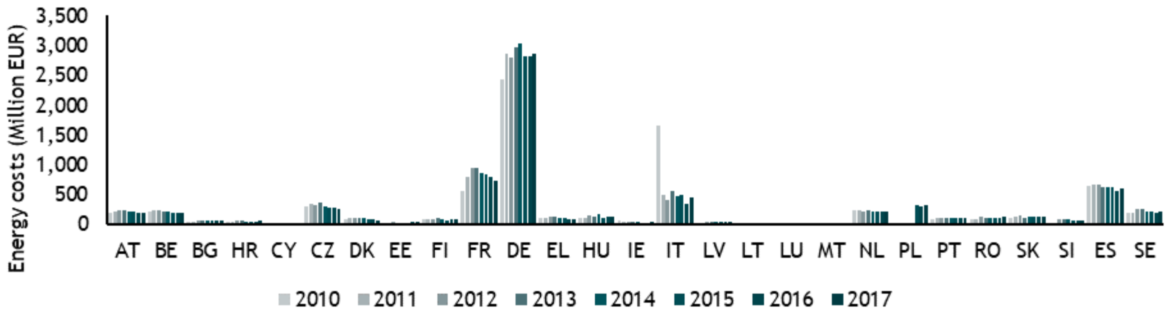
Distribution of costs per Member State in the EU27

Average 2010-2017

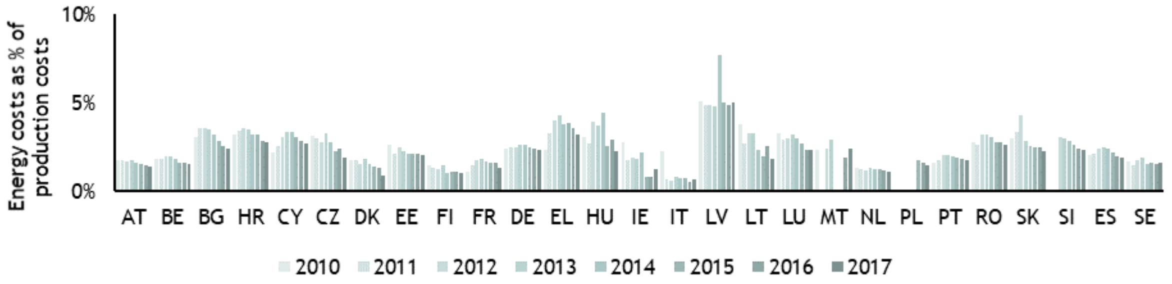


Energy cost shares

Energy costs in value

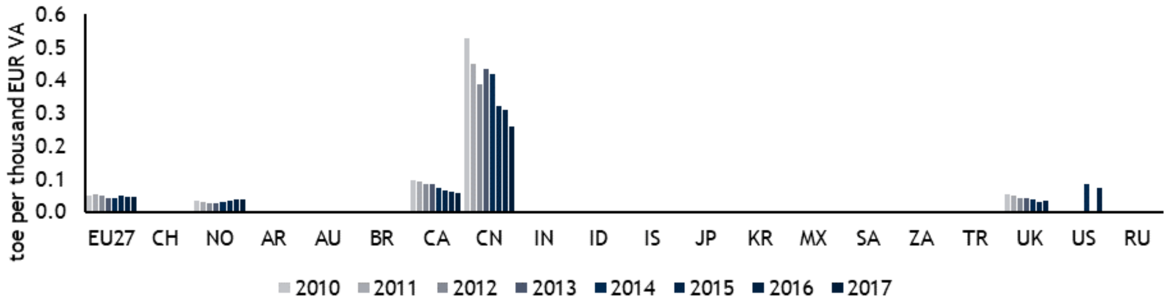


Energy costs as a share of total production costs



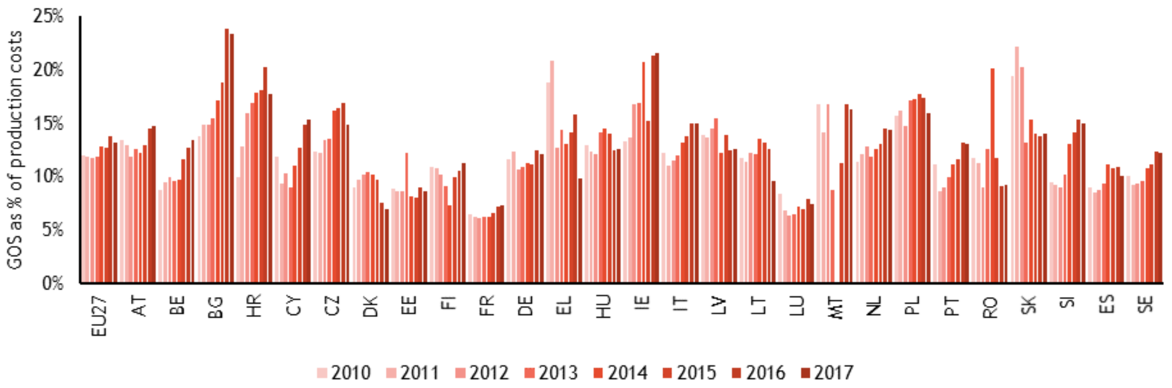
Energy intensity

Consumption of energy per value added



Profitability

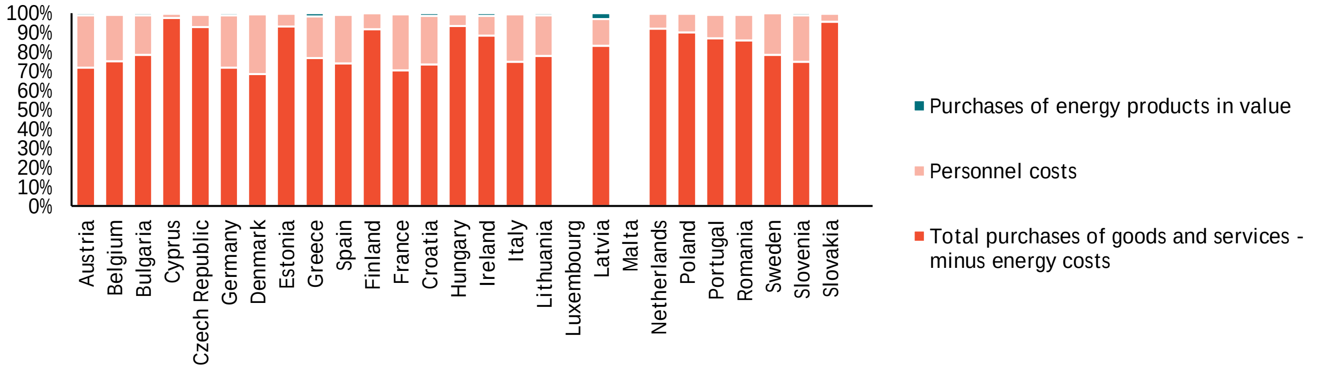
Gross operating surplus as a share of production costs



Cost dynamics for Sector C26 - Manufacture of computer, electronic and optical products

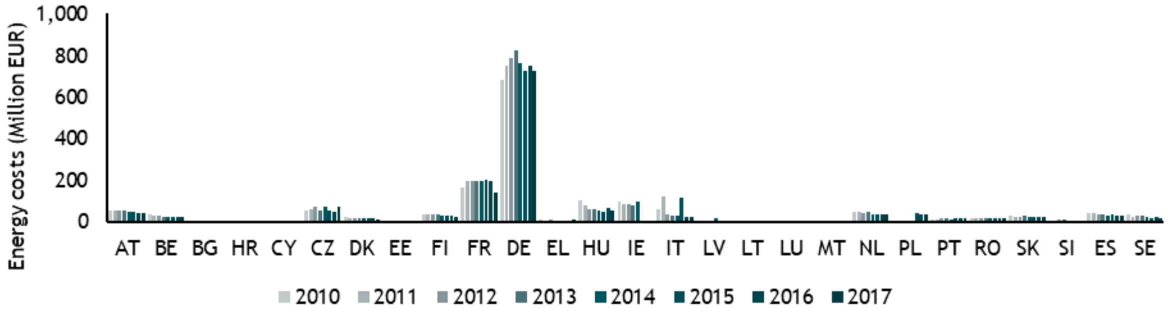
Breakdown of production costs

Distribution of costs per Member State in the EU27
Average 2010-2017

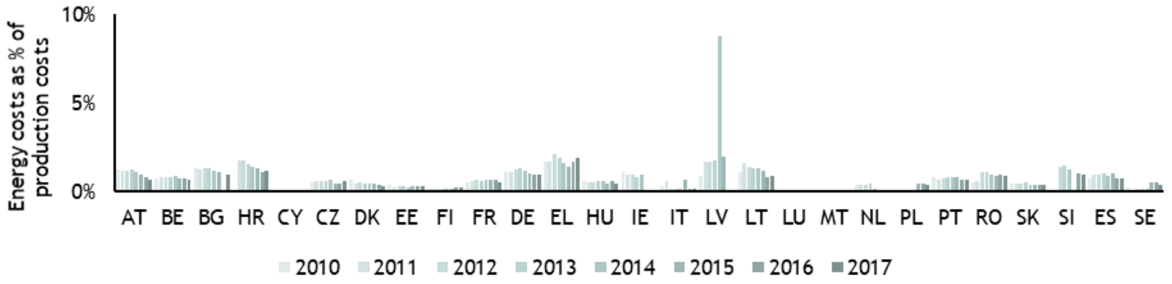


Energy cost shares

Energy costs in value

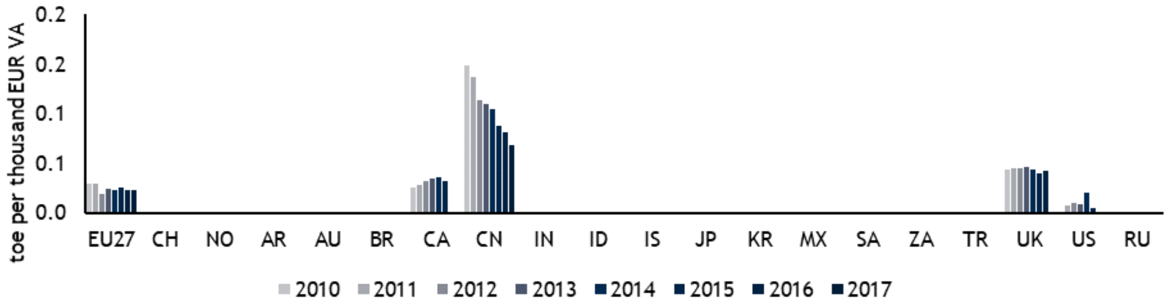


Energy costs as a share of total production costs



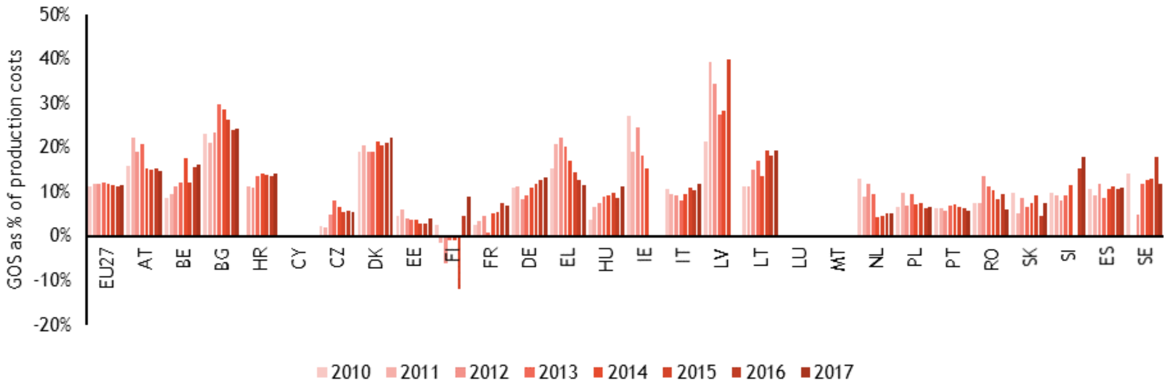
Energy intensity

Consumption of energy per value added



Profitability

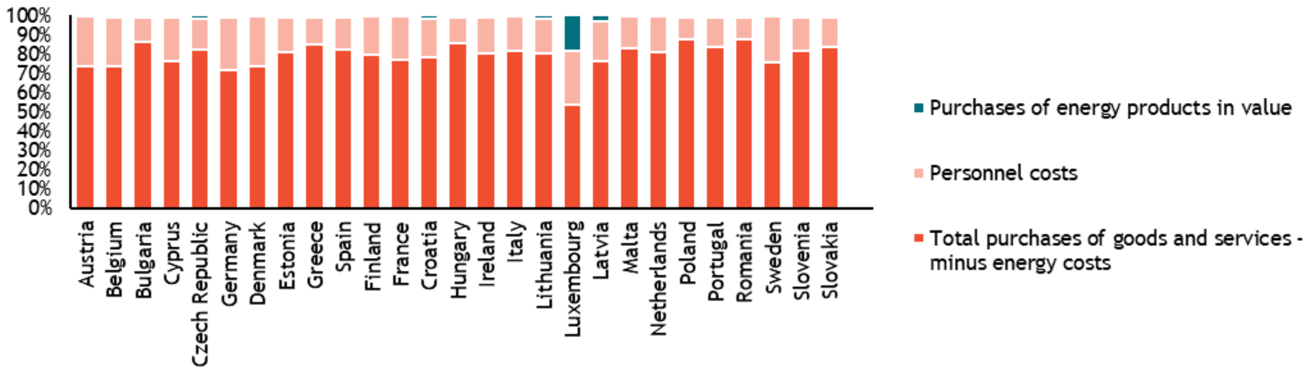
Gross operating surplus as a share of production costs



Cost dynamics for Sector C27 - Manufacture of electrical equipment

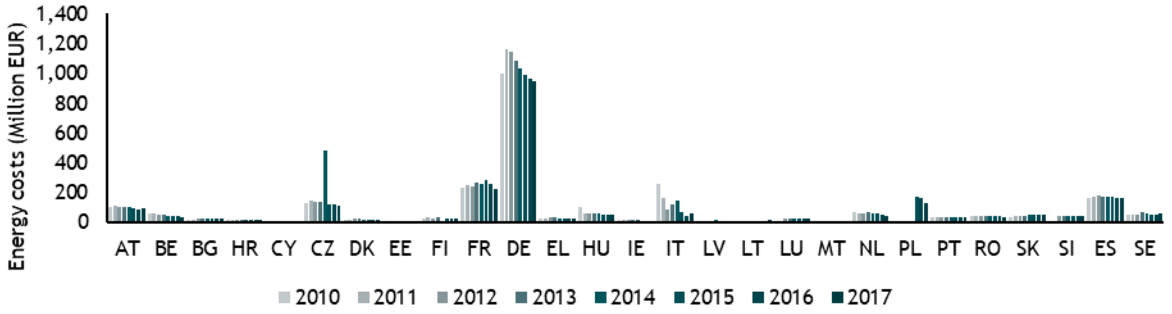
Breakdown of production costs

Distribution of costs per Member State in the EU27
Average 2010-2017

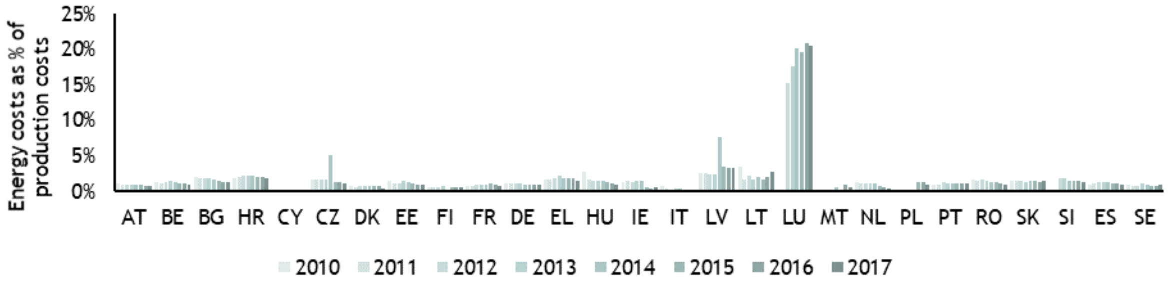


Energy cost shares

Energy costs in value

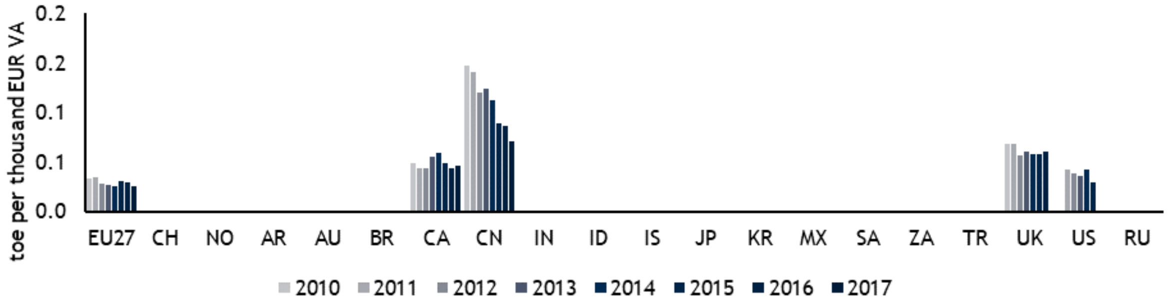


Energy costs as a share of total production costs



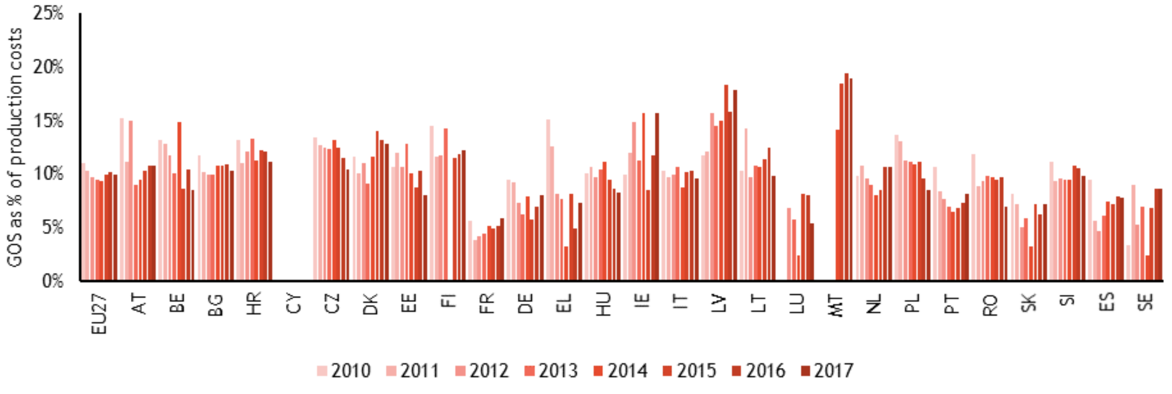
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

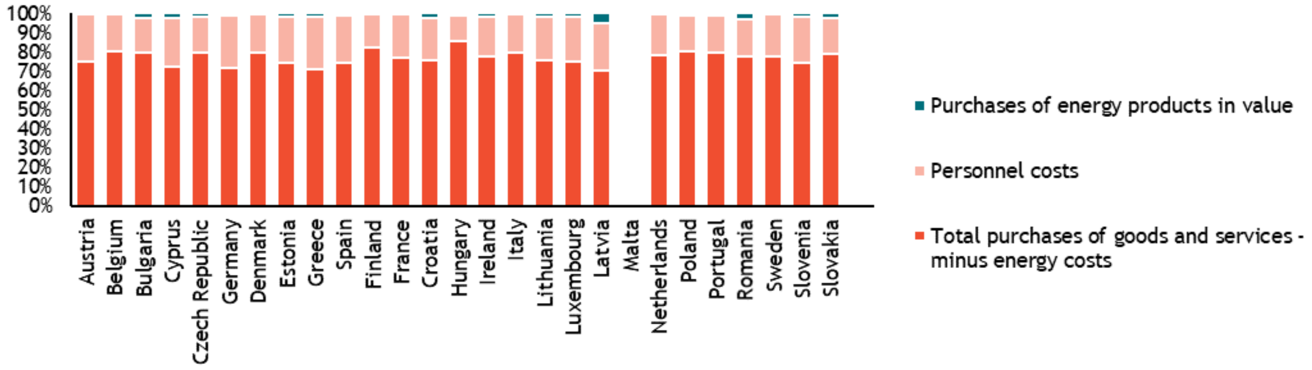


Cost dynamics for Sector C28 - Manufacture of machinery and equipment

Breakdown of production costs

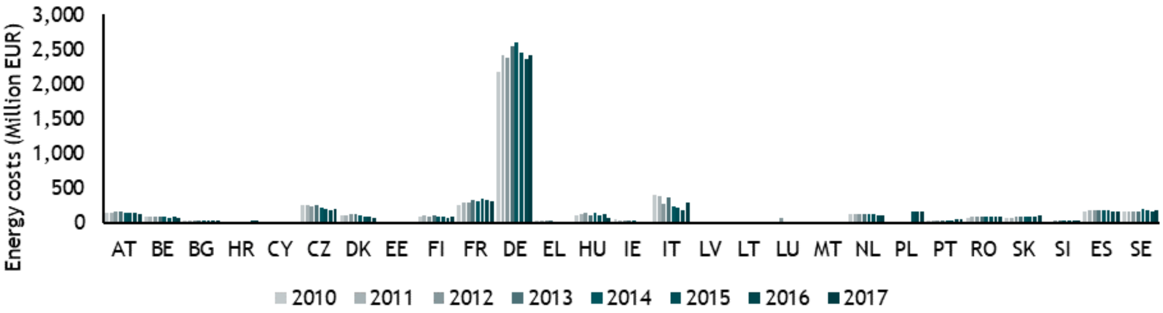
Distribution of costs per Member State in the EU27

Average 2010-2017

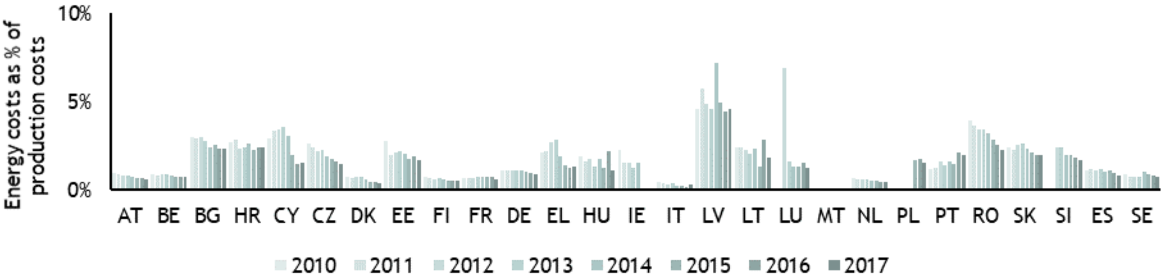


Energy cost shares

Energy costs in value

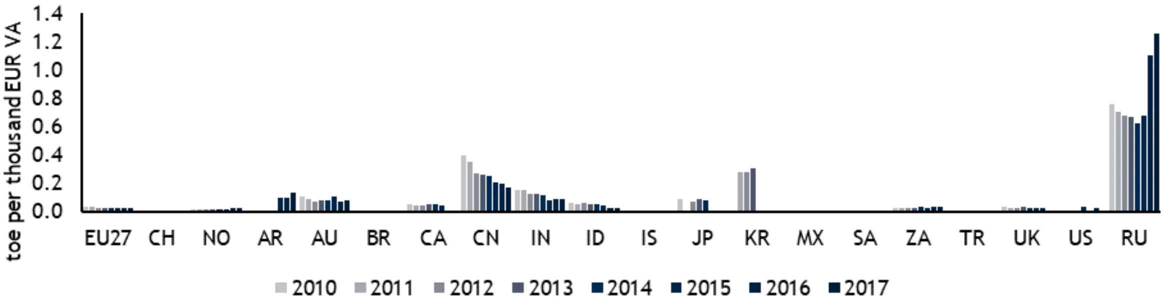


Energy costs as a share of total production costs



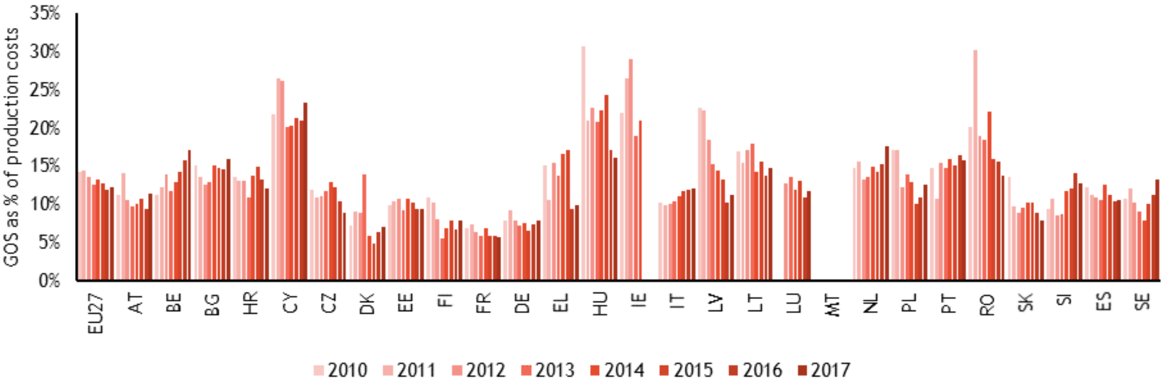
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

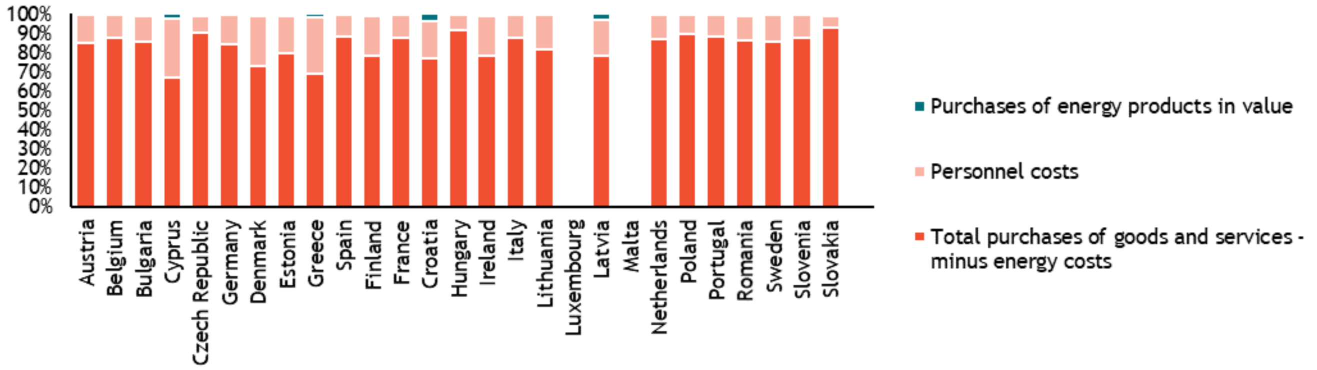


Cost dynamics for Sector C29 - Manufacture of motor vehicles, trailers and semi-trailers

Breakdown of production costs

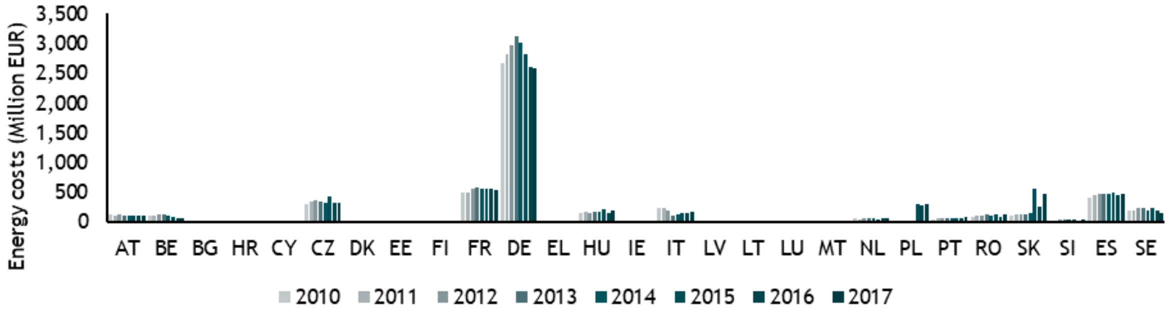
Distribution of costs per Member State in the EU27

Average 2010-2017

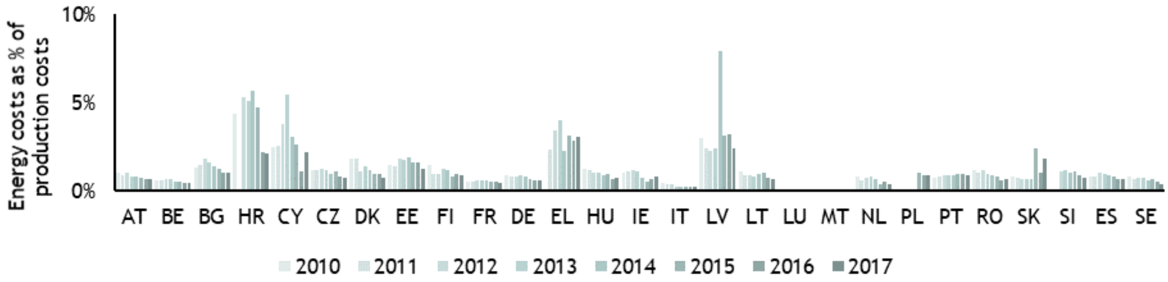


Energy cost shares

Energy costs in value

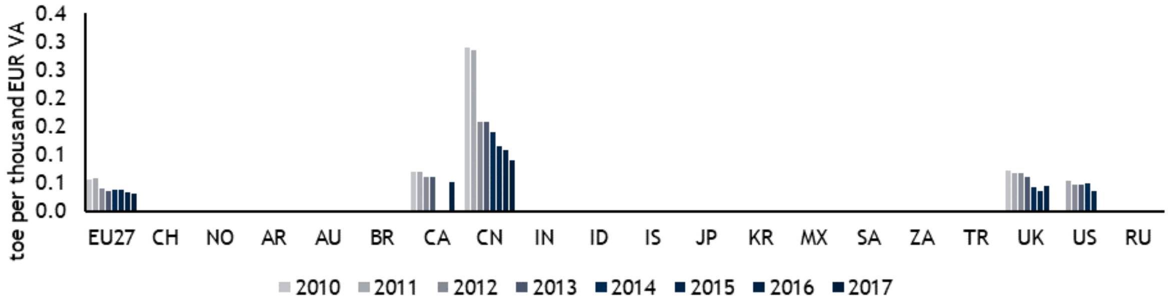


Energy costs as a share of total production costs



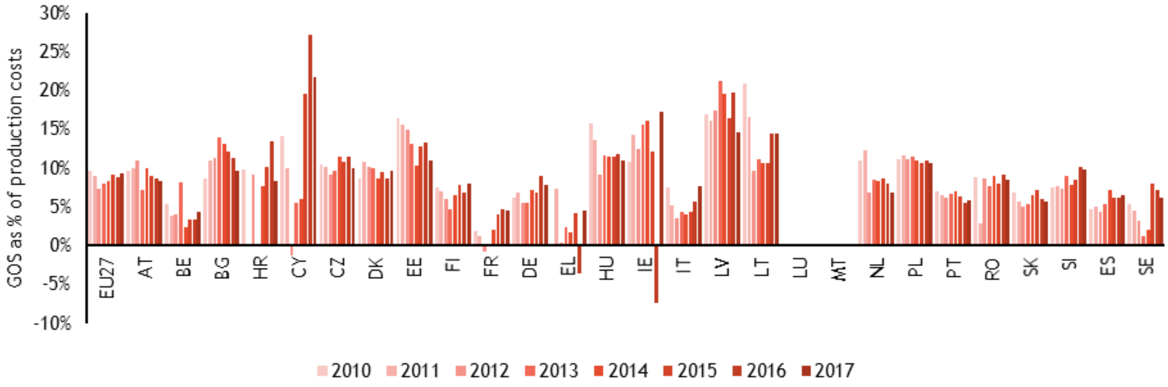
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

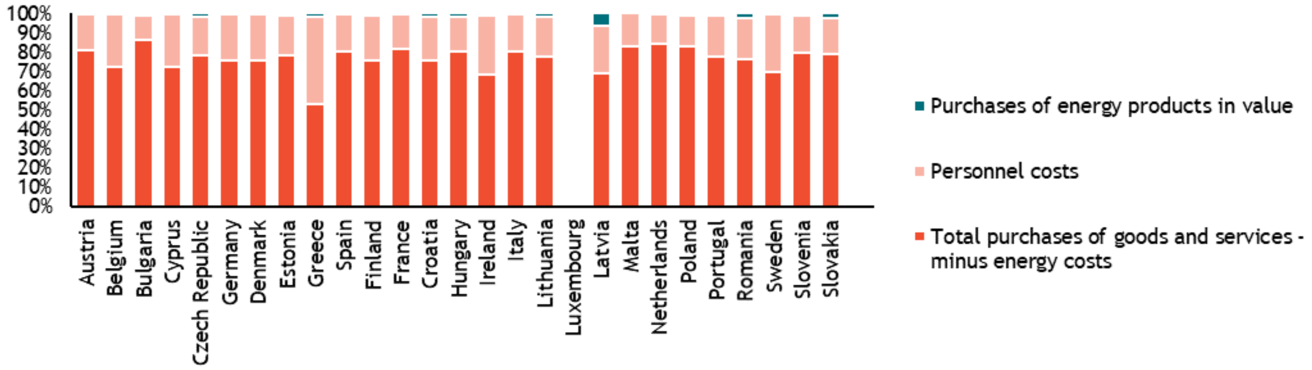


Cost dynamics for Sector C30 - Manufacture of other transport equipment

Breakdown of production costs

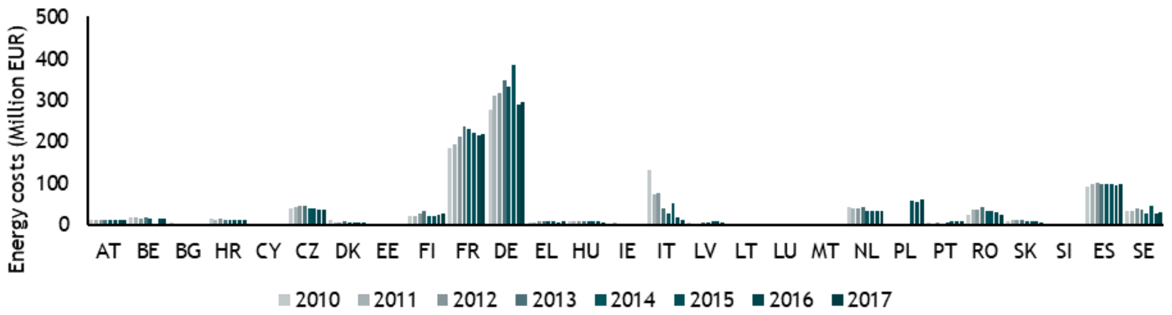
Distribution of costs per Member State in the EU27

Average 2010-2017

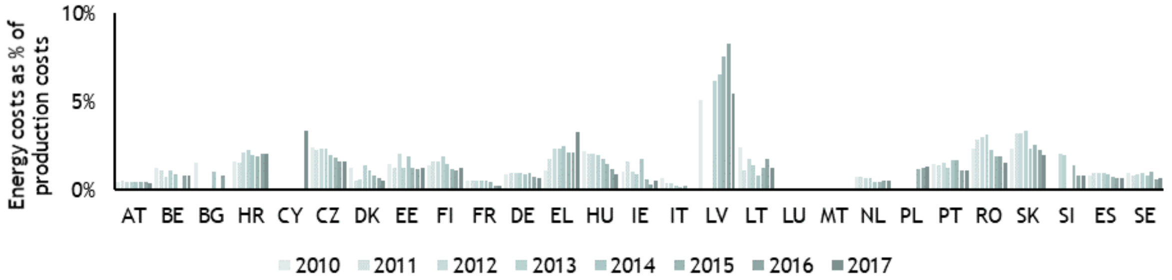


Energy cost shares

Energy costs in value

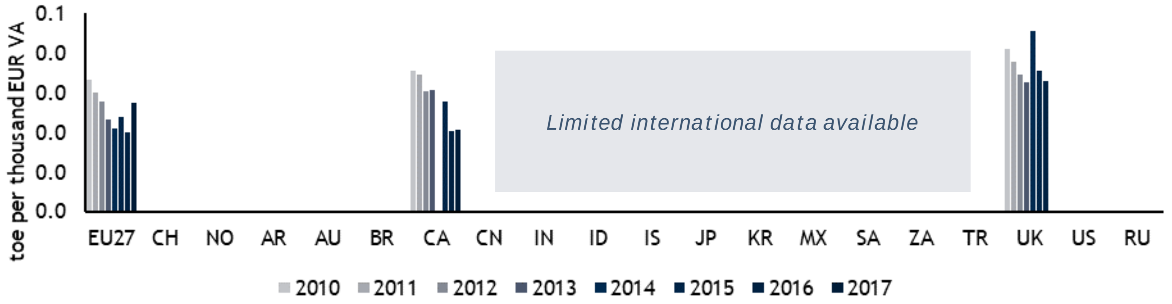


Energy costs as a share of total production costs



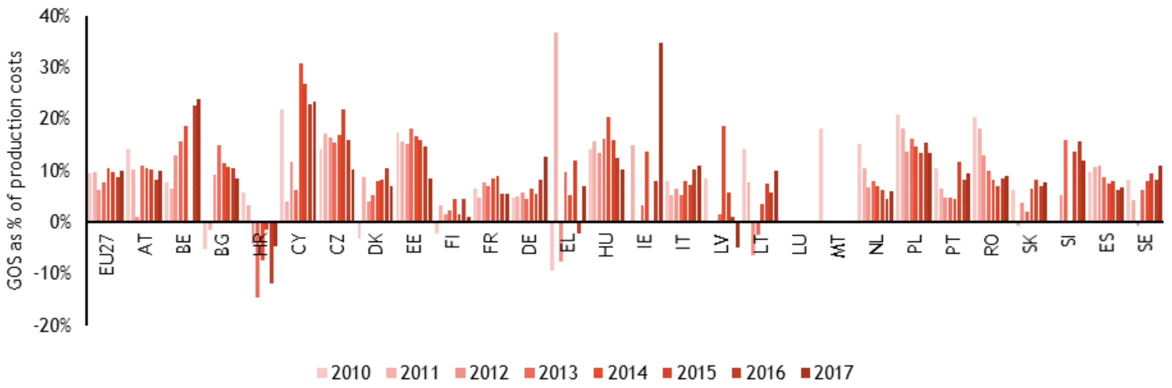
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

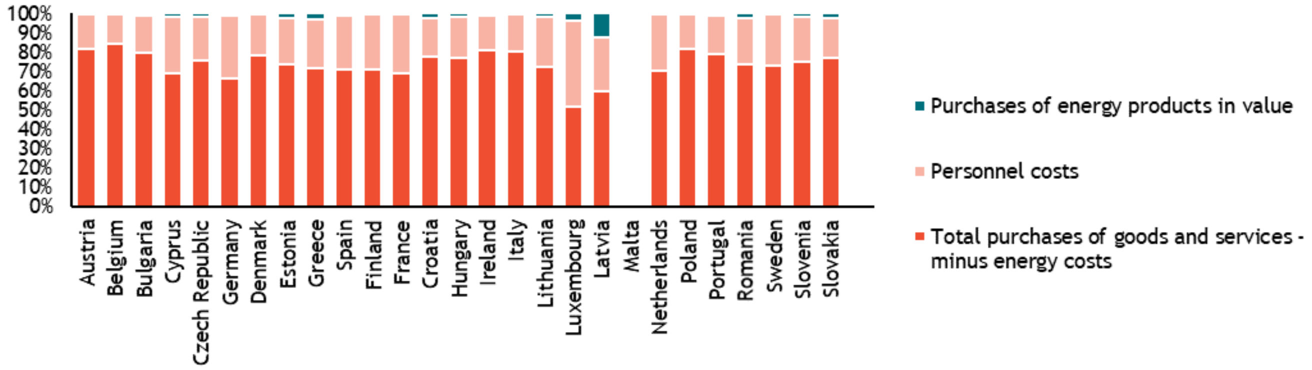


Cost dynamics for Sector C32 - Other manufacturing

Breakdown of production costs

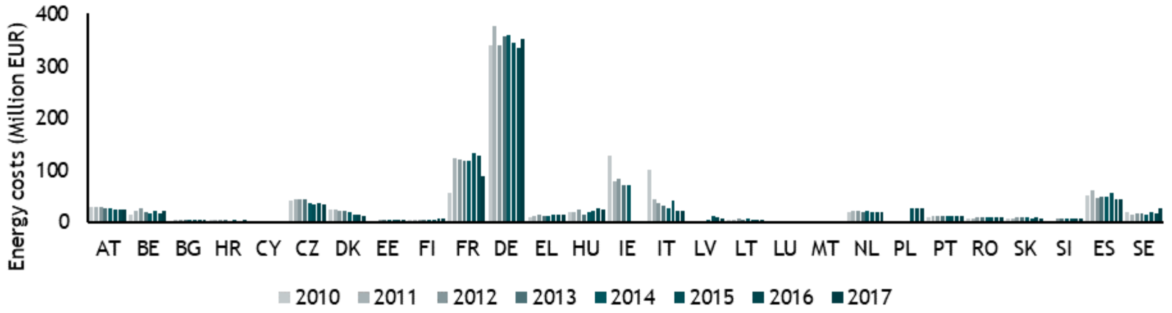
Distribution of costs per Member State in the EU27

Average 2010-2017

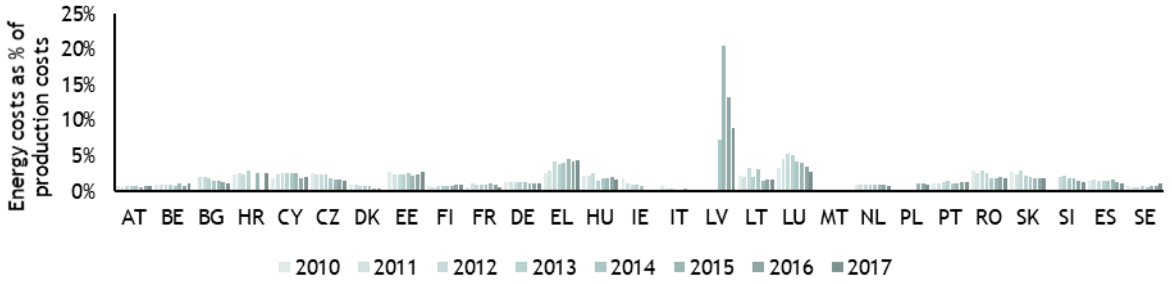


Energy cost shares

Energy costs in value

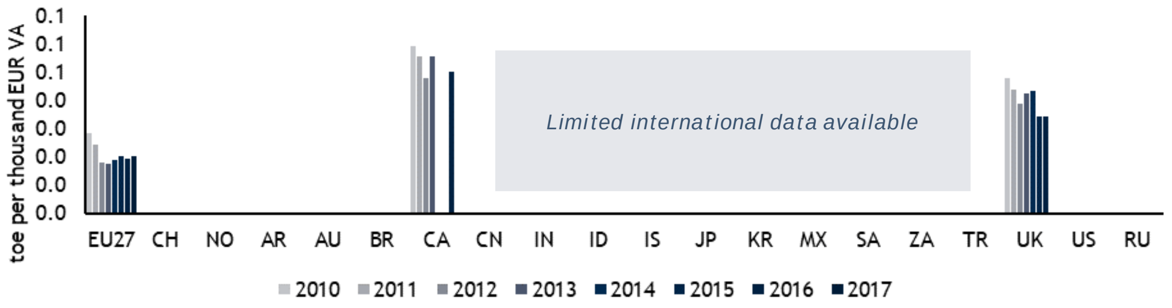


Energy costs as a share of total production costs



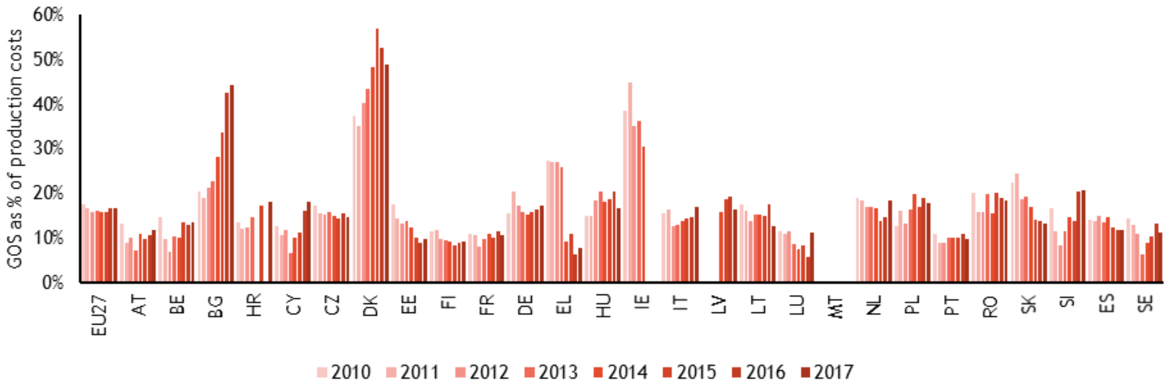
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs

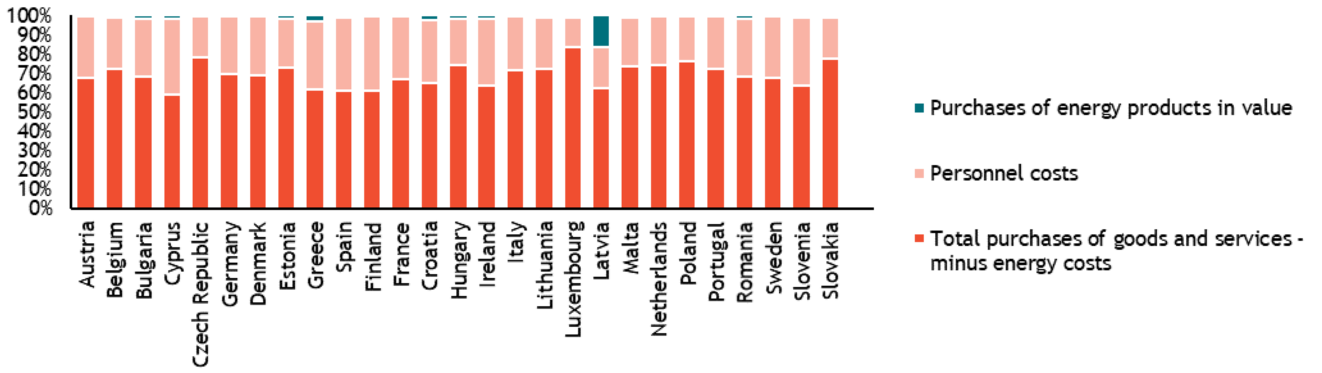


Cost dynamics for Sector C33 - Repair and installation of machinery and equipment

Breakdown of production costs

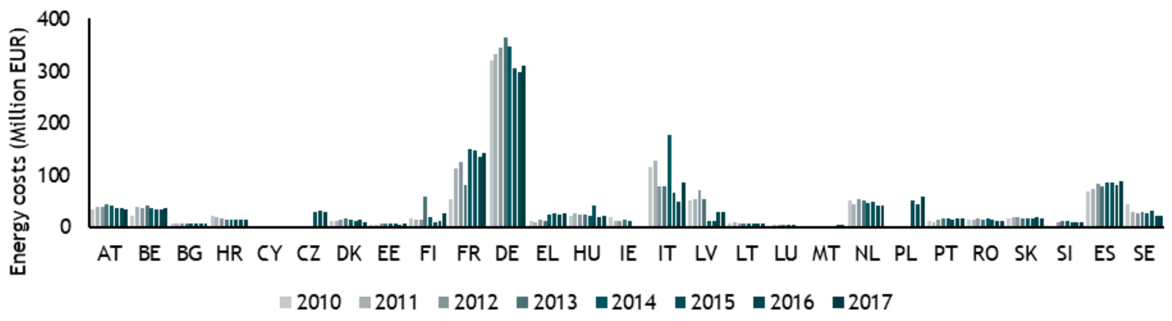
Distribution of costs per Member State in the EU27

Average 2010-2017

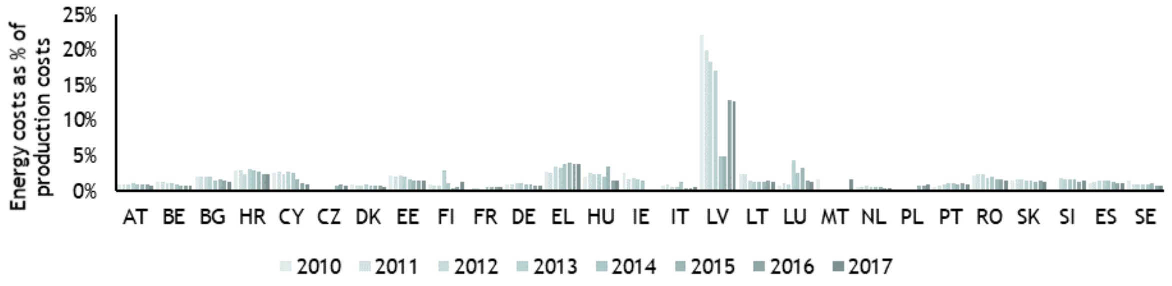


Energy cost shares

Energy costs in value

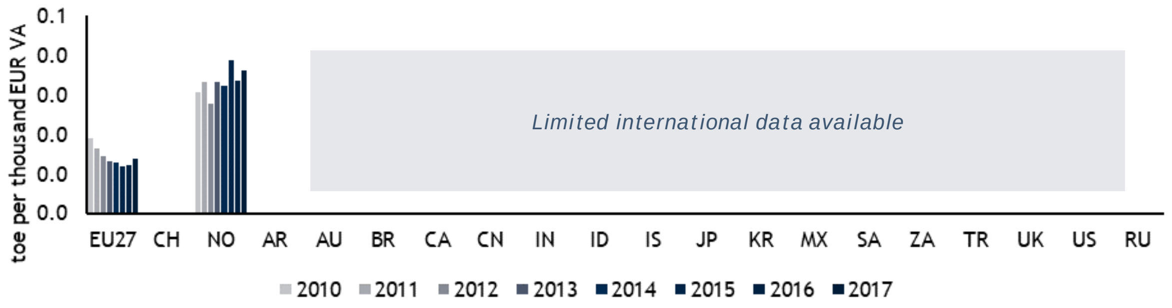


Energy costs as a share of total production costs



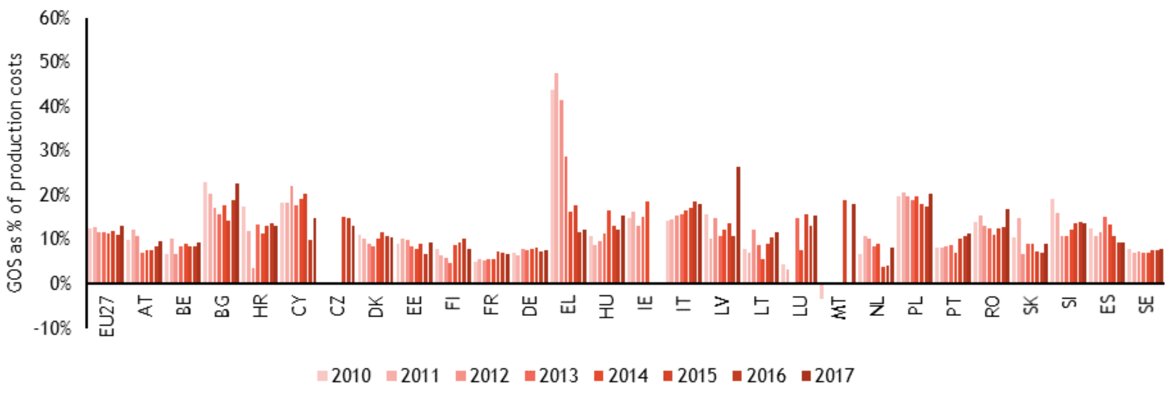
Energy intensity

Consumption of energy per value added



Profitability

Gross operating surplus as a share of production costs



Annex F - Task 2 - EU27 energy cost decomposition analysis charts at NACE 2-digit level

This annex breaks down the drivers of the changes in energy costs over the period 2010-2017 for the manufacturing sectors tabulated in the final report Task 2's decomposition of energy costs.

Figure F-1 Breakdown of drivers of the changes in EU27 food and beverage manufacturing energy costs over the period 2010-2017

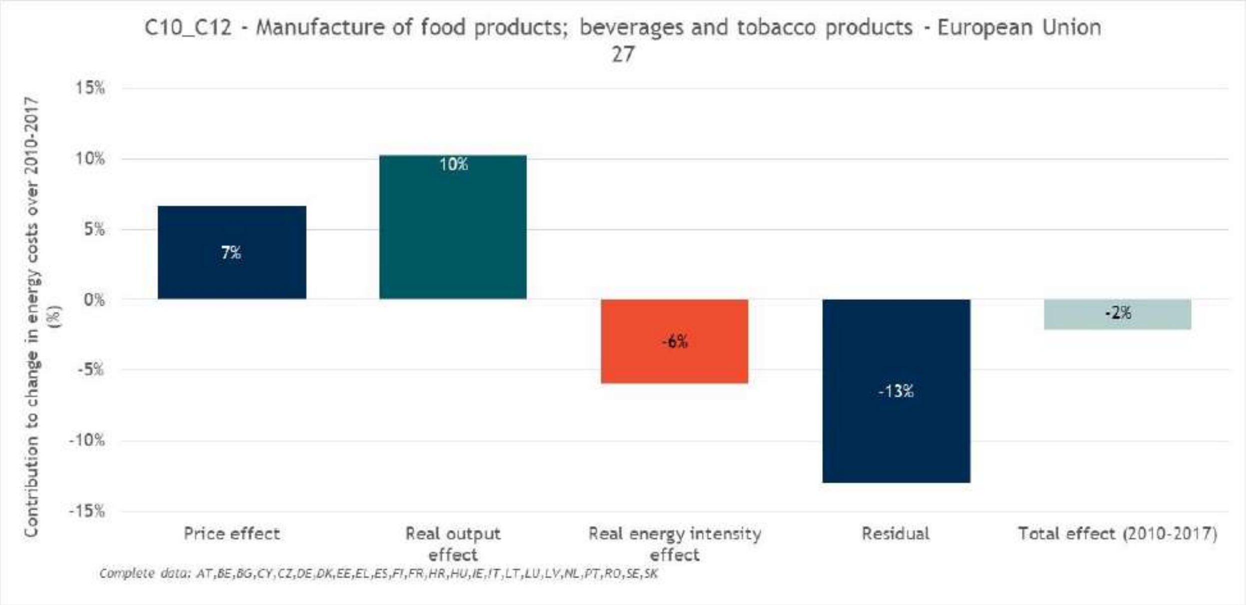


Figure F-2 Breakdown of drivers of the changes in EU27 textiles manufacturing energy costs over the period 2010-2017

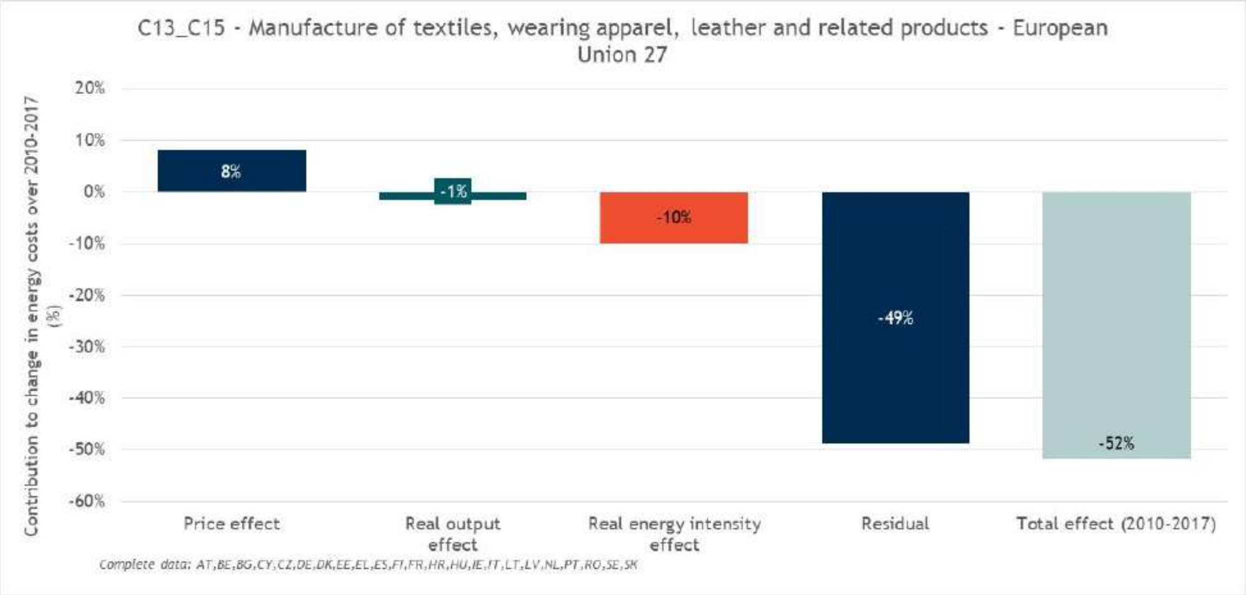


Figure F-3 Breakdown of drivers of the changes in EU27 wood manufacturing energy costs over the period 2010-2017

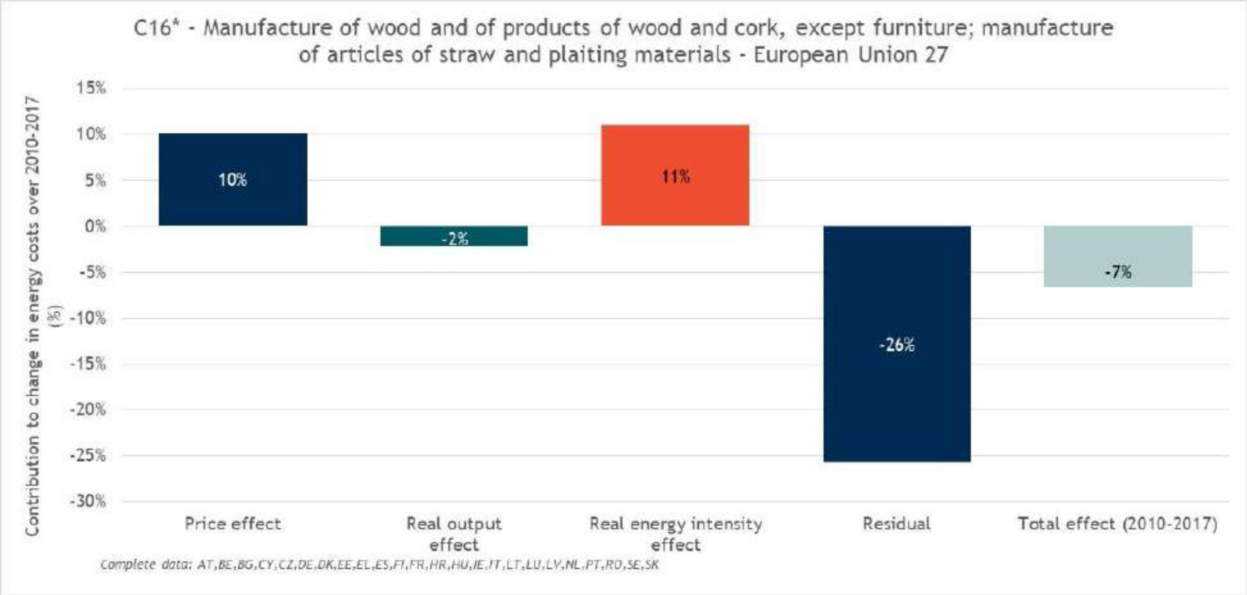


Figure F-4 Breakdown of drivers of the changes in EU27 paper manufacturing energy costs over the period 2010-2017

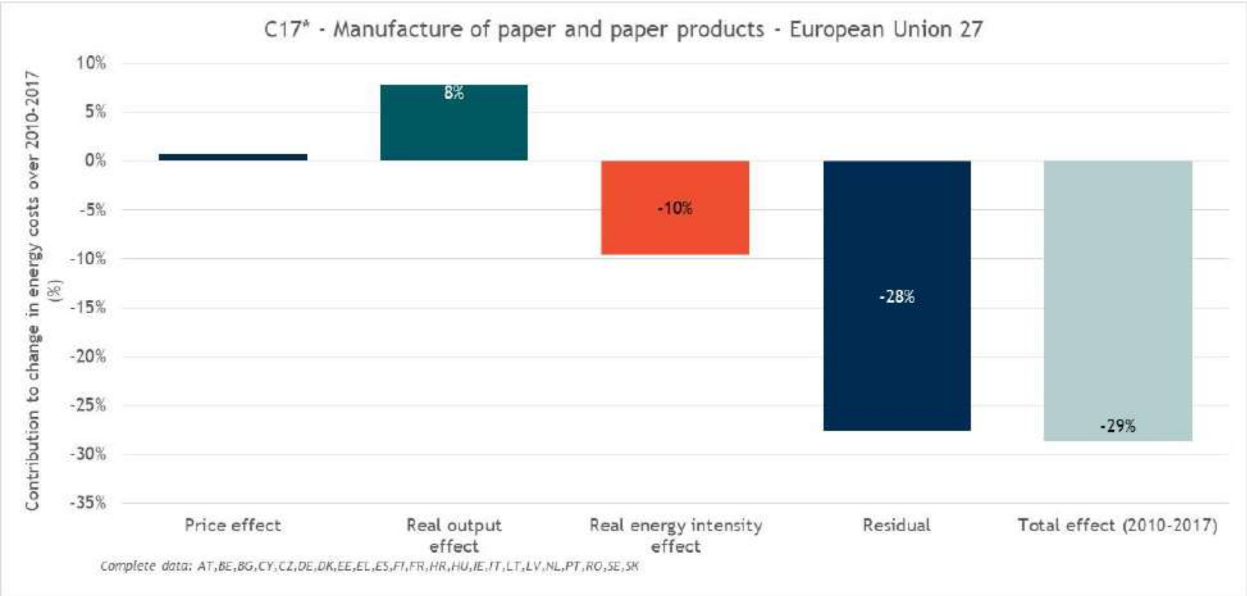


Figure F-5 Breakdown of drivers of the changes in EU27 coke and refined petroleum manufacturing energy costs over the period 2010-2017

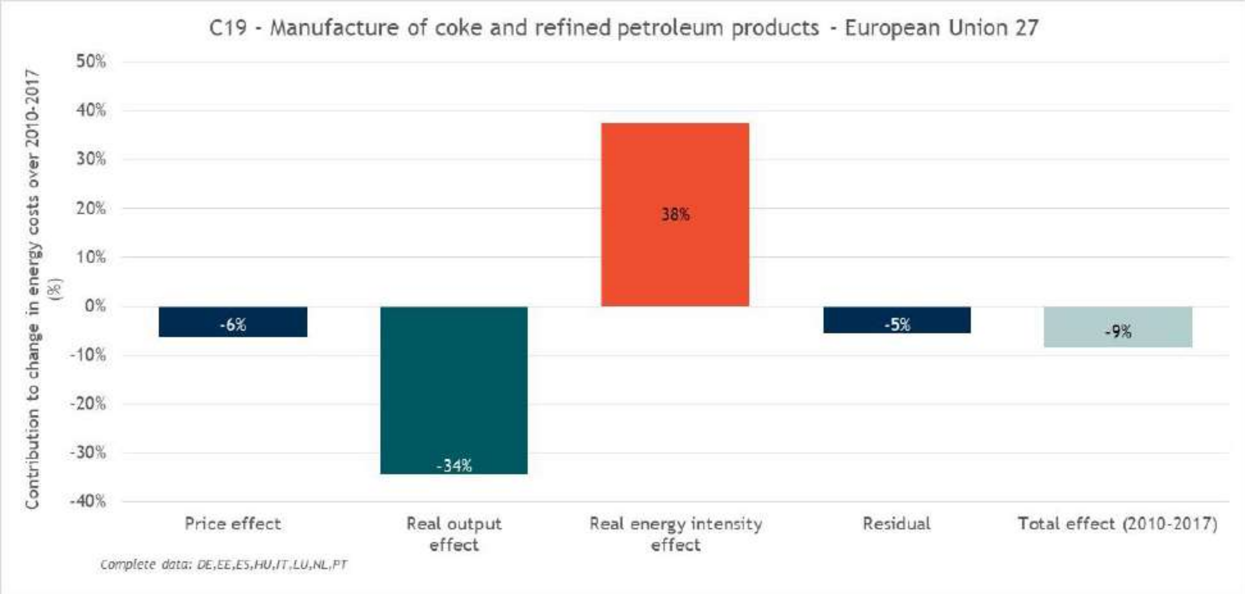


Figure F-6 Breakdown of drivers of the changes in EU27 chemical manufacturing energy costs over the period 2010-2017

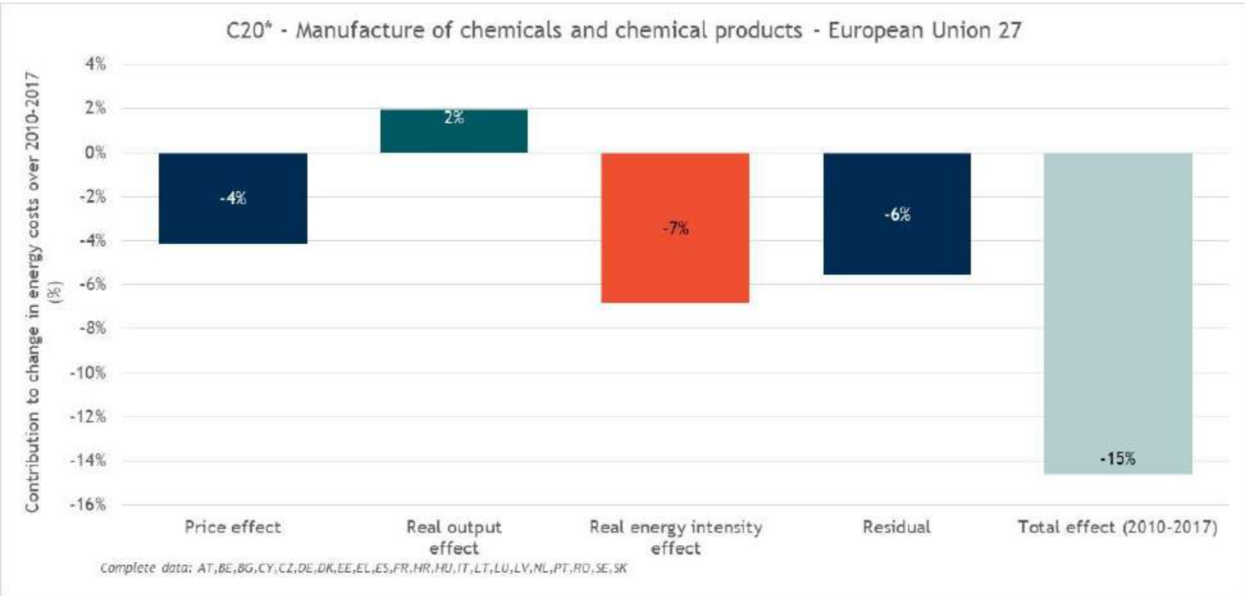


Figure F-7 Breakdown of drivers of the changes in EU27 pharmaceutical manufacturing energy costs over the period 2010-2017

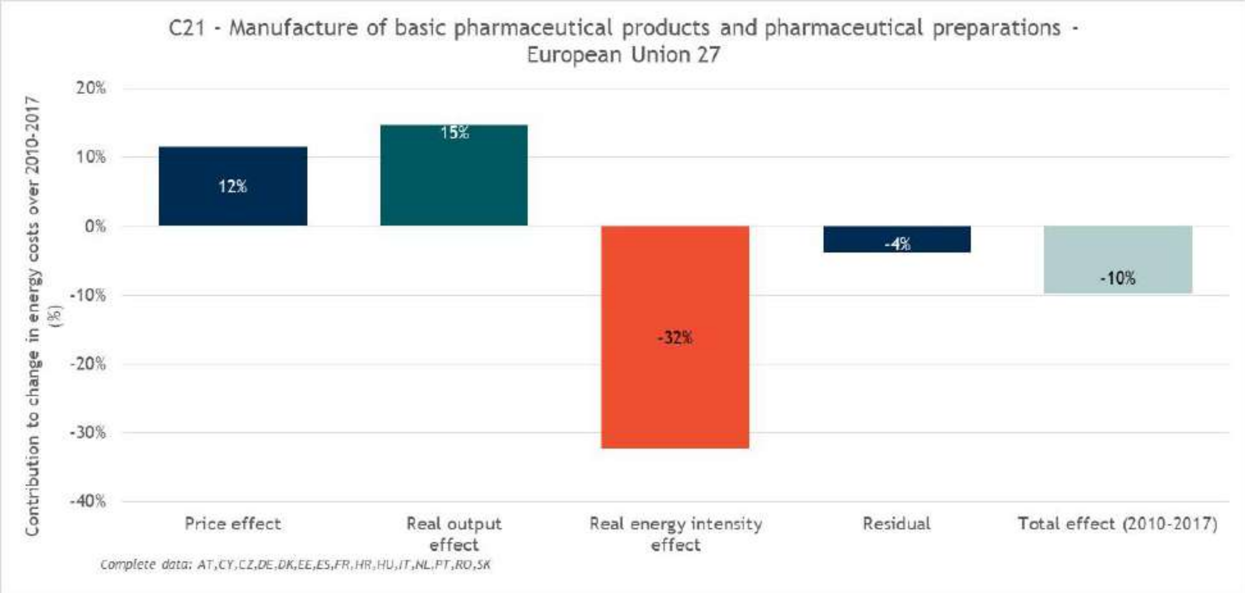


Figure F-8 Breakdown of drivers of the changes in EU27 rubber manufacturing energy costs over the period 2010-2017

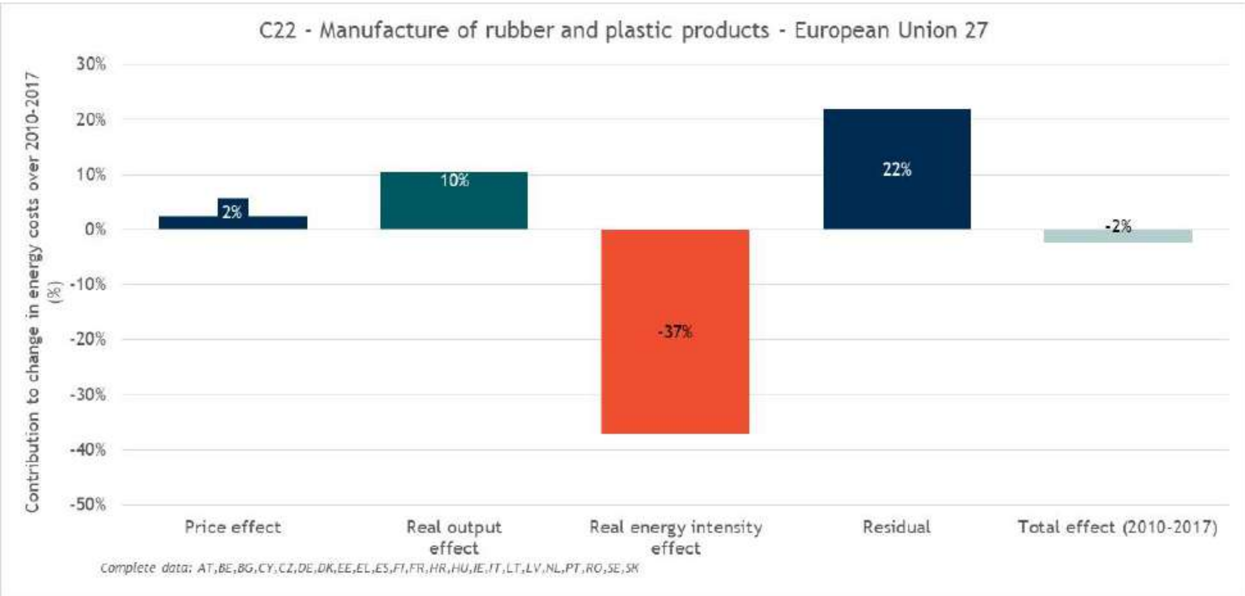


Figure F-9 Breakdown of drivers of the changes in EU27 non-metallic mineral manufacturing energy costs over the period 2010-2017

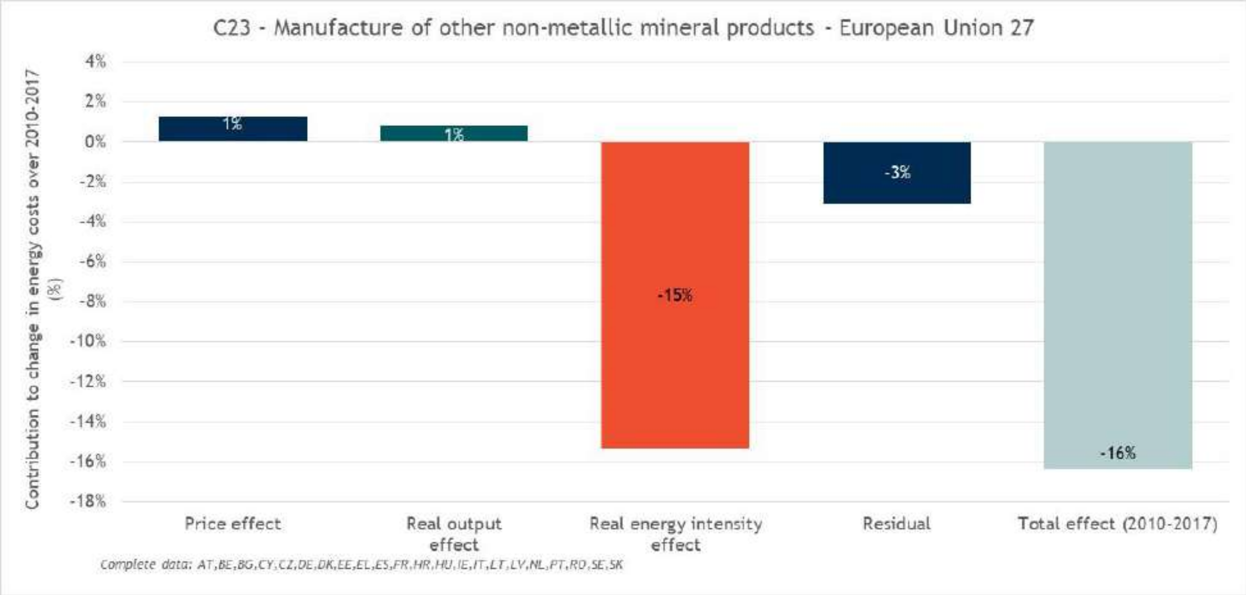


Figure F-10 Breakdown of drivers of the changes in EU27 basic metals manufacturing energy costs over the period 2010-2017

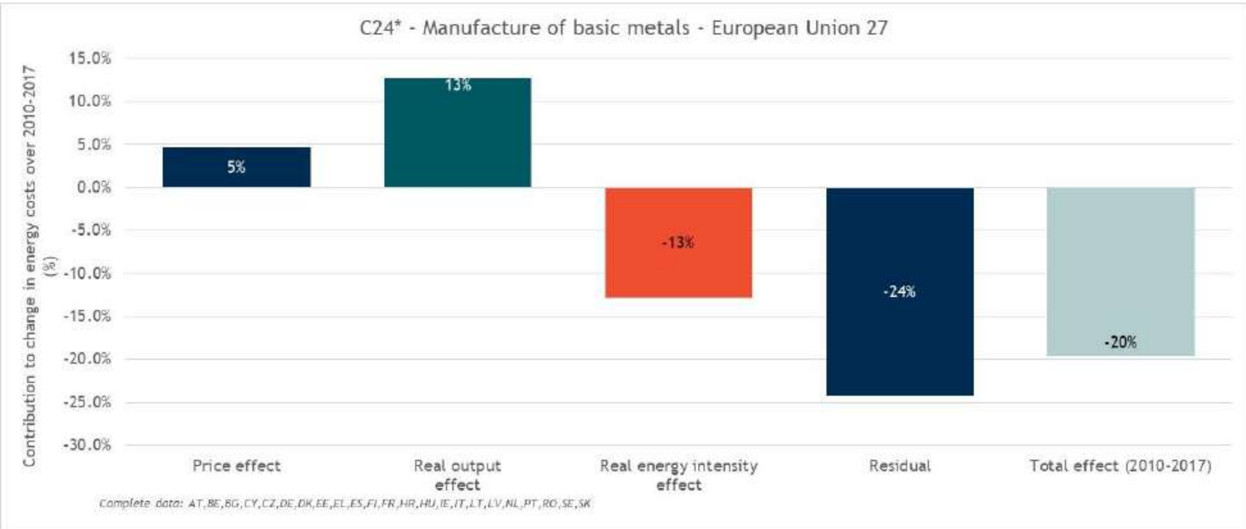


Figure F-11 Breakdown of drivers of the changes in EU27 fabricated metal product manufacturing energy costs over the period 2010-2017

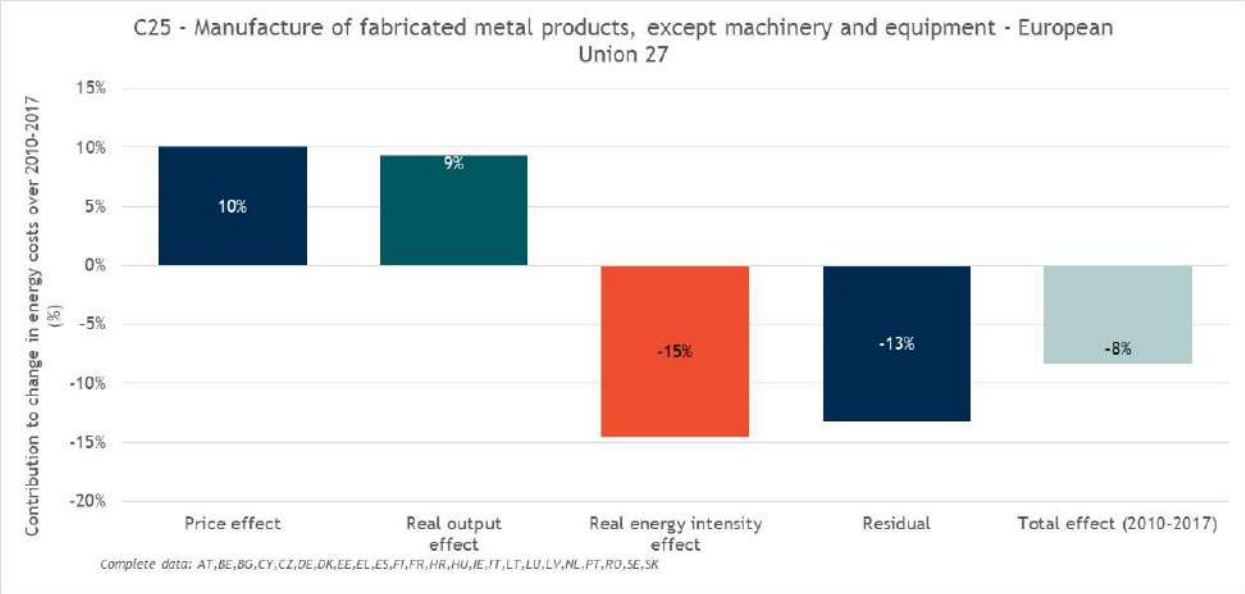


Figure F-12 Breakdown of drivers of the changes in EU27 computer and electronic manufacturing energy costs over the period 2010-2017

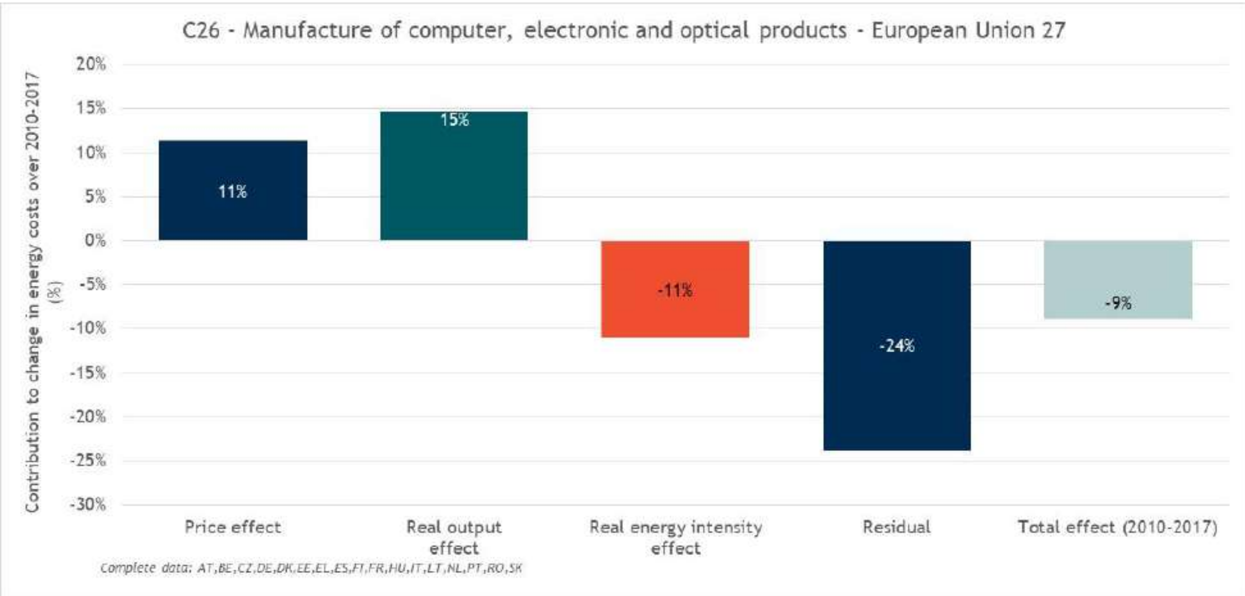


Figure F-13 Breakdown of drivers of the changes in EU27 electrical equipment manufacturing energy costs over the period 2010-2017

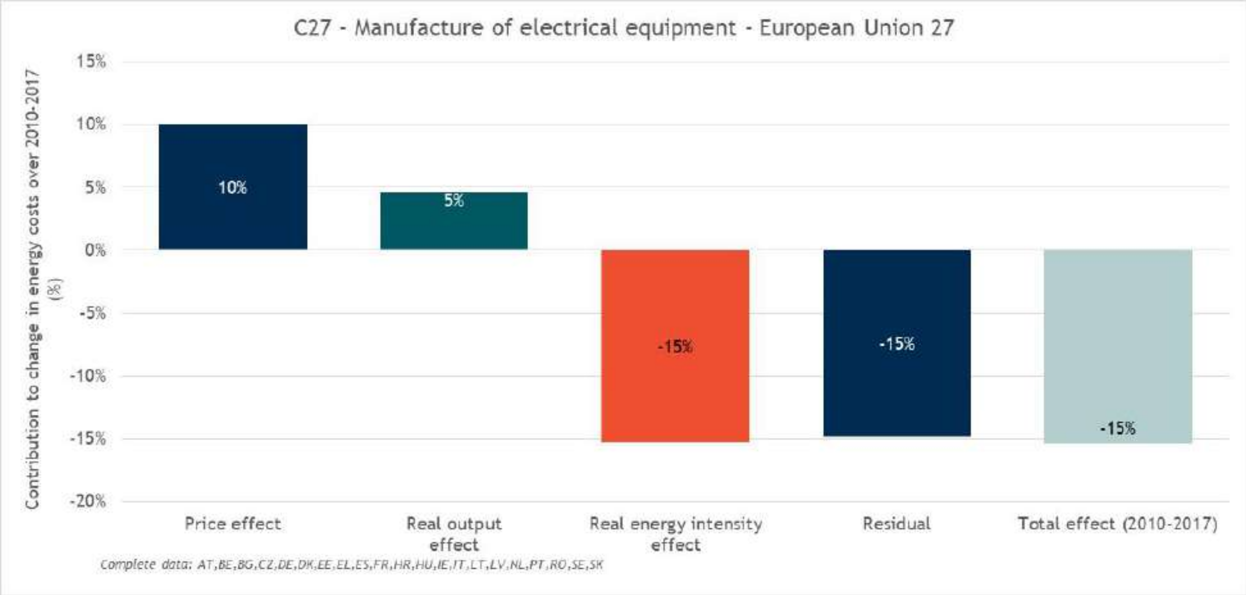


Figure F-14 Breakdown of drivers of the changes in EU27 machinery and equipment manufacturing energy costs over the period 2010-2017

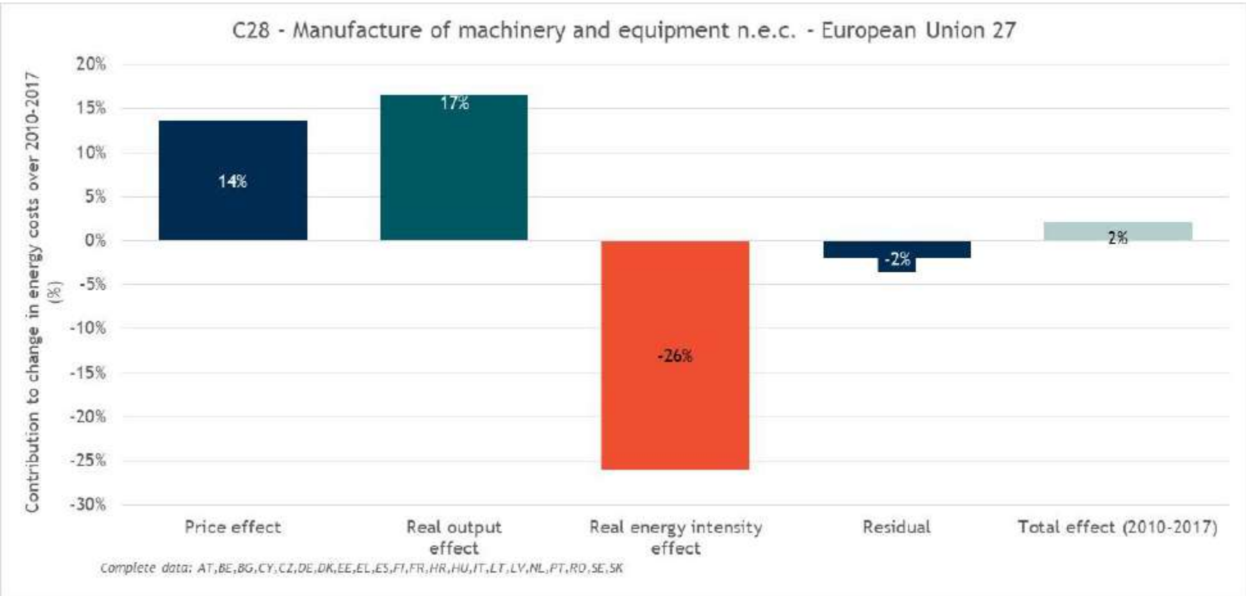


Figure F-15 Breakdown of drivers of the changes in EU27 motor vehicle manufacturing energy costs over the period 2010-2017

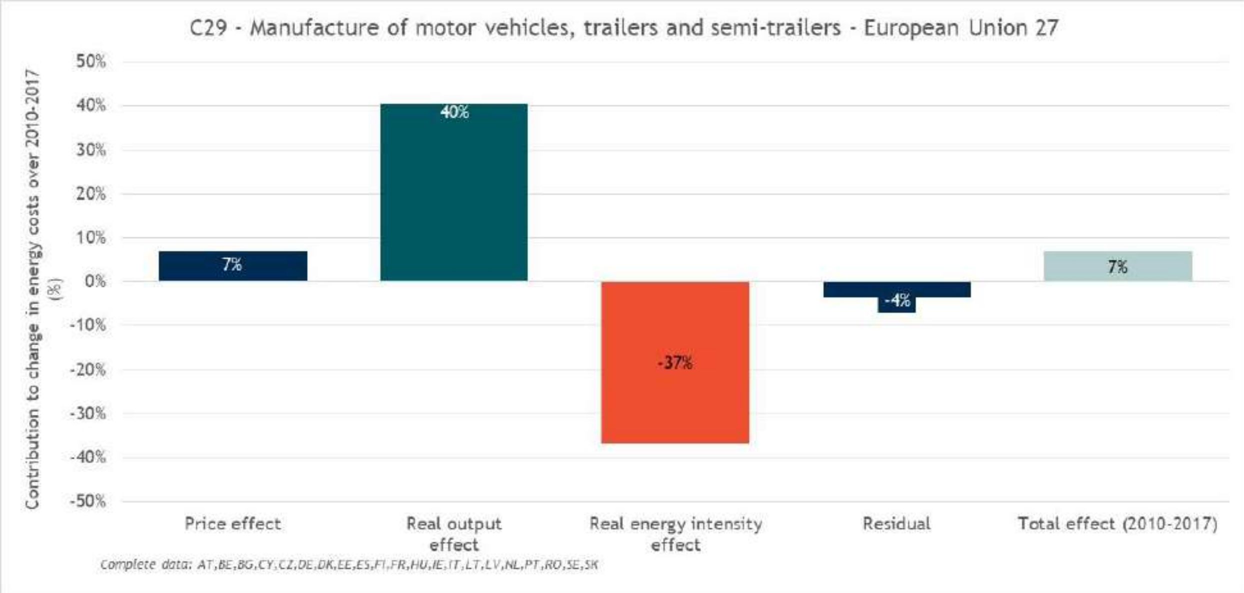


Figure F-16 Breakdown of drivers of the changes in EU27 other transport manufacturing energy costs over the period 2010-2017

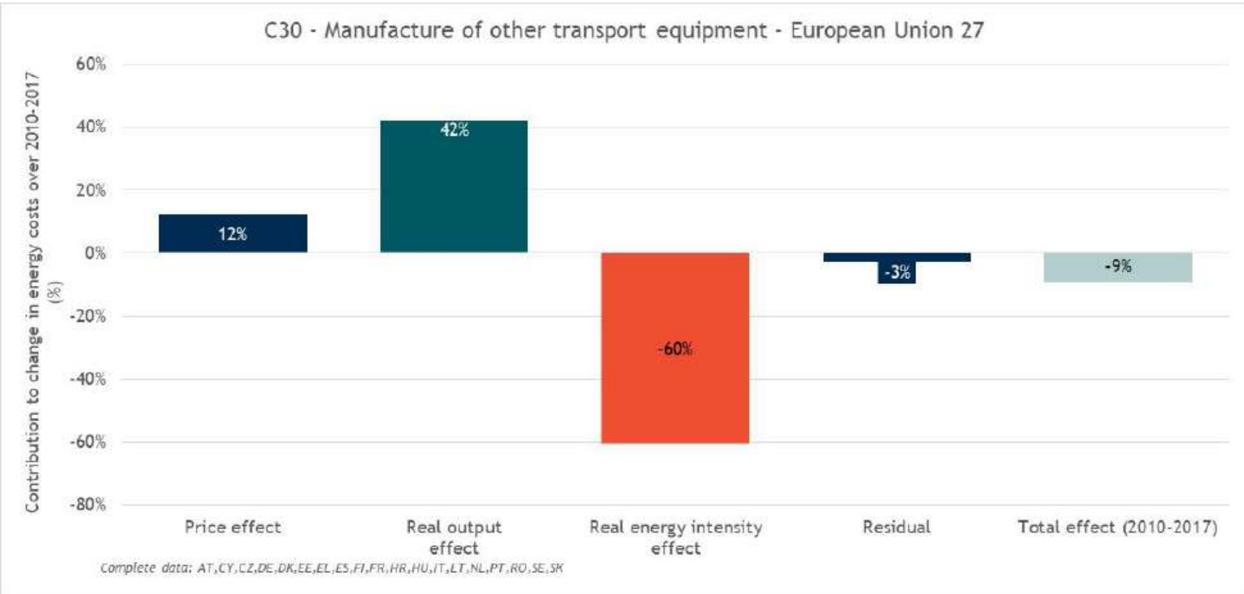


Figure F-17 Breakdown of drivers of the changes in EU27 furniture manufacturing energy costs over the period 2010-2017

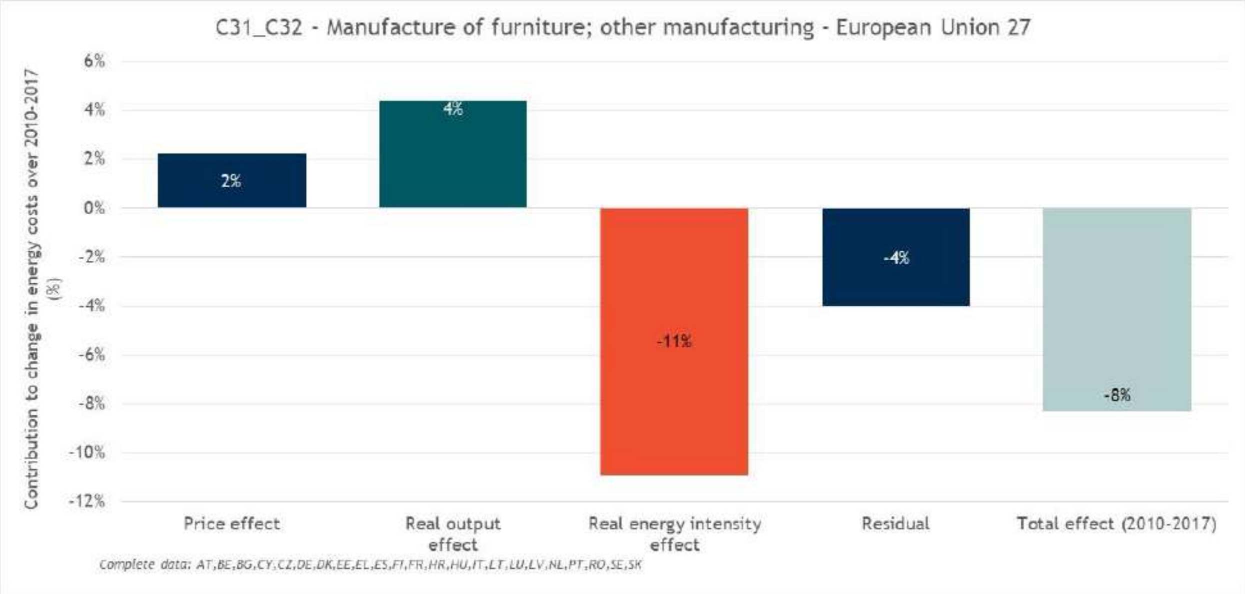
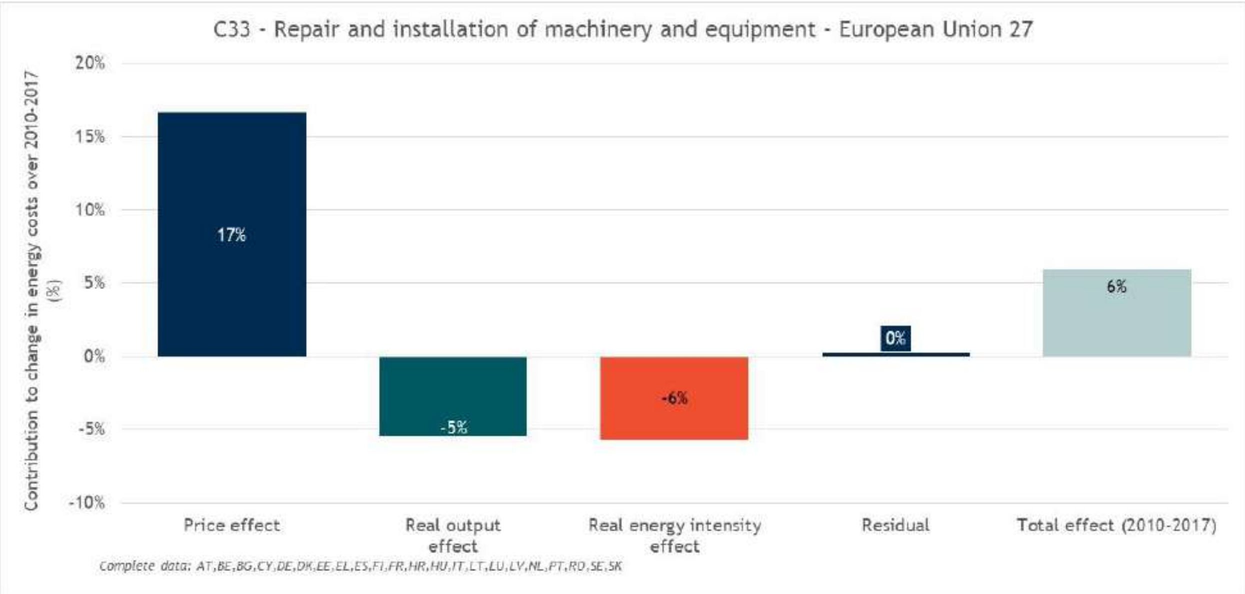


Figure F-18 Breakdown of drivers of the changes in EU27 repair and installation of machinery and equipment energy costs over the period 2010-2017



Annex G - Task 2 - Detailed G20 decomposition results

Energy Decomposition results

This section summarises the energy decomposition analysis results for G20 countries for each individual sector where sufficient data was available.

Manufacture of food products; beverages and tobacco products (C10_C12)

Table G-1 Decomposition for EU and G20 countries for Manufacture of food products; beverages and tobacco products (C10_C12)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe per **million €**)
US*	C10_C12	Manufacture of food products; beverages and tobacco products	5.0%	8.9%	2.2%	N/A	16.1%	31.15
TR			-36.1%	13.9%	29.3%	N/A	7.1%	36.00
EU27			6.7%	10.2%	-6.0%	-2.1%	-13.0%	29.24
CN			61.9%	90.1%	-98.6%	N/A	53.4%	23.42
UK			24.9%	6.7%	-11.8%	N/A	19.8%	21.05

Energy costs in *Manufacture of food products; beverages and tobacco products (C10_C12)* increased in the US, the UK, Turkey, and China and slightly fell in the EU27. In the case of the EU27, a fall in energy costs is mostly unexplained due to a large residual effect.

Energy costs increased because of higher average prices and gross output over time in the US, China, and the UK as well as the EU27. In the US and the UK, the sector mainly relies on natural gas whereas coal is the dominant fuel used in China. Turkey was the only country, which experienced a fall in energy prices and higher output. In Turkey, the sector is highly reliant on gas consumption, which experienced falling prices between 2010-2017.

Energy costs fell because of lower energy intensity in the EU27, China, and UK. Apart from a large increase in gross output, China managed to reduce energy consumption. This suggests that significant improvements were made over time to improve the sector's energy efficiency, that the sector is benefiting from economies of scale, or a combination of both. The US increased both its output and energy consumption but a smaller increase in output drove up energy intensity. A positive real energy intensity effect in Turkey put upward pressure on energy costs because of increased energy consumption, possibly due to lower average energy prices.

Manufacture of textiles, wearing apparel, leather and related products (C13_C15)

Table G-2 Decomposition for EU and G20 countries for Manufacture of textiles, wearing apparel, leather and related products (C13_C15)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
UK	C13_C15	Manufacture of textiles, wearing apparel, leather and related products	24.1%	-11.9%	-2.6%	N/A	9.6%	*48.55*
TR			-52.9%	6.7%	55.8%	N/A	9.5%	*30.63*
US*			19.8%	20.0%	-16.1%	N/A	23.7%	*28.79*
CN			68.7%	73.4%	-77.4%	N/A	64.7%	*29.24*
EU27			8.1%	-1.4%	-9.9%	-51.8%	-48.7%	*22.15*
MX*			-26.4%	-36.3%	53.7%	N/A	-9.0%	*0.31*

Manufacture of textiles, wearing apparel, leather and related products (C13_C15) energy costs fell significantly in the EU27 and slightly in Mexico. In the EU27, costs fell due to lower energy intensity and output but, mainly, cost reductions are unexplained due to a large residual effect. In Mexico, energy cost fell because of lower average energy prices and lower output.

Energy costs increased in the UK, Turkey, the US, and China. Gross output increased in Turkey, the US, and China but fell in the UK. Although lower output reduces energy costs, higher UK energy prices drove up energy costs overall.

A very large increase in China's gross output drove up energy costs but lower energy intensity (as a result of lower energy consumption) drove then down. Turkey is the only country which experienced reduced average energy prices due to decreasing electricity and gas prices over time. Lower energy prices might be a reason why the Turkish *Manufacture of textiles* sector has experienced a very large increase in energy consumption along with a moderate increase in gross output.

Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16)

Table G-3 Decomposition for EU and G20 countries for Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
TR	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-41.0%	18.1%	74.3%	N/A	51.4%	90.37
EU27			10.2%	-2.2%	11.0%	-6.7%	-25.7%	75.05
US*			-2.0%	25.6%	-20.2%	N/A	3.4%	46.21
UK			39.8%	-42.0%	80.5%	N/A	78.3%	22.67
CN			73.3%	88.8%	-115.0%	N/A	47.0%	14.55

Sectoral energy costs increased in Turkey, the US, the UK, and China, the four G20 countries analysed, while they fell at the EU27-level. Because of higher energy prices, increased energy consumption, and lower output, the UK experienced the largest increase in energy costs. Similarly, EU27 sectoral prices and energy intensity have increased, leading to higher energy costs. However, overall EU27 reductions in energy costs between 2010-2017 is largely unexplained, as the residual effect dominates. Out of the five areas analysed, the EU27 has had the highest average sectoral price of energy in 2017. These results suggest that both the UK and the EU27 are losing international competitiveness in the *Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16)*.

In contrast, Turkey, the US, and China have experienced growth in sectoral gross output over time, leading to higher energy costs. In the US and China, this increase in costs was either matched or overtaken by lower costs due to improved energy intensities as both countries managed to reduce sectoral energy consumption over time, suggesting that the they have managed to improve their competitiveness in the m*anufacture of wood and of wood products (C16)*. **China's increased** production and decreased energy consumption has made it the least energy intensive country producing *wood and of wood products*. This may be a response to concurrent increases in sectoral average energy prices, since China had the highest average sectoral energy price from all G20 countries analysed in 2016.

Turkey experienced a positive energy intensity effect and a negative price effect. As a result of cheaper energy prices, **Turkey's** data shows that it has had the cheapest average energy price from all five areas analysed. Lower prices might have been a reason why Turkish total energy consumption grew at a faster rate than sectoral output.

Manufacture of paper and paper products (C17)

Table G-4 Decomposition for EU and G20 countries for Manufacture of paper and paper products (C17)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
US*	C17	Manufacture of paper and paper products	20.0%	3.6%	-3.2%	N/A	20.4%	242.86
EU27			0.7%	7.9%	-9.6%	-28.7%	-27.7%	187.89
UK			44.7%	-12.3%	23.1%	N/A	55.5%	169.39
TR			-40.1%	26.9%	53.1%	N/A	39.9%	83.96
CN			74.4%	64.9%	-90.0%	N/A	49.3%	65.16

China, Turkey, the UK, and the US's data show an increase in estimated sectoral energy costs, while the EU27 data show a reduction in sectoral energy costs. The *Manufacture of paper and paper products (C17)* is one of the most energy intensive sectors reviewed. The US, Turkey, China, and the EU27 have increased production over time while the UK has decreased its sectoral output. Improved energy intensity led to cost reductions that neutralised or outweighed cost increases because of higher production in China, the US, and the EU27.

On the other hand, Turkey has increased its sectoral output and sectoral energy intensity. Turkey was the only country, which experienced lower costs due to lower energy prices. Higher energy prices drove up energy costs in the US, UK, China, and the EU27. In China, coal is the main fuel used[216].

[216] Since Chinese coal prices are not available, this increase in the average price of energy is partly driven by the G20 average coal price.

However, coal has been gradually replaced by electricity in China over time. In absolute terms, the UK had the highest sectoral average energy price in 2017 since industrial processes in this sector have remained reliant on expensive electricity over time. In the US, much like the EU, this sector is dominate by other fuel consumption, such as biomass and waste, so there the cost calculations are likely to not capture the price effect of these alternative fuels.

Manufacture of coke, refined petroleum products, chemicals and chemical products, basic pharmaceutical products, and pharmaceutical preparations (C19_C21)

Table G-5 Decomposition for EU and G20 countries Manufacture of coke, refined petroleum products, chemicals and chemical products, basic pharmaceutical products, and pharmaceutical preparations (C19_C21)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
EU27	C19_C21	Manufacture of coke, refined petroleum products, chemicals and chemical products, basic pharmaceutical products, and pharmaceutical preparations (C19_C21)	-3.6%	-3.2%	-1.1%	-5.4%	-13.4%	141.95
CN			31.7%	86.8%	-54.1%	N/A	64.5%	70.35
TR			-34.5%	4.0%	66.3%	N/A	35.7%	88.41
US*			-2.2%	8.3%	-5.3%	N/A	0.8%	47.40
UK			28.4%	-41.5%	15.2%	N/A	2.1%	32.97

In contrast to the EU27, Energy costs increased in China, Turkey, the US, and the UK, with China seeing the largest increase in energy costs between 2010-2016. This was driven by an increase in sectoral gross output in Turkey, China, and the US (thus the energy demand increased). Meanwhile, the UK's output has shrunk over time, driving down energy costs.

In the UK, decreased energy costs brought about by less sectoral output were cancelled out by an increase in cost because of higher energy prices and energy intensity. Energy prices also increased in China, driving up energy costs further. The US's average energy price fell slightly over the period while Turkey's average energy price fell significantly. The US registers the lowest sectoral average price as the sector is mainly reliant on natural gas, which is very cheap when compared to the price series in China and the UK.

Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)

Table G-6 Decomposition for EU and G20 countries Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
CN	C19_C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	-0.6%	104.3%	-49.2%	N/A	54.5%	31.47
EU27			11.6%	14.7%	-32.3%	-9.8%	-3.8%	19.55
UK			28.0%	-14.6%	-8.8%	N/A	4.6%	9.78

Similarly to the results for the combined *Manufacture of coke, petroleum products, chemical and pharmaceutical products (C19_C21)* sector, energy costs in China and the UK have increased between 2010 and 2016 in M*anufacture of basic pharmaceutical products and pharmaceutical preparations (C21)*. This was driven by large increase in gross output in China whereas the UK has experienced a reduction in output over time. In contrast, the EU27 has seen a reduction in energy costs between 2010 and 2017. In the EU27, output increased (driving up costs of energy) and energy intensity has fallen, suggesting that the EU27 is strongly positioned to compete with China in the *Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)*.

Notably, although the price effect significantly drives up Chinese energy costs in *manufacture of coke, petroleum products, chemicals and pharmaceutical products (C19_C21)*, it slightly drives them down in the *manufacture of pharmaceuticals* (C21) whereas increase in energy price increased costs in the UK and the EU27. In China, *Manufacture of basic pharmaceutical products (C21)* mainly relies on coal, followed by electricity. The share of electricity fell from one quarter to one fifth between 2010 and 2016 and, concurrently, coal consumption increased to about three quarters of all consumption. The reduction in China's average price[217] suggests that the sector is very sensitive to changes in price. In fact, although output rises substantially, energy consumption increased at a more modest rate over time. This has improved the sector's energy intensity and driven down energy costs.

Manufacture of rubber, plastic products, and other non-metallic mineral products (C22_C23)

Table G-7 Decomposition for EU and G20 countries Manufacture of rubber, plastic products, and other non-metallic mineral products (C22_C23)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe per million €)
CN	C22_C23	Manufacture of rubber, plastic products, and other non-metallic mineral products	29.1%	75.7%	-73.7%	N/A	31.1%	142.62
TR			-6.3%	13.0%	-6.6%	N/A	0.1%	144.09
EU27			1.6%	3.8%	-22.2%	4.9%	-11.9%	84.09
US*			1.7%	16.3%	-3.0%	N/A	15.0%	51.09
UK			20.4%	1.3%	-12.3%	N/A	9.5%	44.18

Sectoral energy prices and gross output increased in China, Turkey, the US, and the UK, which has driven up energy costs. Overall, all four G20 countries have experienced lower energy intensity, with China seeing the largest reduction in energy cost because of improved sectoral energy intensity. This contrast with the EU27 where energy price increases and output where outweighed by improvements in energy efficiency

However, a positive price and/or real output effects resulted in an overall increase in energy costs. The only G20 country which as seen a reduction in average prices is Turkey. It is interesting to note that in all other sectors explored so far, Turkish energy intensity increased when price decreased. In this case, energy intensity fell. One potential explanation is because the *Manufacture of rubber and plastic products* (*C22_C23)* is heavily dependent on coal consumption in Turkey. Coal is a fuel which has

[217] It is important to note that Chinese coal prices were not available for this analysis and, therefore, sectors with a heavy reliance on coal consumption, *Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)*, are priced using G20 average prices.

experienced increased prices over time in Turkey whereas electricity, gas, and oil prices have fallen. In fact, the average energy price fell since some energy consumption is derived from other fuels. These results show that this industry has been responsive to increases in coal prices over time and have improved their energy intensity while increasing output.

Manufacture of basic metals (C24)

Table G-8 Decomposition for EU and G20 countries Manufacture of basic metals (C24)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe per million €)
EU27	C24	Manufacture of basic metals	4.7%	12.7%	-12.8%	-19.6%	-24.2%	174.91
CN			48.0%	83.8%	-59.6%	N/A	72.2%	134.11
US*			9.5%	-4.6%	-3.5%	N/A	1.5%	115.80
TR			-11.4%	3.7%	19.5%	N/A	11.7%	156.59
UK			21.0%	-37.9%	7.2%	N/A	-9.6%	95.94

Overall, the data suggests that energy costs have decreased in the EU27 and in the UK but increased in China, Turkey, and the US. In the UK, a reduction in costs is driven by less sectoral output. However, in the EU27, sectoral output has increased (driving up costs), but energy costs fell because of improved energy efficiency and other unexplained effects.

In China, the US, the UK and in the EU27, energy costs increased because of higher energy prices. This effect is most prominent in China, where coal is the main fuel used[218]. Having said that, more electricity consumption (for which Chinese price data is available) is evident as fuel shares shift from coal to electricity between 2010 and 2016. Turkey was the only country, which experienced falls in average energy prices over time, leading to lower energy costs. Although prices fell, Turkey experienced higher overall energy costs due to increased energy intensity driven by higher energy consumption.

China has managed to increase output while only modestly increase in energy consumption. This indicates that China has invested heavily in more efficient plants and processes, which has driven down energy costs. Chinese output and energy consumption data suggests similar large reduction in energy intensity for all Chinese sectors reported. Although such large improvement in energy intensity can partially be explained by energy efficiency improvements and/or economies of scale, the magnitude of improvement over a limited time frame (2010-2016) suggests that there are other drivers of reduced energy intensity.

[218] It is again worth noting that because Chinese coal prices are unavailable, China's average energy price for *Manufacture of basic metals (C24)* is reliant on G20 average coal prices.

Manufacture of fabricated metal products, except machinery and equipment (C25)

Table G-9 Decomposition for EU and G20 countries Manufacture of fabricated metal products, except machinery and equipment (C25)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
CN	C25	Manufacture of fabricated metal products, except machinery and	23.7%	64.9%	-31.6%	N/A	57.0%	53.79
EU27			10.1%	9.3%	-14.5%	-8.4%	-13.2%	18.63
UK			24.4%	-0.7%	-10.5%	N/A	13.2%	14.53

Both China and the UK have seen increases in energy costs over time whereas the EU27 has seen a reduction in energy costs. In China, the UK, and the EU27, energy costs are driven upwards by higher average energy prices. Whereas China heavily relies on electricity and other fuel consumption, the UK splits consumption between electricity and gas.

Although gross output increased in China and the EU27, it fell in the UK. Lower UK output also led to lower energy consumption, resulting in improved energy intensity driving down energy costs. Similarly, China and the EU27 have experienced improved energy intensity.

Manufacture of computer, electronic and optical products (C26)

Table G-10 Decomposition for EU and G20 countries Manufacture of computer, electronic and optical products (C26)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
UK	C26	Manufacture of computer, electronic and optical products	28.8%	-12.8%	8.6%	N/A	24.6%	15.50
CN			42.4%	59.5%	-34.5%	N/A	67.4%	12.12
EU27			11.4%	14.7%	-11.1%	-8.9%	-23.8%	6.42

Estimated energy costs suggests that the *Manufacture of computer, electronics and optical products (C26)* sector faced higher energy costs in both China and the UK while the Eurostat SBS data suggests lower sectoral energy costs in the EU27. The relative increase in costs was larger in China than the UK due to a large increase in output. In contrast, the UK has seen a large decrease in gross output. This has driven down UK energy costs but higher energy prices and higher energy intensity led to an overall increase in UK energy costs.

In China, average energy prices also increased over time, driving up energy costs, but improvements in sectoral energy intensity drove down energy costs. However, large increase in Chinese output are the main drivers of higher energy costs.

Manufacture of electrical equipment (C27)

Table G-11 Decomposition for EU and G20 countries Manufacture of electrical equipment (C27)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
UK	C27	Manufacture of electrical equipment	23.2%	-2.4%	3.9%	N/A	24.7%	22.04
CN			9.0%	56.1%	-33.3%	N/A	31.9%	14.06
EU27			10.1%	4.6%	-15.3%	-15.4%	-14.8%	9.49

Manufacture of electrical equipment (C27) energy costs increases in the UK and China over time are primarily driven by increased average prices in the UK and increased output in China. Output increases have driven up costs in China and the EU27 while reductions in output have driven them down in the UK. Furthermore, energy consumption increased in China and the UK while it fell at the EU27-level. In China, increases in output overtake increases in energy consumption, leading to improved energy intensity and a reduction in energy costs. On the other hand, an increase in consumption in the UK occurs in line with a reduction in output, driving up sectoral energy-intensity and energy costs.

Manufacture of machinery and equipment n.e.c. (C28)

Table G-12 Decomposition for EU and G20 countries Manufacture of machinery and equipment n.e.c. (C28)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe **per million €)**
TR	C28	Manufacture of machinery and equipment n.e.c.	-30.1%	44.3%	0.5%	N/A	14.7%	40.92
CN			58.1%	54.2%	-50.3%	N/A	62.0%	36.05
US*			7.9%	-7.8%	12.9%	N/A	13.0%	11.33
EU27			13.6%	16.6%	-26.0%	2.1%	-2.0%	10.23
UK			25.3%	-9.4%	-2.5%	N/A	13.4%	8.26
MX*			-65.1%	-20.2%	21.4%	N/A	-63.9%	2.61

Manufacture of machinery and equipment (C28) energy costs have increased in China, Turkey, the US, the UK over time. Higher costs are partially a result of higher energy prices in China, the US, the UK. Alternatively, Turkey and Mexico's results show that lower energy prices have sharply driven down energy costs over time. In fact, Mexico had the cheapest 2016 average energy price in all G20 countries reviewed. A review of each country's fuel mix shows that Mexico favours oil, a resource that has experienced falling prices, as the leading energy source. On the other hand, electricity is the main energy carrier in Turkey, the EU27, China, the US, and the UK.

Higher output in China, Turkey, and the EU27 has increased energy costs. This is paired with a negative energy intensity effect in these three countries except Turkey, leading to improvements in energy intensity over time. The UK, US and Mexico, instead, have experienced falling gross output (driving down energy costs) but the UK also managed to decrease energy intensity over time.

Manufacture of motor vehicles, trailers and semi-trailers (C29)

Table G-13 Decomposition for EU and G20 countries Manufacture of motor vehicles, trailers and semi-trailers (C29)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe per million €)
CN	C29	Manufacture of motor vehicles, trailers and semi-trailers	37.5%	63.9%	-81.7%	N/A	19.6%	16.68
UK			4.9%	32.2%	-13.1%	N/A	24.0%	11.89
EU27			6.9%	40.4%	-36.7%	7.0%	-3.5%	6.36

Higher energy costs in China, the UK, and the EU27's *Manufacture of motor vehicles, trailers and semi-trailers (C29)* are driven up by increased average energy prices and increased gross output. In terms of fuels used, China has reduced its coal and oil consumption and increased its electricity and natural gas shares over time. By 2016, electricity accounted for half of sectoral consumption. On the other hand, electricity only makes up one quarter of the UK's consumption, a figure that has fallen since 2010. Instead, the UK has increased its shares of natural gas and oil consumption, allowing it to keep its increase in sectoral energy prices limited. Similarly, the EU27 has reduced its share of electricity consumption over time in favour of natural gas.

China has seen very large increases in sectoral output between 2010 and 2016, while the UK has moderately increased its output. Concurrently, China has decreased energy consumption, suggesting that the industrial processes used have become much more efficient over time, while the UK and the EU27's sectoral energy consumption has increased, driven by increases in production post-recession that exceed the improvements in energy efficiency over the period. Due to an improvement in energy efficiency, China's energy costs have decreased but its sectoral energy intensity is higher than the UK's and the EU27's. This suggests that European production already uses highly energy efficient technology and that further cost reduction as a result of energy efficiency improvement are difficult to achieve.

Manufacture of other transport equipment (C30)

Table G-14 Decomposition for EU and G20 countries Manufacture of other transport equipment (C30)

Country	Code	Description	Price effect	Real output effect	Real energy intensity effect	Residual effect	Total effect	2016 Energy Intensity (toe per million €)
UK	C30	Manufacture of other transport equipment	4.1%	29.6%	-11.6%	N/A	22.0%	9.60
EU27			12.3%	42.0%	-60.5%	-9.2%	-3.0%	4.37

The only G20 country with a consistent data set for the *Manufacture of other transport equipment (C30)* is the UK. In the UK, higher energy costs over the time are driven by a higher sectoral average energy price and an increase in production. Gas is the main UK energy carrier in 2016 while both electricity and gas are important fuels at the EU27-level. Over time, electricity's share in the UK's energy mix has decreased while oil and gas's share increased slightly.

Increased UK production led to lower sectoral energy intensity, which drove down energy costs. At the EU27-level, energy costs have decreased as a result of energy intensity reductions, which overtook a positive gross output effect on energy costs.

Output Decomposition analysis comparison with G20 countries

The follow section looks at the difference in drivers of output growth between the EU and several main G20 trading partners for each manufacturing sector.

Manufacture of food products; beverages and tobacco products (C10_C12)

Table G-15 Decomposition of Output - Manufacture of food products; beverages and tobacco products (C10_C12)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C10_C12	Manufacture of food products; beverages and tobacco products	3.3%	4.3%	-1.7%	5.9%
UK			13.9%	4.2%	-6.6%	11.5%
US			14.6%	1.2%	-3.0%	12.7%
CN			131.8%	1.7%	-2.8%	130.7%

Manufacture of food products; beverages and tobacco products (C10_C12) gross output has increased in the EU27, UK, US, and China. In all for areas, higher domestic demand and export increased output. Higher imports reduce output throughout, but this is never large enough to overcome the positive domestic demand and export effects on gross output. China has had the largest overall increase in gross output, driven by a massive increase in domestic demand.

Out of the four areas analysed, the EU27 has exported the highest volume of *food products; beverages and tobacco* products in 2017. In fact, the EU27 has had a larger positive export effect on gross output than the UK, the US, and China.

Manufacture of textiles, wearing apparel, leather and related products (C13_C15)

Table G-16 Decomposition of Output - Manufacture of textiles, wearing apparel, leather and related products (C13_C15)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C13_C15	Manufacture of textiles, wearing apparel, leather and related products	6.9%	14.5%	-20.9%	0.4%
UK			-36.4%	12.3%	8.8%	-15.3%
US			44.3%	1.8%	-12.2%	33.9%
CN			93.6%	4.6%	-0.8%	97.4%

Gross output in the *Manufacture of textiles, wearing apparel, leather and related products (C13_C15)* sector has increased in the EU27, the US, and China between 2010-2017. While the EU27's 2017 gross output is only 0.4% higher than that produced in 2010, China and the US have had very large increases in output. On the other hand, the UK has seen a reduction in sectoral gross output over time.

Higher domestic demand has driven up gross output in the EU27, the US, and China but lower UK domestic demand has contributed to a fall in sectoral gross output. Higher exports contributed to higher gross output in all areas, but higher imports decreased output down in the EU27, US, and China. UK imports have fallen over time, driving up gross output. This suggests that UK consumers have reduced their demand for *textiles and related products* over time as the consumption of both domestically produced and foreign produced goods has decreased.

Both China and the US have had large increases in domestic demand, and moderate increases in exports. However, in the EU27, higher exports were the main positive driver of sectoral gross output. This suggests that the **EU27's demand for locally produced** *textile, wearing apparel, leather and related products (C13_C15)* has been stable while global demand increased. Having said that EU27 imports have increased and, therefore, the EU's overall demand for *textile products* increased due to a larger consumption of foreign goods.

Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16)

Table G-17 Decomposition of Output - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	-2.5%	3.0%	-0.4%	0.0%
UK			-28.3%	-1.7%	6.4%	-23.5%
US			41.3%	3.7%	-9.1%	35.9%
CN			135.4%	1.0%	-4.4%	132.0%

The EU27's has managed to keep 2017 gross output at 2010 level while the US and China have seen large increases in output between 2010-2017, driven by large increases in domestic demand for locally produced *wood and wood products (C16)*. The UK's gross output in 2017 was lower than in 2010. Lower UK output was caused by lower domestic demand and lower exports. Although imports also decreased, this was not enough to outweigh lower gross output caused by lower domestic demand and exports.

In the EU27, US, and China, higher exports have driven up gross output but higher imports have driven sectoral output down. In China and the EU27, 2017 exports have exceeded imports in absolute terms. In fact, in the EU27, domestic demand for goods has fallen over time while exports increased significantly and imports remained stable. This shows that EU27 demand for *wood and wood products* has been stable but manufacturing firms have managed to grow as a result of higher demand **by the EU's** major trading partners.

The US has had a very large increase in both domestic consumption and imports of *wood and wood products* between 2010-2017. In fact, in 2017, the US imported the highest volume of *wood and wood products* out of the areas reviewed. This suggests that the US is a country which has contributed to overall increased demand for these goods.

Manufacture of paper and paper products (C17)

Table G-18 Decomposition of Output - Manufacture of paper and paper products (C17)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C17	Manufacture of paper and paper products	1.3%	0.7%	0.4%	2.3%
UK			-7.6%	-5.6%	15.2%	2.1%
US			7.9%	-0.3%	0.6%	8.1%
CN			89.3%	4.3%	-3.6%	90.0%

The EU27, the UK, the US, and China has seen an increase in sectoral gross output related to the *Manufacture of paper and paper products (C17)* between 2010-2017. In the EU27, the US, and China, higher gross output was caused by increased domestic demand and, to a lesser extent, increased exports. While higher imports slightly contributed to lower gross output in the US and China, lower imports increased gross output in the UK and the EU27.

Paper and paper products (C17) are not highly traded goods and that changes in domestic demand greatly affect changes in output. Lower EU27 imports and more domestic demand suggests that EU firms have positioned themselves to meet the bloc's increased demand for *paper and paper products* over time. However, the UK's data shows that demand for *paper and paper products* has fallen as both domestic demand and imports fell. In fact, lower imports were the main driver of increased UK sectoral gross output.

Manufacture of coke and refined petroleum products (C19)

Table G-19 Decomposition of Output - Manufacture of coke and refined petroleum products (C19)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C19	Manufacture of coke and refined petroleum products	-29.9%	-6.6%	7.6%	-28.9%
UK			-33.7%	-22.7%	7.1%	-49.3%
US			-0.6%	15.1%	-1.1%	13.3%
CN			89.8%	1.2%	0.8%	91.8%

While the US and China have seen a substantial increase in the gross output relating to the *Manufacture of coke and refined petroleum products (C19)* over time, the EU27 and the UK has seen a reduction in gross output between 2010-2017. In both cases, reductions in gross output is mainly driven by lower domestic demand. A reduction in imports has slightly driven up gross output but this effect shows that the **UK's and the EU27's demand** for *coke and refined petroleum products* has decreased, irrespective of where it is manufactured. At the same time, EU27 and UK exports of these products have fallen over time.

Demand for *coke and refined petroleum products* in the US and China has increased significantly between 2010-2017 as a result of increased domestic demand and higher imports. At the same time, both the US and China has seen higher export volumes, with the US experiencing a massive boom of *coke and refined petroleum products* exports between 2010-2017.

Manufacture of chemicals and chemical products (C20)

Table G-20 Decomposition of Output - Manufacture of chemicals and chemical products (C20)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C20	Manufacture of chemicals and chemical products	1.1%	4.8%	-5.1%	0.9%
UK			-23.5%	-25.8%	24.9%	-24.5%
US			7.8%	0.9%	-1.6%	7.2%
CN			123.8%	4.1%	-2.9%	125.0%

Between 2010-2017, the EU27, the US, and China have had increased *Manufacture of chemicals and chemical products (C20)* gross output while UK output has fallen. Increased domestic demand has been the main driver of higher sectoral gross output in both the US and China. Although both areas have managed to increase their exports, the positive export effect (leading to higher output) was matched by higher imports (leading to lower output) in both cases. On the other hand, the EU27's increased gross output was mainly due to higher exports rather than increased domestic demand.

This suggests that demand for *chemicals and chemical products* is increasing and that China and the US have managed to meet some of that increased global demand while meeting increased local/regional demand. While the EU27 also increased exports, higher overall demand by EU27 consumers was mainly met by the consumption of imported products as domestic demand growth was very small over time.

The UK's *Manufacture of chemicals and chemical products (C20)* gross output has fallen as a result of lower domestic demand and lower exports. Falling imports show that UK consumers of *chemical and chemical* products have decreased their demand overall.

Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)

Table G-21 Decomposition of Output - Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	1.1%	4.8%	-5.1%	0.9%
UK			-23.5%	-25.8%	24.9%	-24.5%
US			7.8%	0.9%	-1.6%	7.2%
CN			123.8%	4.1%	-2.9%	125.0%

The EU27, the US, and China's sectoral gross output has increased between 2010-2017 while the UK experienced lower output. While higher gross output was driven by higher domestic demand in the US and China, higher exports were the main driver of increased output in the EU27 *Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)* sector.

Over time, EU27 exports increased, domestic demand fell, and imports increased. This suggests that EU27 producers have shifted towards meeting international demand for *pharmaceutical products*. The data suggests that demand for this product has increased over time as imports have increased in all four areas analysed while exports have increased in the EU27, the UK, and China.

Manufacture of rubber and plastic products (C22)

Table G-22 Decomposition of Output - Manufacture of rubber and plastic products (C22)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C22	Manufacture of rubber and plastic products	15.0%	5.8%	-5.0%	15.8%
UK			8.6%	0.7%	-5.3%	4.0%
US			27.4%	3.0%	-7.6%	22.8%
CN			84.4%	9.5%	0.7%	94.6%

Sectoral gross output in the *Manufacture of rubber and plastic products (C22)* has increased in the EU27, the UK, the US, and China. In all four areas, higher domestic demand and increased exports have contributed to an increase in gross output. At the same time, imports have increased in all four areas but the combined positive domestic demand and export effects on gross output have outweighed the negative imports effect. These results clearly show that the demand for *rubber and plastic products* has increased in all four areas analysed. Higher exports in all areas also suggest that demand for these products has increased between 2010-2017 and that EU27, UK, US, and Chinese producers have managed to meet some of this increased global demand.

Manufacture of other non-metallic mineral products (C23)

Table G-23 Decomposition of Output - Manufacture of other non-metallic mineral products (C23)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C23	Manufacture of other non-metallic mineral products	1.2%	3.5%	-1.9%	2.8%
UK			12.0%	0.4%	-4.5%	7.9%
US			27.9%	0.8%	-5.0%	23.8%
CN			129.5%	3.3%	-0.9%	131.9%

Higher domestic demand for *non-metallic mineral products* between 2010-2017 was the main driver of increased sectoral gross output in the UK, the US, and China while higher exports mainly contributed to higher output in the EU27. EU27 and UK consumers have only modestly increased their domestic demand of this product over time, whereas the increase in domestic demand was much more aggressive in the US and China.

Overall demand for *other non-metallic mineral products* has increased over time but that the EU27 and the UK were not the main catalyst. China and the US have had a much bigger role to play when it comes to increased global demand for *other non-metallic mineral products* between 2010-2017. The EU27, the UK, and the US, and China have all increased exports and imports. Lower output as a result of higher imports overtook higher output as a result of higher exports in the UK and the US.

Manufacture of basic metals (C24)

Table G-24 Decomposition of Output - Manufacture of basic metals (C24)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C24	Manufacture of basic metals	20.0%	1.3%	-6.9%	14.4%
UK			24.9%	41.1%	-92.2%	-26.3%
US			13.8%	5.3%	-12.0%	7.1%
CN			112.7%	0.9%	-3.1%	110.6%

Higher EU27, US, and Chinese *Manufacture of basic metals (C24)* gross output was a result of higher domestic demand and higher exports. Although all four areas have seen increased imports, a massive relative increase in UK imports of *basic metal* products has led to lower UK gross output between 2010-2017.

Higher domestic demand and higher imports in all areas suggest an increased appetite for *basic metals* in the EU27 and its three major G20 trading partners. While the EU27, the US, and China have managed to mostly meet this demand through locally/regionally produced goods, the UK heavily relied on foreign production. Interestingly, while UK consumers imported a large volume of *basic metals*, UK exports also increased. This suggests that UK suppliers may not be producing the same goods which are needed by UK consumers, or that UK consumers find it generally cheaper to source foreign produced *basic metals*.

Manufacture of fabricated metal products, except machinery and equipment (C25)

Table G-25 Decomposition of Output - Manufacture of fabricated metal products, except machinery and equipment (C25)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C25	Manufacture of fabricated metal products, except machinery and equipment	13.1%	3.5%	-3.3%	13.3%
UK			2.6%	2.2%	-3.5%	1.4%
US			34.1%	1.4%	-5.2%	30.2%
CN			72.3%	6.4%	-0.1%	78.7%

When compared to 2010, the EU27, the UK, the US, and China have all had higher levels of output in 2017. Although international trade of *fabricated metal products* has increased over time, changes in domestic consumption patterns seem to determine **the sector's overall outlook in the EU27 and its** three major G20 trading partners. All four areas increased domestic demand and exports related to the *Manufacture of fabricated metal products, except machinery and equipment (C25)*. Meanwhile, all four areas have seen increases in imports between 2010-2017, which balance or outweighed the increased output resulting from higher exports.

Manufacture of computer, electronic and optical products (C26)

Table G-26 Decomposition of Output - Manufacture of computer, electronic and optical products (C26)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C26	Manufacture of computer, electronic and optical products	24.0%	22.7%	-35.4%	11.2%
UK			0.5%	-10.6%	1.6%	-8.5%
US			35.7%	6.1%	-24.9%	16.9%
CN			76.3%	6.4%	-8.5%	74.2%

The EU27, the US, and China have had positive gross output growth driven by increased domestic demand for *computer, electronic and optical products* between 2010-2017. At the same time, all three areas have ramped up their exports and their imports of these products.

While the UK has had an increased domestic demand for *computer, electronic and optical products*, very large reductions in exports have led to a reduction of sectoral gross output between 2010-2017. This indicates that **while global demand has increased, the UK's industry was less well placed than** its competitors in the EU27, China, and the US to meet this demand.

Manufacture of electrical equipment (C27)

Table G-27 Decomposition of Output - Manufacture of electrical equipment (C27)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C27	Manufacture of electrical equipment	3.8%	8.2%	-11.3%	0.7%
UK			26.1%	11.6%	-37.8%	-0.1%
US			37.8%	11.1%	-38.2%	10.7%
CN			72.7%	8.2%	0.2%	81.1%

Results for the *Manufacture of electrical equipment (C27)* are very similar to the ones for the *Manufacture of computer, electronic and optical products (C26)*. The EU27, the UK, the US, and China have all had higher output as a result of higher domestic demand and export. At the same time, all four areas have imported more *electrical equipment*, which has driven down sectoral gross output. In the EU27, the US, and China, positive domestic demand and export effects have outweighed the negative imports effect, while in the UK, there has been a substitution from domestic production to imports, leading to a small reduction in gross output between 2010-2017.

Manufacture of machinery and equipment n.e.c. (C28)

Table G-28 Decomposition of Output - Manufacture of machinery and equipment n.e.c. (C28)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C28	Manufacture of electrical equipment	11.7%	6.3%	-4.3%	13.7%
UK			-0.1%	-10.9%	3.5%	-7.5%
US			30.0%	-1.1%	-14.8%	14.0%
CN			64.9%	4.2%	1.4%	70.4%

In the EU27, US, and China, large positive domestic demand effects were the main contributor to sectoral increases in gross output in contrast. The three areas have all had increased exports of *machinery and equipment (C28)* between 2010 and 2017, driving up gross output. In the same period, all three areas have increased their sectoral imports, which drove down gross output. In the UK, reduced exports and lower import volumes jointly resulted in a reduction in sectoral gross output between 2010-2017.

Manufacture of motor vehicles, trailers and semi-trailers (C29)

Table G-29 Decomposition of Output - Manufacture of motor vehicles, trailers and semi-trailers (C29)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C29	Manufacture of motor vehicles, trailers and semi-trailers	31.0%	13.5%	-8.5%	35.9%
UK			38.6%	24.6%	-31.0%	32.2%
US			69.5%	6.9%	-23.4%	53.1%
CN			101.9%	3.0%	-3.3%	101.6%

Higher exports and domestic demand have led to an overall growth in EU27, the UK, the US, and Chinese gross output relating to the *Manufacture of motor vehicles, trailers and semi-trailers (C29)*. Increased exports and domestic demand in all four areas suggests that while global demand for *motor vehicles* grew, manufacturers in the EU27 and its three major trading partners have managed to meet this demand as well as burgeoning local demand by expanding their production, leading to positive economic effects in all four areas. Finally, all four areas also experienced increased imports. However, the strong positive exports and domestic demand effect outweighed the negative imports effect throughout.

Manufacture of other transport equipment (C30)

Table G-30 Decomposition of Output - Manufacture of other transport equipment (C30)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C30	Manufacture of other transport equipment	10.1%	18.1%	-3.4%	24.8%
UK			18.8%	51.3%	-25.9%	44.2%
US			9.5%	17.1%	-6.9%	19.6%
CN			62.2%	-6.5%	-5.2%	50.4%

Similarly, the EU27, the UK, the US, and China have seen an overall increase in gross output relating to the *Manufacture of other transport equipment (C30)*. Although higher imports driving gross output downwards was a common factor in all four areas between 2010-2017, higher domestic demand increased output in EU27, the UK, the US, and China.

The UK's increase in gross output was mainly driven by higher exports of *other transport equipment*. A reduction in UK output has been a recurring theme in most of the manufacturing sectors analysed, suggesting that it has lost international competitiveness in manufacturing when compared to the EU27, China, and the US. In contrast to this, UK *motor vehicles, trailers and semi-trailers (C29)* and *other transport equipment (C30)* manufacturing performed well between 2010-2017, mainly driven by higher exports of UK vehicles, which are typically high value products.

Manufacture of furniture & other manufacturing (C31_C32)

Table G-31 Decomposition of Output - Manufacture of furniture & other manufacturing (C31_C32)

Area	Code	Description	Domestic demand effect	Export effect	Import effect	Total effect (2010-2017)
EU27	C31_C32	Manufacture of furniture & other manufacturing	-3.5%	10.5%	-8.2%	-1.2%
UK			40.6%	23.4%	-36.6%	27.4%
US			15.5%	6.9%	-15.4%	7.0%

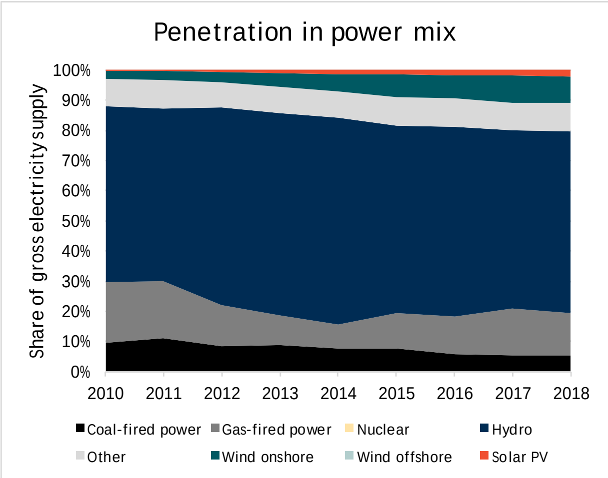
Complete data related to the *Manufacture of furniture; other manufacturing (C31_C32)* was only available for the EU27, the UK, and the US. In the EU27, domestic demand has decreased between 2010-2017 whereas exports and imports have increased. This has led to a slight negative gross output effect between 2010-2017 in the EU27. In the US and UK gross output between 2010-2017 has increased as a result of higher domestic demand and higher export levels.

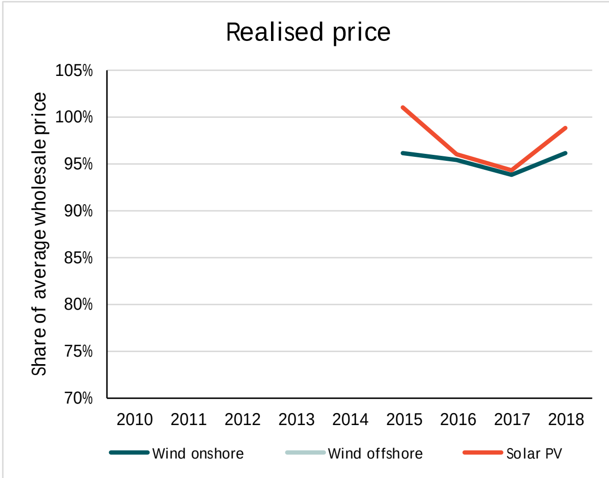
Annex H - Task 3 - Country factsheets

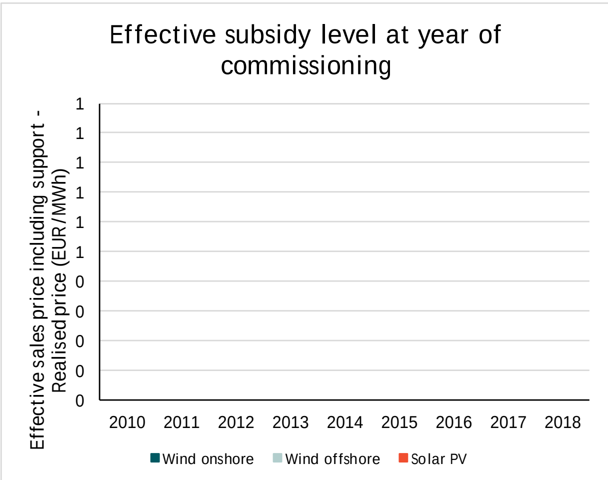
This Annex provides a selection of country factsheets for Task 3. Only countries with sufficient data to properly evaluate trends in realised prices and profitability.

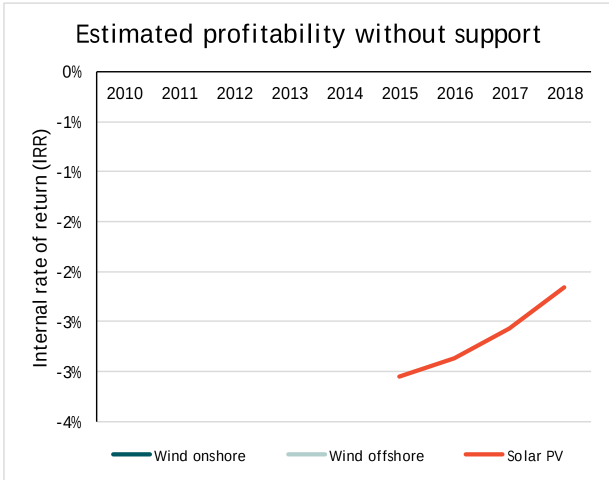
Austria

Austria

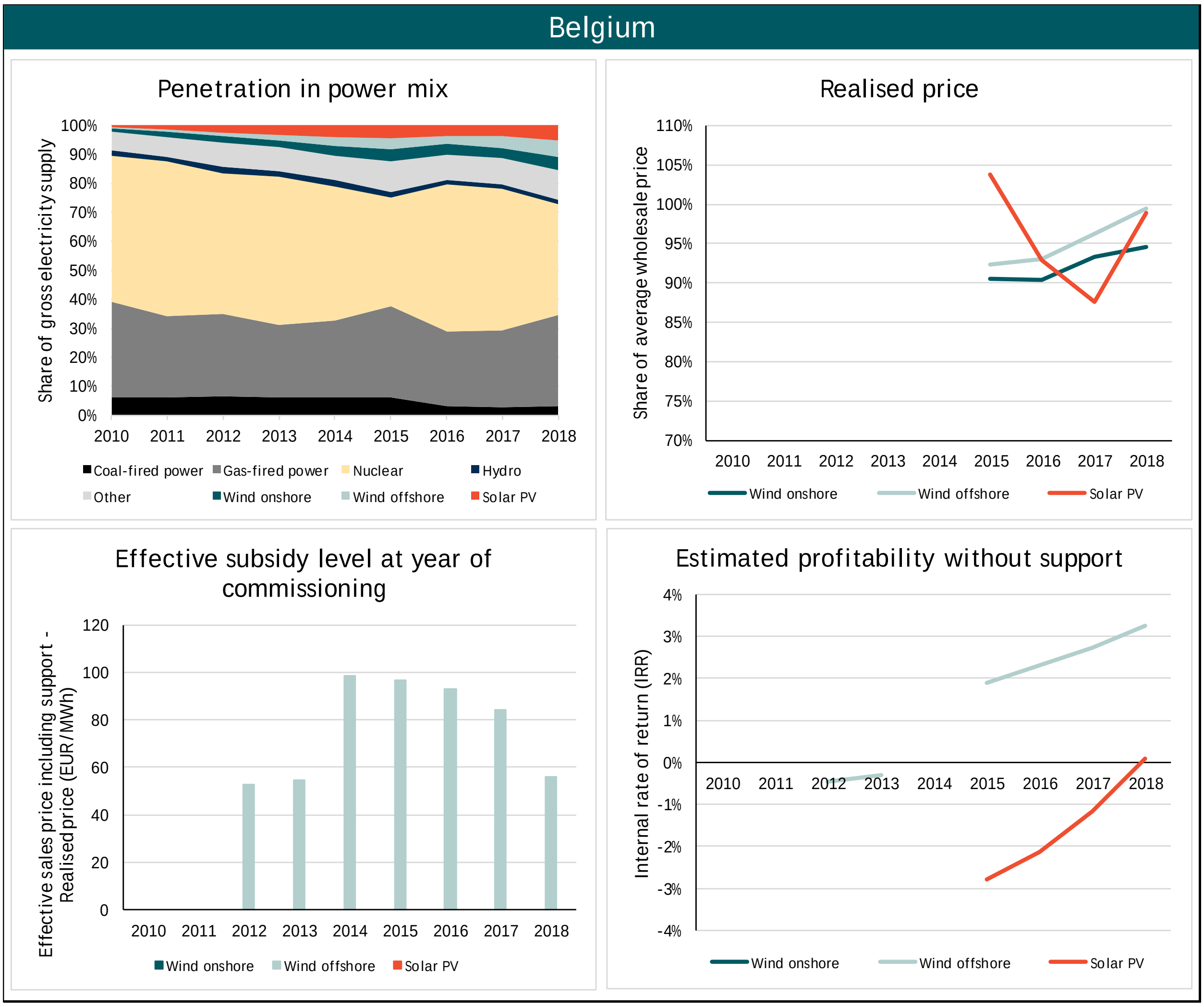




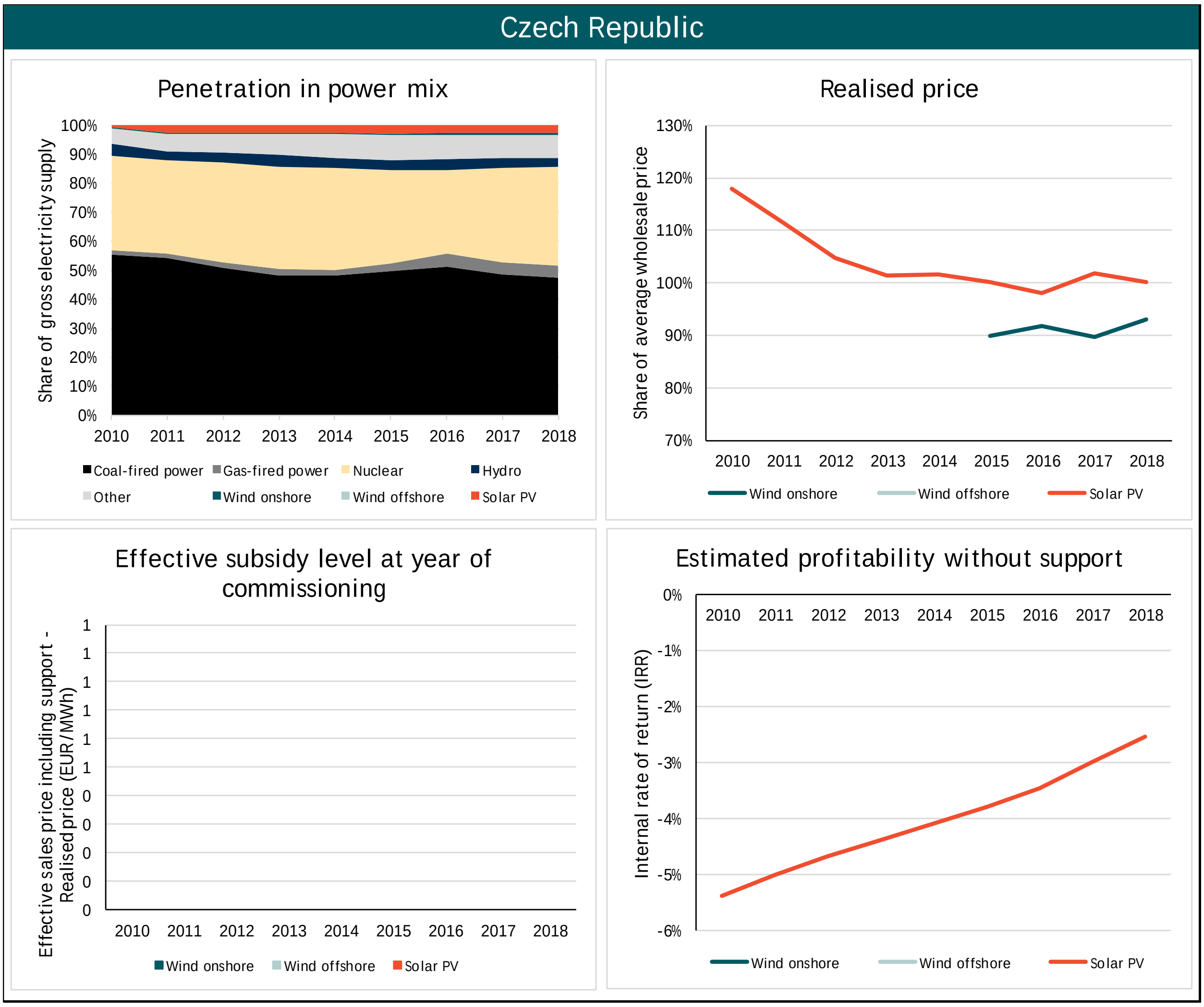




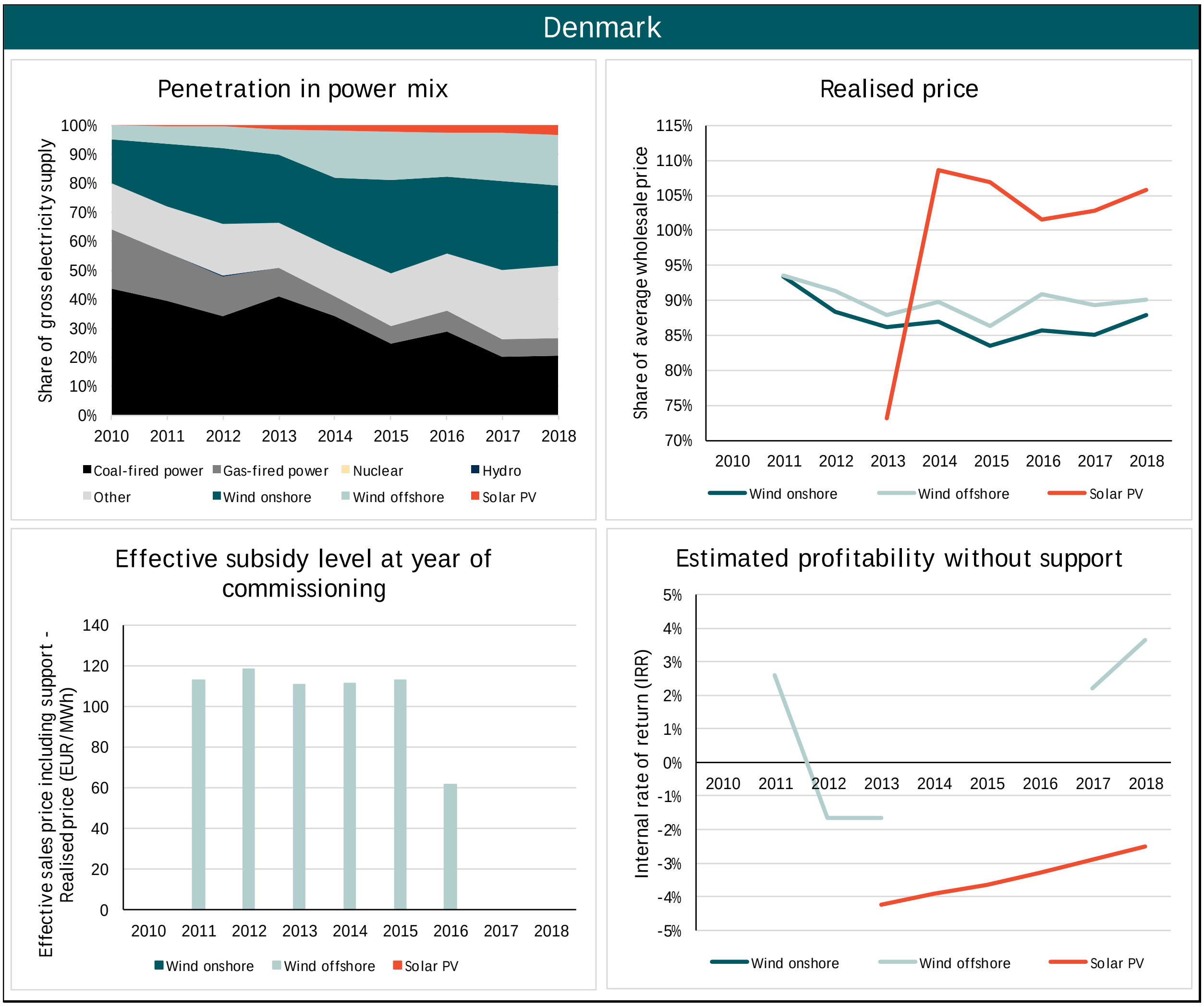
Belgium


Belgium
Penetration in power mix
Share of gross electricity supply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010
2011
2012
2013
2014
2015
2016
2017
2018
Coal-fired power
Gas-fired power
Nuclear
Hydro
Other
Wind onshore
Wind offshore
Solar PV
Realised price
Share of average wholesale price
110%
105%
100%
95%
90%
85%
80%
75%
70%
2010
2011
2012
2013
2014
2015
2016
2017
2018
Wind onshore
Wind offshore
Solar PV
Effective subsidy level at year of commissioning
Effective sales price including support - Realised price (EUR/MWh)
120
100
80
60
40
20
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
Wind onshore
Wind offshore
Solar PV
Estimated profitability without support
Internal rate of return (IRR)
4%
3%
2%
1%
0%
-1%
-2%
-3%
-4%
2010
2011
2012
2013
2014
2015
2016
2017
2018
Wind onshore
Wind offshore
Solar PV

Czech Republic



Denmark

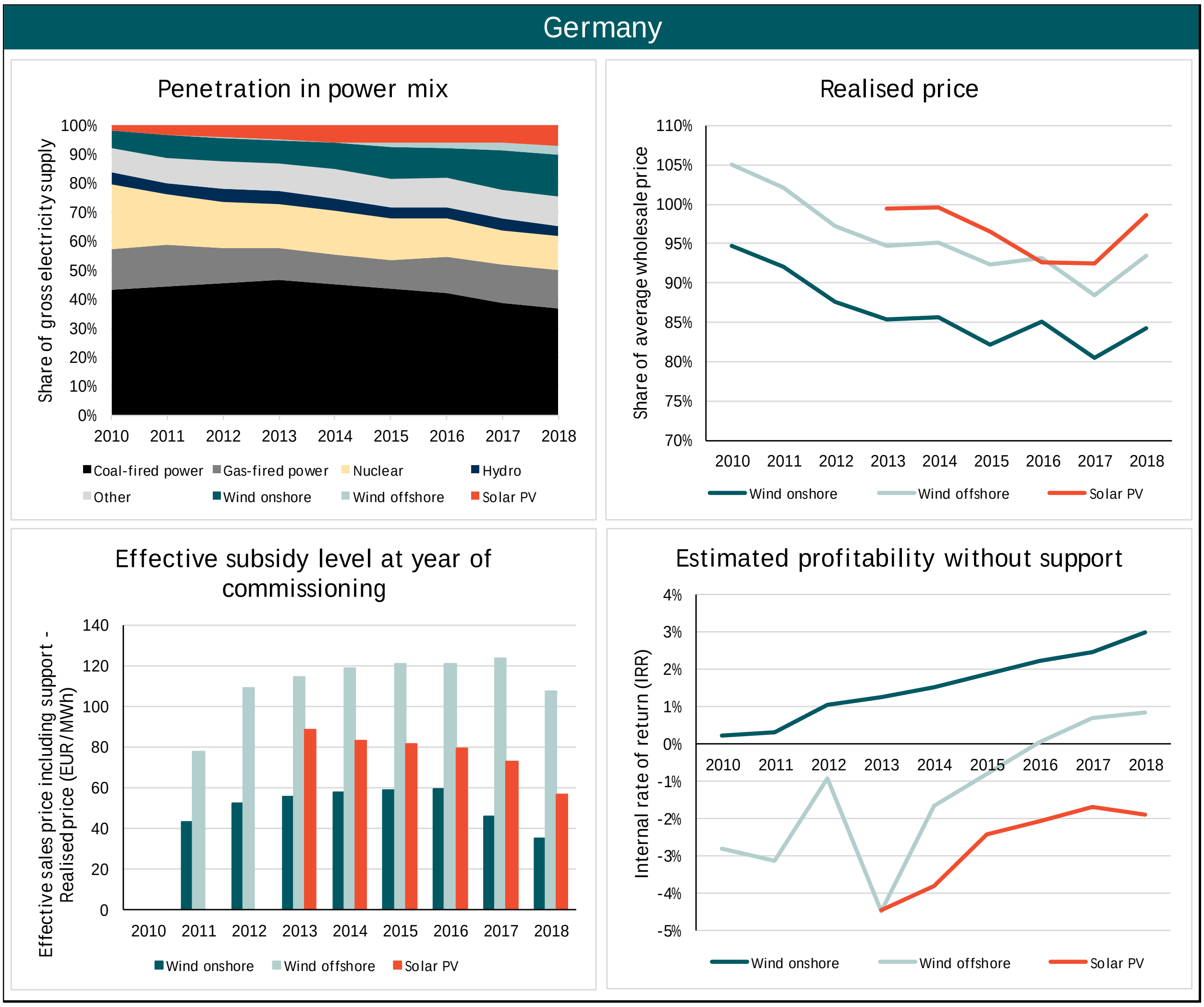

Denmark
Penetration in power mix
Share of gross electricity supply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Coal-fired power
Gas-fired power
Nuclear
Hydro
Other
Wind onshore
Wind offshore
Solar PV
Realised price
Share of average wholesale price
115%
110%
105%
100%
95%
90%
85%
80%
75%
70%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Effective subsidy level at year of commissioning
Effective sales price including support - Realised price (EUR/MWh)
140
120
100
80
60
40
20
0
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Estimated profitability without support
Internal rate of return (IRR)
5%
4%
3%
2%
1%
0%
-1%
-2%
-3%
-4%
-5%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV

France

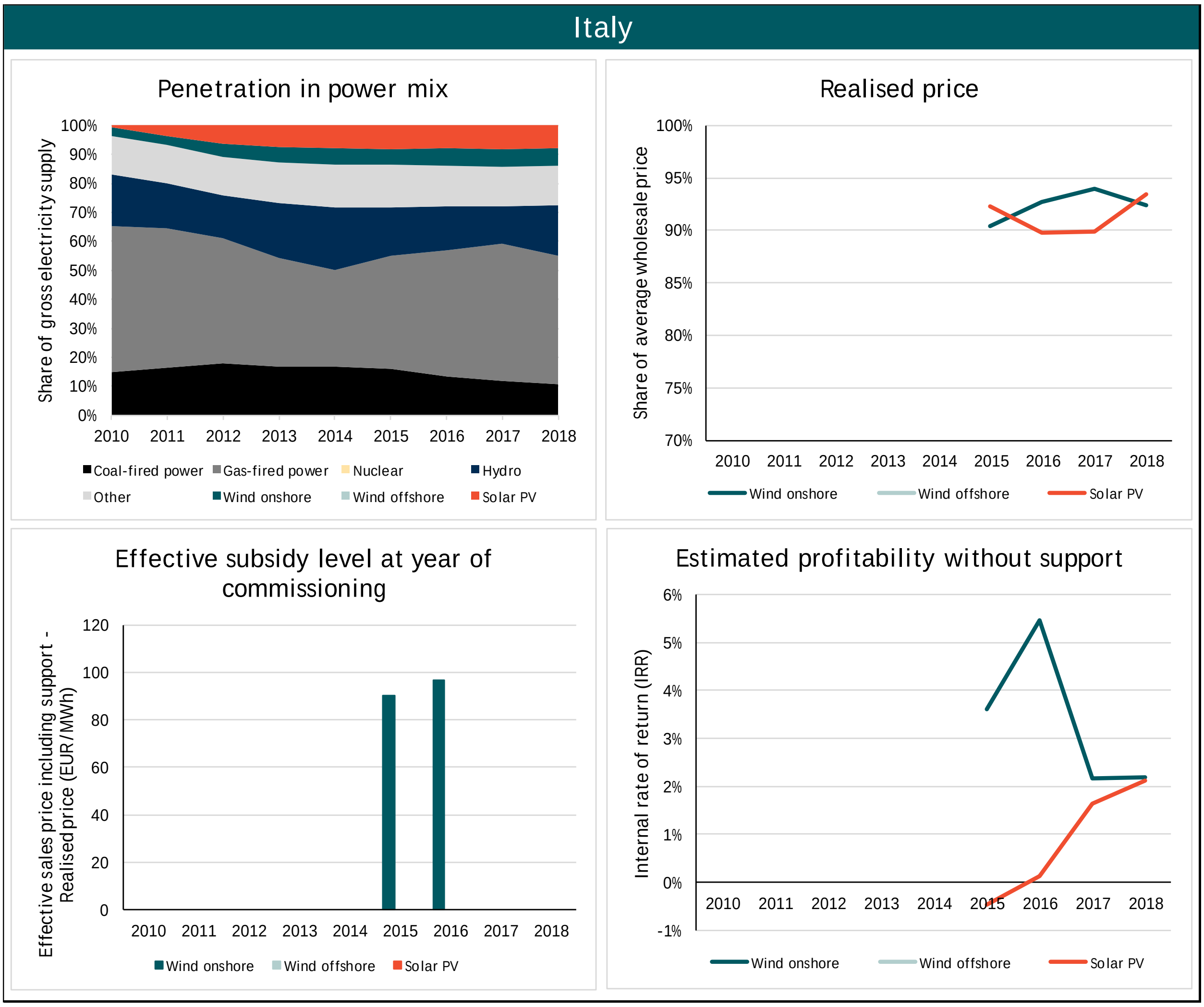

France
Penetration in power mix
Share of gross electricity supply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Coal-fired power
Gas-fired power
Nuclear
Hydro
Other
Wind onshore
Wind offshore
Solar PV
Realised price
Share of average wholesale price
115%
110%
105%
100%
95%
90%
85%
80%
75%
70%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Effective subsidy level at year of commissioning
Effective sales price including support - Realised price (EUR/MWh)
160
140
120
100
80
60
40
20
0
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Estimated profitability without support
Internal rate of return (IRR)
6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV

Source: Study on energy prices, costs and their impact on industry and households

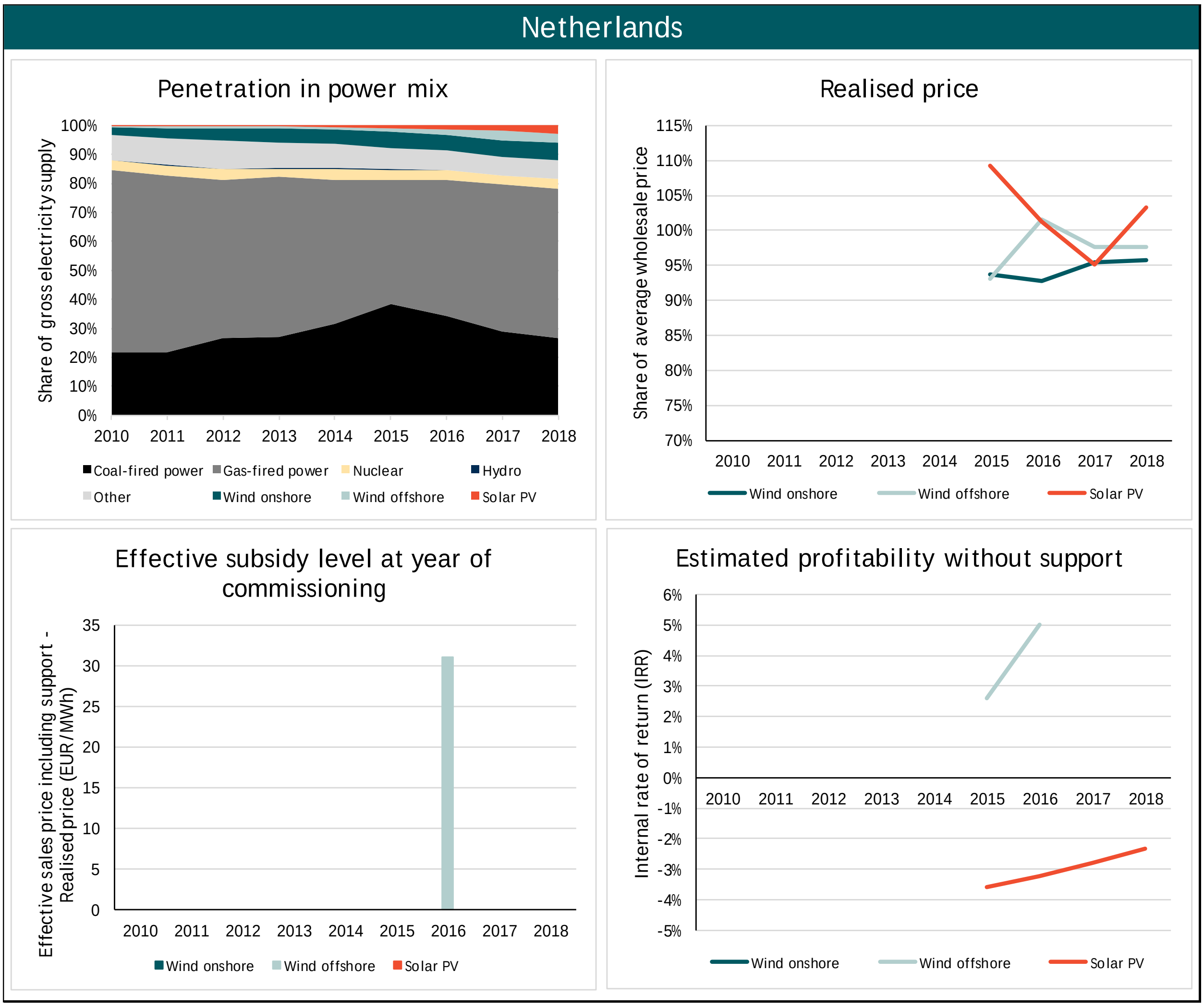
Germany



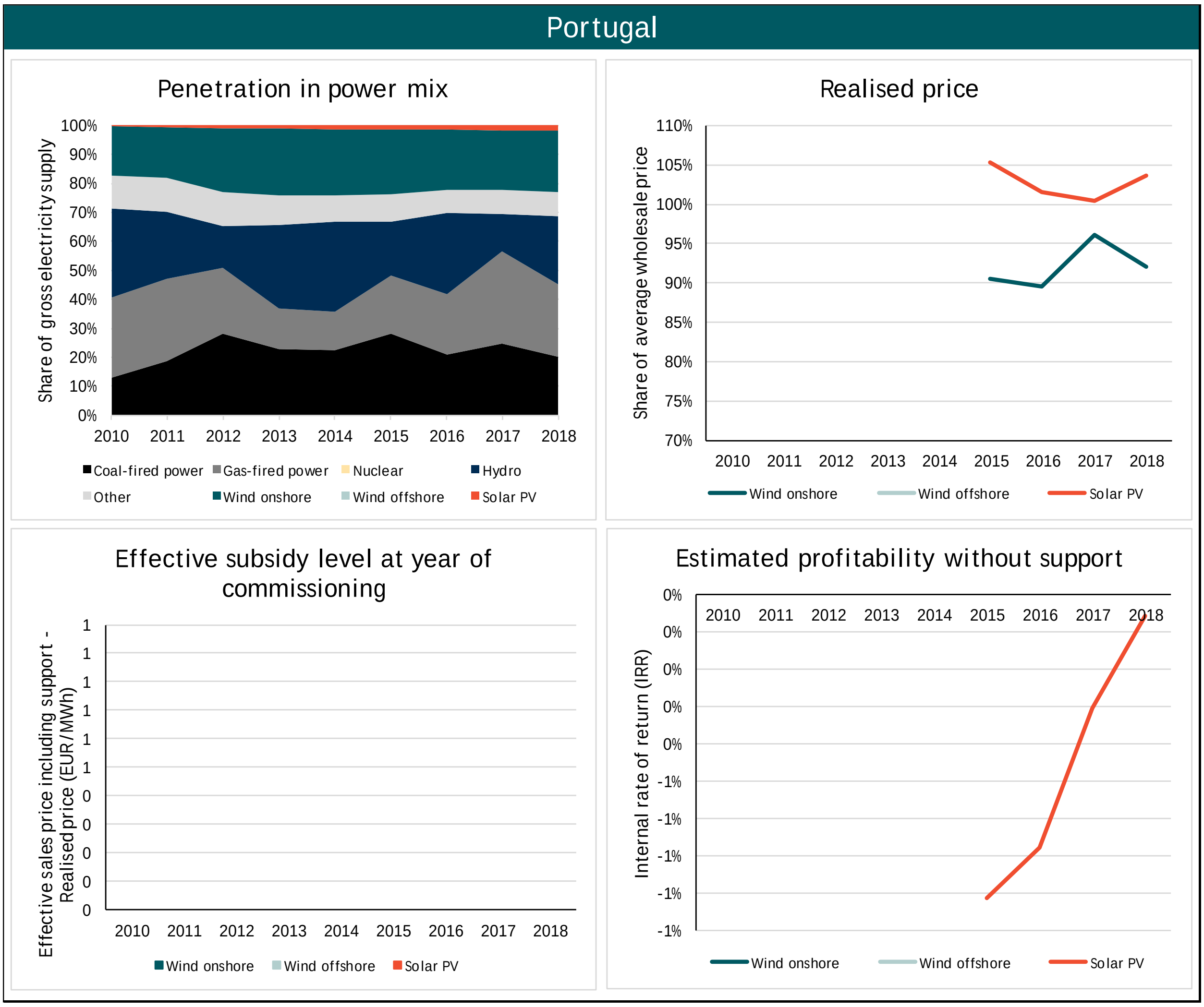
Italy


Italy
Penetration in power mix
Share of gross electricity supply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Coal-fired power
Gas-fired power
Nuclear
Hydro
Other
Wind onshore
Wind offshore
Solar PV
Realised price
Share of average wholesale price
100%
95%
90%
85%
80%
75%
70%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Effective subsidy level at year of commissioning
Effective sales price including support - Realised price (EUR/MWh)
120
100
80
60
40
20
0
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Estimated profitability without support
Internal rate of return (IRR)
6%
5%
4%
3%
2%
1%
0%
-1%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV

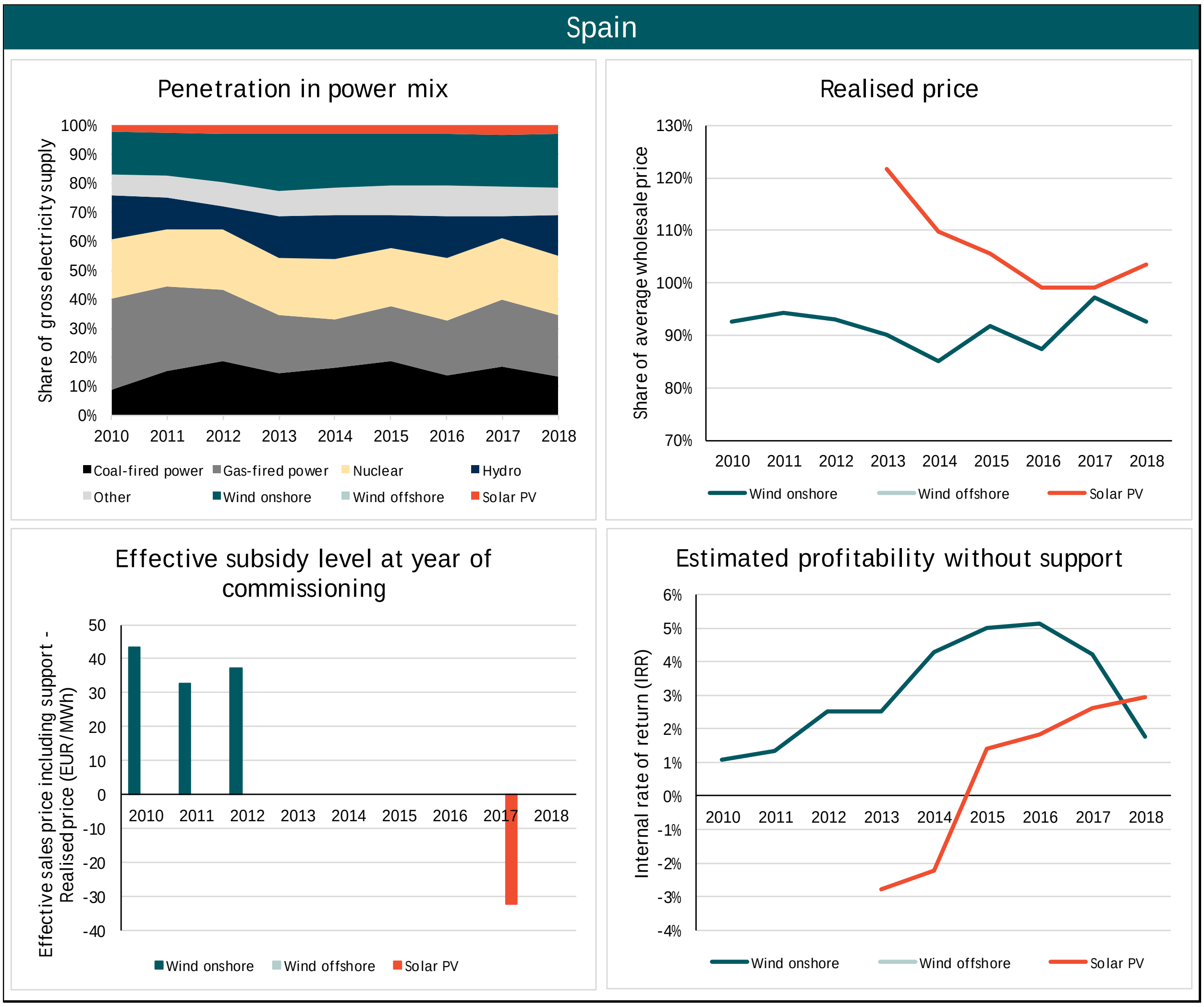
Netherlands



Portugal


Portugal
Penetration in power mix
Share of gross electricity supply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Coal-fired power
Gas-fired power
Nuclear
Hydro
Other
Wind onshore
Wind offshore
Solar PV
Realised price
Share of average wholesale price
110%
105%
100%
95%
90%
85%
80%
75%
70%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Effective subsidy level at year of commissioning
Effective sales price including support - Realised price (EUR/MWh)
1
0
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Estimated profitability without support
Internal rate of return (IRR)
0%
-1%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV

Spain

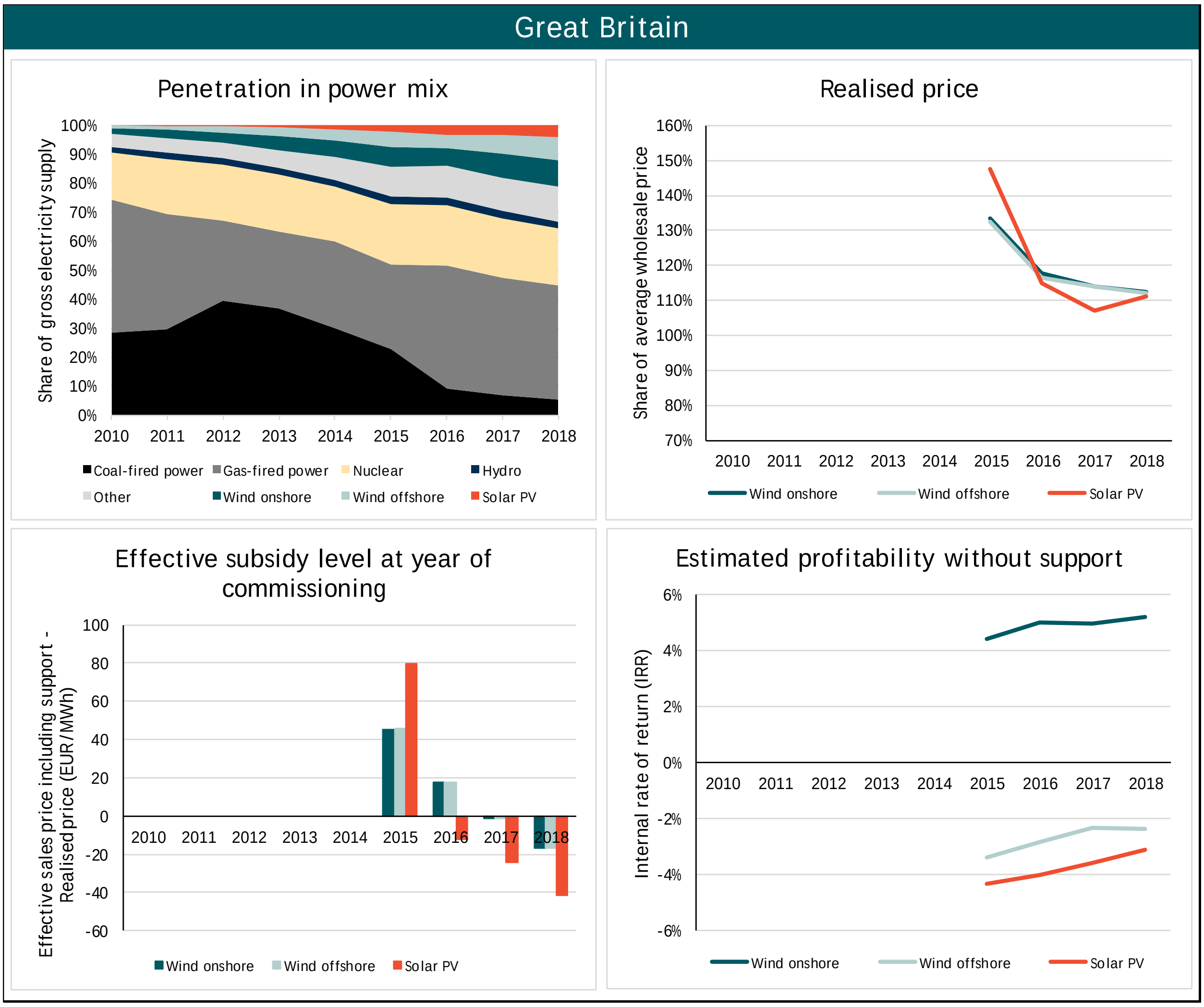

Spain
Penetration in power mix
Share of gross electricity supply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Coal-fired power
Gas-fired power
Nuclear
Hydro
Other
Wind onshore
Wind offshore
Solar PV
Realised price
Share of average wholesale price
130%
120%
110%
100%
90%
80%
70%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Effective subsidy level at year of commissioning
Effective sales price including support - Realised price (EUR/MWh)
50
40
30
20
10
0
-10
-20
-30
-40
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV
Estimated profitability without support
Internal rate of return (IRR)
6%
5%
4%
3%
2%
1%
0%
-1%
-2%
-3%
-4%
2010 2011 2012 2013 2014 2015 2016 2017 2018
Wind onshore
Wind offshore
Solar PV

Source: Study on energy prices, costs and their impact on industry and households

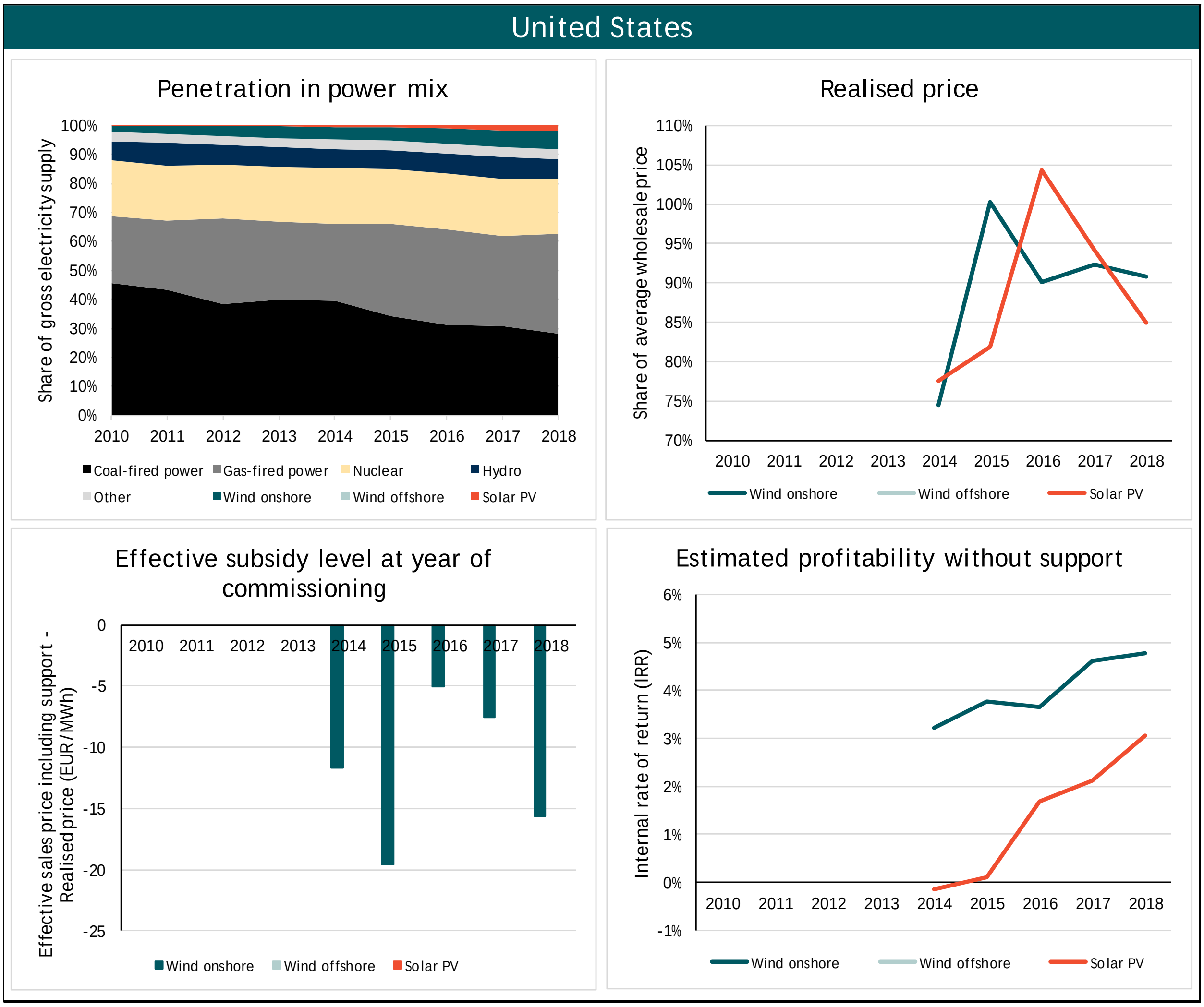
Sweden

Source: Study on energy prices, costs and their impact on industry and households

Great Britain



United States



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