Final report

Study on energy prices and costs: evaluating impacts on households and industry - 2023 edition

Written by Trinomics et al.

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1 Introduction

The 2023 edition[1] of the energy prices and costs report, covering developments between 2020 and 2022, comes at a time of almost unprecedented upheavals in European and global energy markets; a time of great international economic and political instability. The changes brought by the energy transition were already having a profound impact on energy markets, which were hit by two major crises in succession. First, the Covid-19 pandemic in 2020 led to a sudden sharp reduction in energy demand and energy prices, as worldwide lockdown restrictions led to decreasing household consumption and industrial production. The gradual reopening of society in 2021 and the fast recovery of demand led to significant energy price increases - to higher price levels than ever seen before.

The seeds of the second of these shocks, the gas supply crisis, were planted already in the summer of 2021. This was the time when Russian state-owned Gazprom did not refill its gas storages in Western Europe and refused to offer additional natural gas supplies on the European spot markets. The crisis was further amplified by Russia's preparations for and the eventual start of the invasion of Ukraine in February 2022. Sanctions and countersanctions led to a sudden drop in Russian gas supplies to the EU, which could not be compensated in time with additional pipeline or LNG gas or other fuels.

The confluence of these economic and geopolitical factors have driven European gas and electricity prices to peaks no one could have predicted before, with serious implications for European households, industry, the broader economy and public finances. Neither of these shocks could have been predicted at the time of the last report[2]. Together, these have focused an unprecedented level of attention on various aspects of energy policy, most importantly on security of supply, the competitiveness of European industry, the survival of small and medium enterprises (SMEs), and the affordability of energy for European households.

Even in these difficult times, the EU has not given up on its clean energy and climate ambitions. In fact, a green and digital energy system is seen by the EU as the foundation for a resilient European economy. European leaders agreed in March 2022 to phase out the EU's dependence on Russian fossil fuels, which is the basis of the REPowerEU Plan of the European Commission. This plan outlined the EU's intention to end energy dependence on Russia through saving energy, diversifying supplies and accelerating the roll-out of low-carbon energy technologies.

At the same time and in preparation for the winter of 2022/23, the EU and its Member States took immediate steps to prevent energy (gas and electricity) supply disruptions. Member States reached an agreement on gas storage targets as well as savings targets. This has helped the EU to prepare for the winter and to bring down energy prices closer to their pre-war level. The reform of the electricity market was ongoing at the time this report was prepared but it is seen as essential to ensure the functioning of the single market and European industrial competitiveness.

[1] Note from the editor: Due to the unprecedented turbulence in European and global energy markets, the publication of this study has been repeatedly delayed. All data in this report refers to the situation as of end-2022.
[2] Trinomics et al (2020). Study on energy prices, costs and their impact on industry and households 2020.

The main objective of the 2023 edition of the energy prices and costs report is to put these crises into context, and to help understanding their impact on energy prices and costs in the EU and globally, based on official data and statistics. The report provides analysis across the following sections:

- **Part I** of the report provides the regular review of developments on **wholesale and retail prices for electricity** (Chapter 2) and **gas** (Chapter 3). The analysis of the cost elements of retail energy prices provides the most extensive, currently available, breakdown of components affecting prices, in particular for taxes and levies. These chapters, together with the econometric analysis in Chapter 9, provide an insight into the evolution, composition and drivers of retail prices together with international comparisons of the prices for petroleum, gas and electricity products.
- **Part II** of the report provides the **analysis of price developments for oil, coal and other fuels** (Chapter 4); and looks at the **evolution of households' energy consumption and expenditure** (Chapter 5), the drivers behind these changes and the impact on households' budgets across income levels and energy poverty.
- **Part III** of the report addresses the impact of increasing **energy costs on European industry** (Chapter 6). The assessment of energy-related costs for manufacturing, agriculture and services sectors (more than 40 economic sectors) focused on the most energy intensive industries, these sectors' energy costs shares, energy intensities and energy prices and, where possible, comparisons with international partners.
- **Part IV** of the report addresses the **EU's energy import bill** (Chapter 7), as well as the **taxes imposed on energy products** (Chapter 8), and assesses their impact on public finances and the retail prices of these products.
- **Part V** of the report provides an econometric analysis of the energy crisis, its drivers and impacts (Chapter 9), followed by an examination of the impacts of the price increases on two key technologies necessary for the green transition: heat pumps and electric vehicles (Chapter 10).
- **Part VI** of this report is the Annexes that present factsheets of each Member State with detailed information about their energy prices and costs.

2 Electricity prices

2.1 Wholesale prices

Main Findings

- Reduced economic activity due to Covid-19 lockdown measures led to historically low wholesale electricity prices in 2020, with an EU average day-ahead price of 36 EUR/MWh.
- Economic recovery following the relaxation of Covid-19 measures, together with increasing tensions with Russia, which culminated in the Russian invasion in Ukraine, led to increased wholesale electricity prices reaching unprecedented levels in the EU: the average day-ahead price in the first half of 2022 (199 EUR/MWh) was 4 times higher than the average price between 2010-2020.
- In the first half of 2021, global economic recovery was the main driver of wholesale prices, along with increasing carbon allowance costs in response to proposed plans to strengthen the EU ETS under the Commission's 'Fit for 55' proposal. Increasing gas prices (see Chapter 3), caused partially by Russia's preparations for war, have begun to drive electricity price increases from Q3 2021 onwards (see box A). The limited short-term options to replace gas-fired electricity generation with other fuels, and shortfalls in hydropower (due to low water levels) and nuclear power (due to both unplanned maintenance and scheduled shutdowns) have also contributed to keeping prices high for a prolonged period.
- Globally, other regions have also seen electricity price increases. Japan experienced similar price increases as the EU given its large dependence on LNG imports for power generation. A handful of other G20 countries (South Korea, Türkiye, India, South Africa) showed significant price increases in 2021 as well (which continued into 2022), but most other G20 countries did not. For example, prices in the US have stayed comparatively low and stable.
- Renewable energy continued to grow within the EU electricity mix to 36% in 2021, driven especially by increased wind and solar generation. Fossil fuel demand for electricity generation was slowly declining, but the current high gas prices have led to an increase in coal and lignite use for electricity generation and increased LNG imports to compensate for reduced pipeline gas supply from Russia.
- A decline in nuclear power output is also visible since 2021 and continues to be so in 2022 due to decommissioning of plants and unplanned maintenance outages (mainly in France), further contributing to the tightness of the electricity supply in the EU.
- Prices for future contracts have also steadily increased to very high levels. One-year ahead prices in June 2022 were on a similarly high level as the day-ahead price. Two-year and three-year ahead contracts were also above 100 EUR/MWh in June 2022 and have been increasing every month, which indicates that the market increasingly expects high electricity prices to last.
- Moderate price differences between European regions are visible, but prices in all regions show the same trend of very high prices. The Nordic region is the only one where prices are significantly lower, albeit still high, which is the result of hydropower often being the marginal technology in the merit order, while in most other regions expensive fossil fuel-fired power plants are the marginal unit. Since 2021, regions with high fossil fuel reliance and limited interconnection capacity, such as Italy (and the UK) consistently have slightly higher prices.

2.1.1 Evolution of day-ahead wholesale electricity prices

Since 2010, electricity prices in European wholesale day-ahead markets have developed in cycles, influenced by the demand evolution, costs of the input fuels (coal and gas) and carbon allowances, as well as by the changing structure of the electricity generation park. From 2010 to early 2016, prices sank to levels not seen in more than a decade. A turnaround, driven by growing consumption and rising fuel and carbon allowance prices and reinforced by the occasional technical problems at the supply side, started in 2016 and culminated in late 2018 on the back of high coal and gas prices. After reaching a low average of 43 €/MWh in 2017, the European Power Benchmark[3] (EPB) rose to 52 €/MWh in 2018 and declined again in 2019 to 43 €/MWh (Figure 1).

At the beginning of 2019, wholesale electricity prices fell and started to follow a downward trajectory again (43 EUR/MWh EPB average in 2019). This time, slowing economic activity, falling fuel costs and rising renewable electricity penetration combined to drive prices down. The short-term consequences of the Covid-19 pandemic accentuated all these factors: widespread lockdown measures imposed in March 2020 drastically reduced power demand, sent coal and gas prices to extremely low levels and favourable weather significantly increased the relative share of renewable energy in the power mix. As a result, average European wholesale prices on the spot market reached historically low levels in April 2020 and began to recover only slowly in the following months; the EPB benchmark in 2020 averaged 30 EUR/MWh.

Beginning in 2021, prices started to recover and by the end of the year, reached extremely high levels. The increase was mostly due to the higher demand, linked to economic recovery. From mid-2021, several other factors contributed, including rising CO_2 allowance and natural gas prices, unfavourable weather conditions and partial unavailability of the nuclear fleet of France. Electricity prices further increased after the summer to exceptionally high levels, mainly due to Russia already reducing gas flows to Europe. By December 2021 — two months before the Russian invasion of Ukraine — electricity spot prices averaged 239 €/MWh in the EU27, driven by high gas prices. Following the Russian invasion, electricity spot prices stayed extremely high with average levels between 160 and 260 €/MWh in the 1st half of 2022.

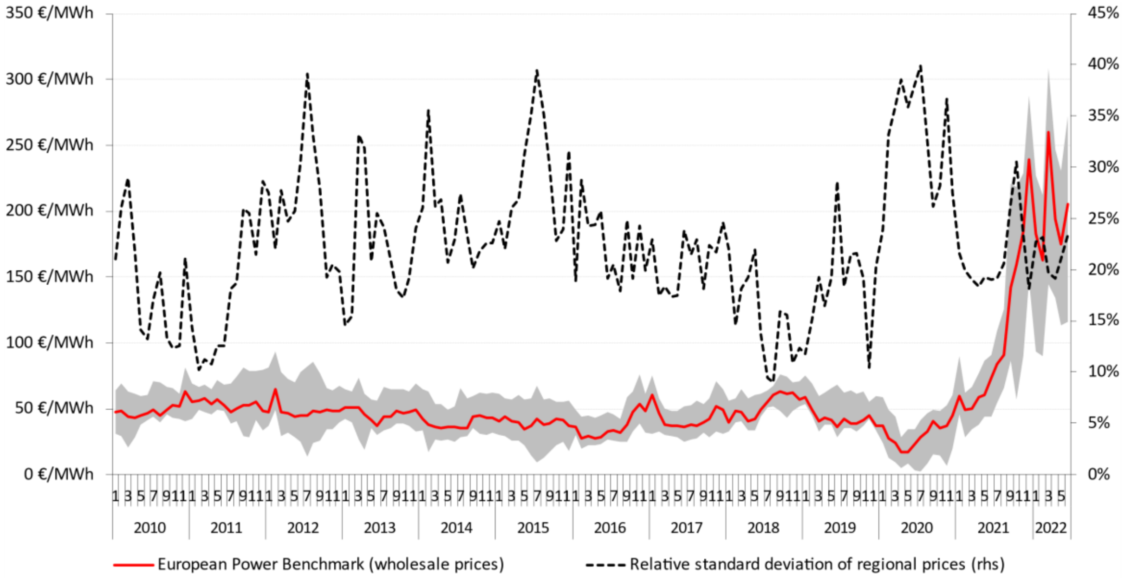


Figure 1: Evolution of monthly average wholesale day-ahead baseload electricity prices in Europe, showing the European Power Benchmark and the range of minimum and maximum prices across the main EU markets.
Source: S&P Platts, ENTSO-E

[3] The EPB is a weighted average of day-ahead prices in nine representative markets, serving as a general European benchmark.

Price convergence

European electricity markets saw mixed developments in terms of price convergence between 2018 and 2021, ranging from almost full convergence in the Baltic zone and significant increases in convergence between Croatia and Slovenia to limited increases or decreases in the Nordic region and the Central Western European Zone. The first semester of 2022 also saw mixed developments.

Figure 2 illustrates the degree of price convergence in day-ahead markets within selected European regions expressed in *percentages of hours* in a given year. The price convergence provides an indication of the level of market integration, though full price convergence is not an objective in itself, as it would require overinvestment in network infrastructure[4]. Its longer-term drivers are market-coupling initiatives, expansion of cross-border interconnection capacity and improved use of available physical capacity. Fluctuations in convergence may also be caused by changes in the amount of cross-zonal capacity designated by grid operators for commercial purposes, outages of transmission lines, shifts in the power generation mix or in consumption patterns.

- In the Central Western European Region (CWE), where flow-based market coupling was implemented in 2015, full price convergence was 50% in 2021, very similar to the 49% level in 2020.
- In the Central Eastern European Region (CEE) convergence increased significantly in 2021 to full price convergence in 54% of the hours. This primarily followed from the coupling of two market-coupled regions – the 4M MC market (of Czechia, Slovakia, Hungary, and Romania) and the Multi Regional Coupling (of 19 European countries), leading to higher convergence despite the price escalations.
- Similar to previous years, price convergence between the Baltic states stayed very high at 88%. Even higher convergence rates have been reached between Slovenia and Croatia (99% in 2021). The launch of Flow-Based Market Coupling in the Core region (Nordics, CWE and CEE) in June 2022 may further increase price convergence rates in the future.
- In the Nordic region, the previously observed trend of decreasing price convergence has continued, driven by growing trade imbalances of the four Scandinavian countries, which is not counterbalanced by an expansion of interconnection capacity. In 2021, the reason behind the low convergence levels could be a combination of new extra-regional interconnections entering into operation (NO-DE and NO-UK) and structural congestions between the Norwegian and Swedish grid.
- Between Ireland and the UK, price convergence increased up to 2020, mainly resulting from market coupling. However, post-Brexit, convergence has plummeted as market frameworks and relationships changed. The decoupling of the implicit system between Ireland and the UK was replaced by an explicit system of trading; consequently, British day-ahead order books are no longer coupled with EU markets. Between the UK and France, price convergence was growing steadily until a similar drop appeared in 2021 for the same reason (from 27% in 2020 to 4% in 2021). A mitigating factor is the new interconnector between the UK and France that is operational since January 2021.
- Full price convergence between Spain and France has stayed relatively stable since 2020 up until the first semester of 2022, while moderate price convergence (1-10 €/MWh diff.) has dropped significantly. This can be explained by the current tight gas market where Spain benefits from its large LNG import capacity, while gas interconnection to France is limited hence leading to higher gas (and consequently electricity) prices in France. Moreover, higher electricity output

[4] ACER (2022). Wholesale Electricity Markets Monitoring 2021. Key developments.

from renewable sources in Spain and maintenance issues with France's nuclear energy plants contribute to the divergence of prices.

In most regions, electricity price convergence decreased in the second half of 2021 in a market with very high electricity prices and tight supply. This trend continued into 2022, with convergence dropping (e.g. CWE, CEE) or staying at overall low values (e.g. ES-FR, GB-IE) in almost all regions in the first semester.

Thus, after gradual increases up to 2020, price convergence levels since 2021 show no clear trends and stay in most case between 5-60%, which underlines the potential for further investment in strengthening network capacities among and within Member States.

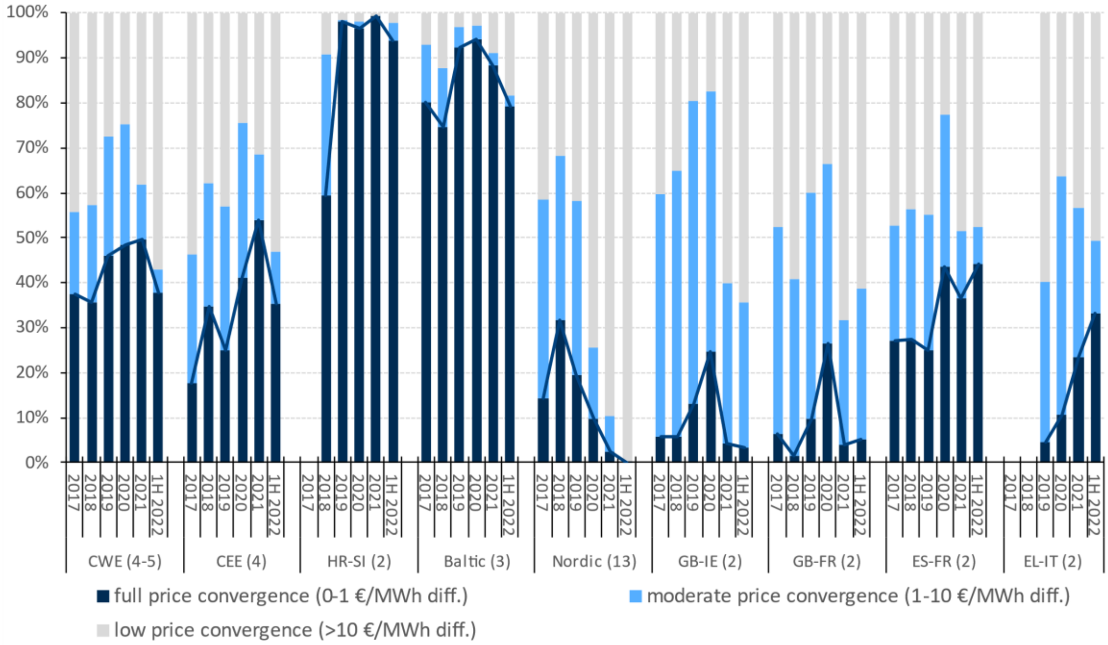


Figure 2: Price convergence on day-ahead markets in selected regions as percentage of hours in a given year
Source: ENTSO-E, OTE, Nord Pool, S&P Platts. The numbers in brackets refer to the number of bidding zones included. The CWE region comprises of BE, FR, NL and DE-LU-AT zones until October 2018, and separate DE-LU and AT zones since then. The CEE region includes CZ, SK, HU, RO bidding zones, which are coupled. The Baltic region includes EE, LV, LT bidding zones. The Nordic region includes 12 bidding zones of Norway, Sweden, Finland and Denmark.

2.1.2 Spot and wholesale futures price trends

In order to obtain a comprehensive picture of how European wholesale electricity prices have developed since 2017, and their impact on the retail prices, a consumption-weighted baseload benchmark (EP5) of the five most advanced markets up to a three-year visibility into the future was created and compared to a day-ahead (spot) equivalent. This indicator, as shown in Figure 3, gives an indication whether the expectations on the future electricity price are higher or lower than the spot price (that is, EP5 spot), providing a view on whether the market anticipates increasing or decreasing electricity prices in the coming months and years.

Typically, the developments in the relation of these prices are mixed: from 2017 to early 2019, spot prices were higher than future prices anticipating price decreases resulting from higher renewable energy penetration and a better supply-demand balance in general. In contrast, for most of 2019 and in 2020, spot prices were below year-ahead prices, which reflected underlying economic conditions: the anticipated economic recovery and increased demand after the lifting of lockdown measures. This

situation changed again in 2021, when spot markets diverged upwards from futures prices.
Figure 3 also shows the evolution of the Dutch TTF[5] gas price index overlaid on the EP5 benchmark electricity prices, which clearly demonstrates how electricity spot prices and TTF prices moved in tandem.

Electricity prices have been increasing in 2021 and 2022 both at the spot market as well as at the forward market for (multiple) year-ahead contracts: as spot prices went from 68 €/MWh in June 2021 to 194 €/MWh in June 2022; three-year ahead prices from 44 €/MWh to 112 €/MWh in the same period. In addition, year ahead prices show that the market expects prices to stay at similarly high levels for at least up to June 2023 (one-year ahead prices up to June 2022 are similar to spot prices). After that, prices would decrease to a level that is still higher than electricity prices seen pre-2021 (three-year ahead still above 100 €/MWh in June 2022). Since the Russian invasion in February 2022, the two-year and three-year ahead prices have increased significantly and the gap between spot and future prices has decreased. This gives an indication that in the past months (February-June 2022) the market expectation of how long high spot prices will remain has significantly increased.

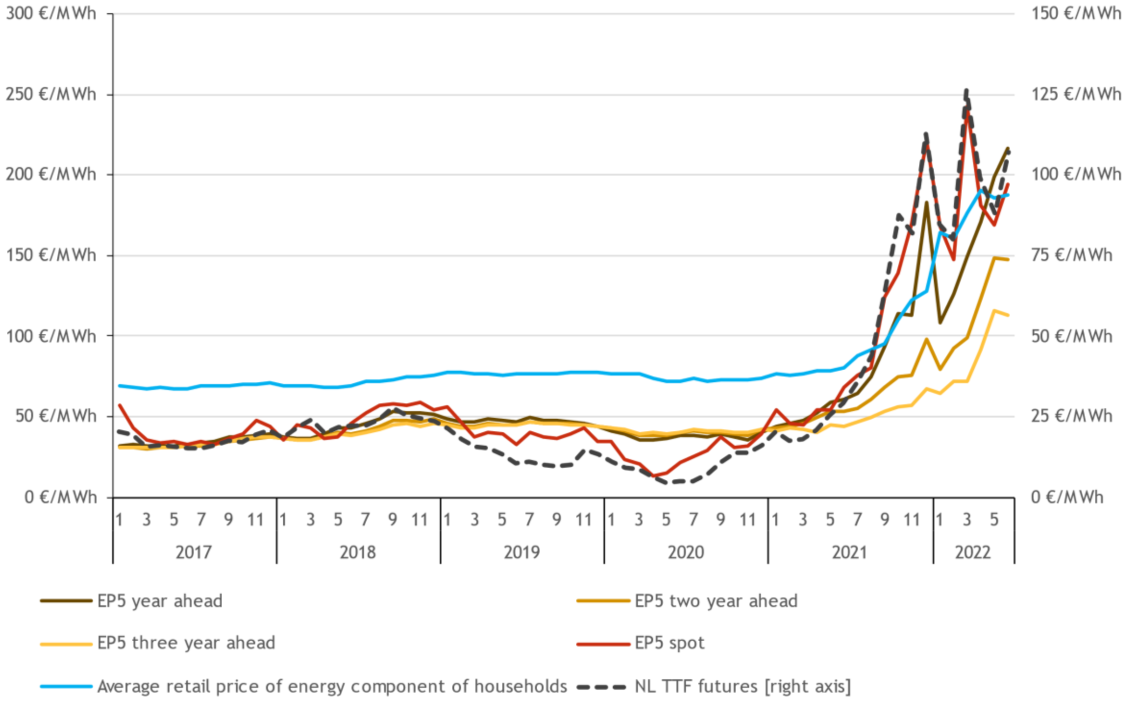


Figure 3: Monthly evolution of spot and forward wholesale electricity prices and the energy component of retail prices in Europe since 2017 in nominal prices. The right axis shows gas TTF future prices.
Source: S&P Platts, VaasaETT. The average energy component of household retail prices is weighted using population figures of EU27 capitals. Note: for households VaasaETT data is used instead of Eurostat, which leads to different prices since different methodologies are used.

Figure 3 also illustrates that the interplay between spot and forward prices is not always straightforward. Market operators buy a significant part of the electricity supply to end-users on the forward market via one or more years-ahead contracts, so forward wholesale prices play a vital role in determining the energy component of retail prices for households and industry. This is one reason why a change in wholesale prices is channelled into retail prices with some delay and usually in a non-linear fashion (as demonstrated in section 2.2.2 on retail prices and in Chapter 9 via the econometric analysis). Since wholesale prices

5 TTF refers to the Dutch Title Transfer Facility (virtual) trading hub, the largest European gas hub in terms of traded volume of gas, hence becoming an important benchmark hub price for natural gas in Europe.

increased in 2021, retail prices have started to increase as well but (as shown in Figure 3)
the increase was not yet strongly visible in 2021. The retail energy price component normally lies above spot and forward wholesale prices to cover the suppliers' costs and profit margin. However, since Q3 2021 retail prices have become lower than spot prices, mostly due to electricity being supplied to end-users at contractually fixed or regulated prices, as well as energy companies having already bought electricity for lower prices before the price increases. Thus, there is a significant lag between changes in wholesale and retail prices, and retail prices could continue to increase well into 2023 as more contracts come up for renewal at higher prices - a trend already emerging in 2022 (see section 2.2).

Figure 4 shows the regional wholesale electricity prices in the North Western Europe (NWE) market coupling area, including Central Western Europe (Germany, France, Austria and the Benelux), Great Britain and Ireland, the Nordic markets (Norway, Sweden, Denmark, Finland and the Baltic States) and the Iberian market (Spain and Portugal). This figure clearly shows the price increases since early 2021 in all markets, with baseload prices sharply increasing in all regions.

Prices in the Nordpool market, despite sharp rises, remained lower than in other markets, clearing at roughly a 100€/MWh – 150€/MWh discount compared to the other markets. Nordpool generally has the lowest wholesale prices in Europe thanks to the prominent role of hydropower and increasing wind energy generation in the region. Prior to the energy crisis, Central Western Europe (CWE) prices moved closer to Nordpool levels between 2018 to 2020 on the back of the rapidly rising share of renewable energy (especially during periods of high wind generation) and stable nuclear power generation.

Up until 2021, wholesale electricity prices in the Iberian region generally exceeded the EPB benchmark. However, since mid-June 2022 (when the so-called "Iberian exception" was implemented to subsidize gas used in electricity generation) prices in Iberia are lower than the EPB. The lower price is partially the result of the market intervention, but also due to the large LNG import capacity and subsequent lower gas prices. While normally, gas pipeline supply is cheaper, after Russia restricted pipeline deliveries, long-term LNG contracts already in place in Iberia provide for cheaper supply than gas traded on European exchanges, such as TTF.

Prices in Great Britain and Ireland (GB) were generally higher between 2018 and 2021 than the EPB; partly due to the carbon price support mechanism in the UK, which places additional costs on electricity from fossil fuels. In the current high price situation, this premium is still visible and GB baseload prices are often the highest in the NWE region, although they follow a very similar trend comparable to the EPB. However, it is worth noting that GB prices also decreased more sharply in the first half of 2022 due to less exposure to Russian energy commodities and higher LNG imports.

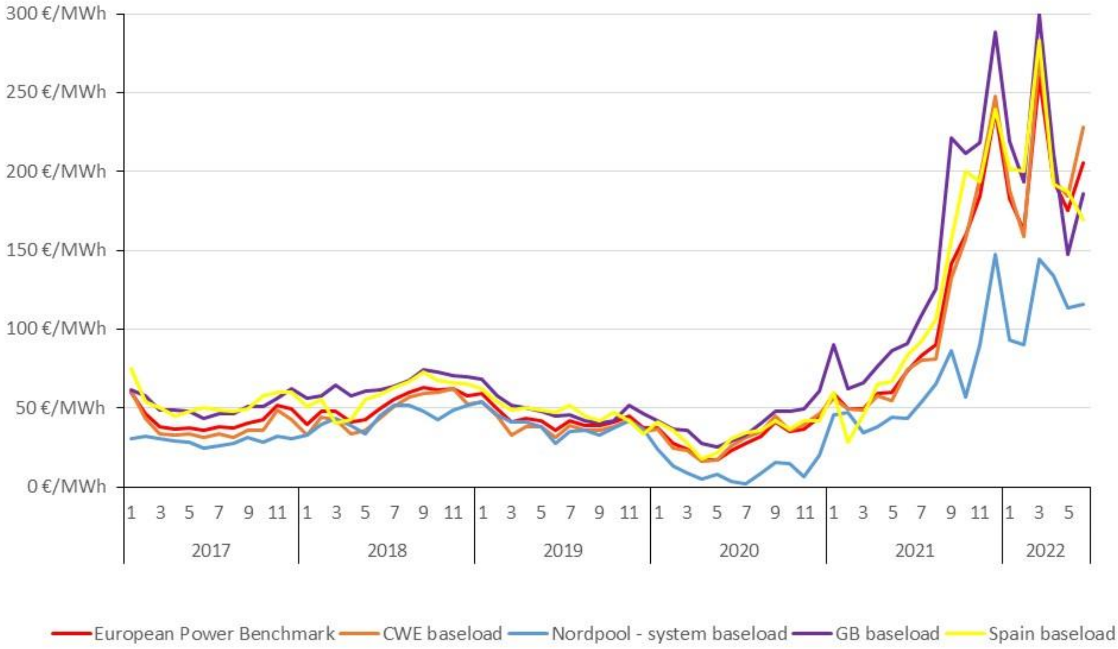


Figure 4: Regional average monthly day-ahead wholesale nominal prices in the North-Western Europe coupled area
Source: S&P Platts, ENTSO-E.

In the Central and Eastern European region (CEE – Poland, Czechia, Slovakia, Hungary, Romania, Croatia and Slovenia) prices followed the EPB closely in 2018 but slightly disconnected in 2019 and 2020 as higher carbon emission prices imposed additional costs on coal and lignite-fuelled power generation, which constitutes a large share of the regional power mix. As a result, in 2020, CEE prices were on average 30% or 10 €/MWh higher than the EPB. Since the electricity price increases that started in 2021, wholesale prices in the CEE have been at all-time highs and very closely tracking the EPB benchmark. As in other regional electricity markets, price increases were mainly triggered by spiking gas prices.

While the average CEE prices converged with the EPB (1% lower average wholesale prices in 2021), prices in most CEE countries, except Poland, were still moderately higher than the EPB. The gas price spike was so strong that coal-fired power plants, despite extra carbon emission costs, were in some cases cheaper to run than gas-fired plants and Poland, which heavily relies on coal/lignite (68% of its electricity generation in the first quarter of 2022) saw significantly lower wholesale prices compared to most other CEE countries. However, increasing coal prices (see section 4.1), coinciding with increasing gas prices, are also having some impact, at least in countries which import significant quantities.

Four CEE day-ahead markets (Czechia, Slovakia, Hungary and Romania) are coupled, but the overall price convergence within the area remains lower than in the CWE region (see Figure 2). The Polish market is coupled with Sweden (and thus with the NWE region). The Croatian market is coupled with the Slovenian market, and, implicitly, with the Hungarian market; the latter two are in the process of coupling.

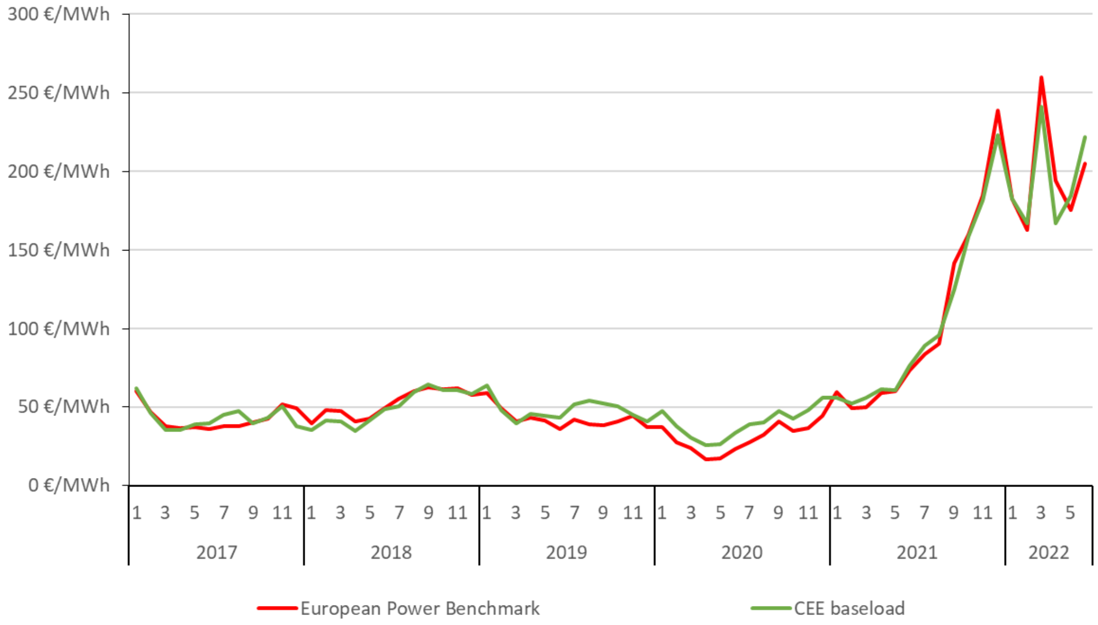


Figure 5: The Central Eastern Europe average day-ahead monthly wholesale price (nominal) and the EPB benchmark.
Source: S&P Platts, ENTSO-E

Italy and Greece traditionally display higher wholesale electricity prices compared to the EPB due to heavy reliance on fossil fuels, particularly gas, in their power generation mix and relatively high reliance on imports (Figure 6). Since 2021, Italy and Greece have — like all other EU Member States — seen all-time high electricity prices.

Prices in Greece only moderately exceeded the EPB in 2017 and 2018 but this price differential significantly increased during 2019 and 2020. This can generally be explained by the fact that during periods of high electricity prices, Greece's local lignite use for power generation has a mitigating effect on the electricity price while during periods of lower electricity prices the high carbon emission cost for lignite (compared with gas or even hard coal) results in a relatively higher electricity price. This lignite use in power generation in Greece is gradually being reduced since 2020, which also reduces this mitigating effect on high prices. Wholesale electricity prices in Italy were generally (until 2021) high as it is a large net importer of electricity (from CWE) and relies heavily on gas for power generation (59% of power generation in Q1 of 2022). Soaring gas prices, high reliance on gas for power, combined with tight supply margins made Italy the most expensive market in Europe in 2021 – H1 2022. A 44% reduction in hydropower production in Q1 2022 compared with Q1 of 2021 was also an important factor, as this technology typically represents 15-20% of total power generation.

Bulgarian wholesale prices in contrast have shifted from a slightly lower level compared to the EBP in 2017 and 2018 to higher level in 2019 and 2020 as a result of lignite use and associated increased carbon (ETS) costs. Since 2021, Bulgarian prices saw similar increases as in the rest of Europe and were quite similar to the EPB. The Bulgarian and Romanian markets are coupled since October 2021, which has increased competition and price convergence with the rest of the zone.

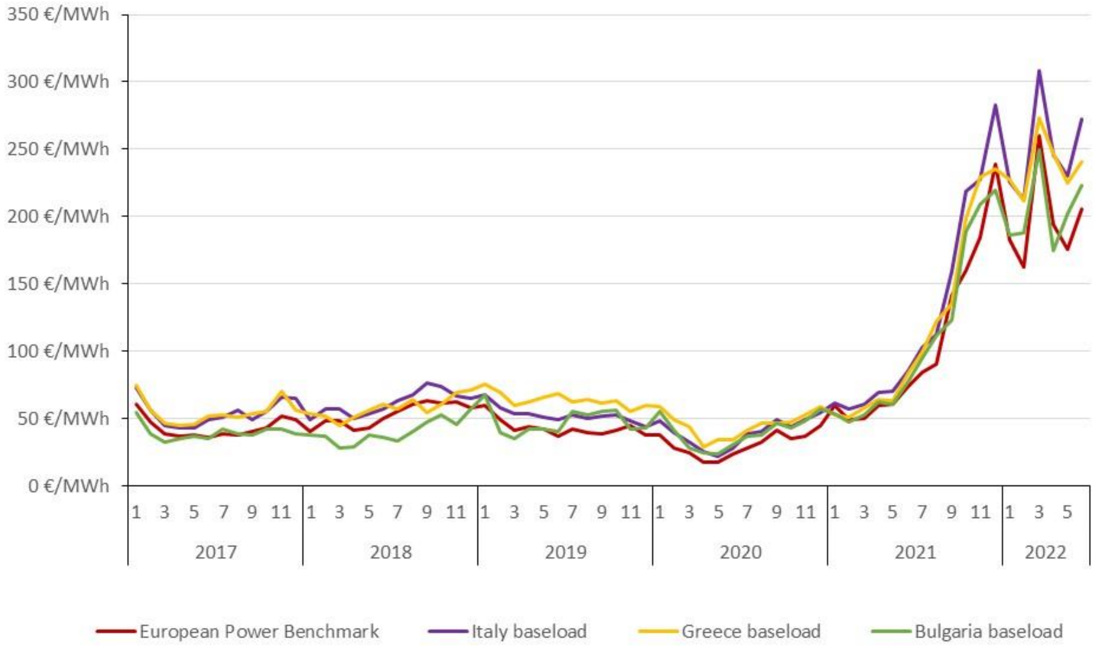


Figure 6: Regional market prices in Italy and South Eastern Europe
Source: S&P Platts, ENTSO-E

2.1.3 Factors impacting the evolution of wholesale electricity prices

On the **demand side** of the electricity market, residential consumption (~30% of total EU electricity consumption in 2020[6]) tends to be driven by the increasing number of households, the proliferation of electric appliances and the electrification of heating; while energy efficiency measures such as improved insulation, LED lightbulbs, and more efficient appliances push electricity demand lower. Seasonal temperatures (e.g. cold or heat waves) play an important role too, by driving demand for heating and/or cooling (more info on gas price drivers in Chapter 3). In the case of businesses, the consumption of electricity is mainly influenced by two similarly countervailing factors: the level of economic activity on the one hand, and energy efficiency measures on the other. Whilst the short-term price elasticity of electricity demand is quite low, the significant increases in prices since 2021 have nevertheless led to a renewed focus on energy efficiency and demand reduction.

Figure 7 shows the trends in electricity consumption, economic activity, and population. The COVID-19 pandemic and associated lockdowns greatly slowed down the EU27 economy, as represented by 6% dip in GDP in 2020. While electricity consumption was already observing a decoupling from population growth, indicating the strengthening effect of efficiency measures, the stark reduction in economic activity further drove down electricity consumption between 2019 and 2020. In 2021, both electricity consumption and GDP bounced back to pre-COVID levels.

6 Source: Eurostat

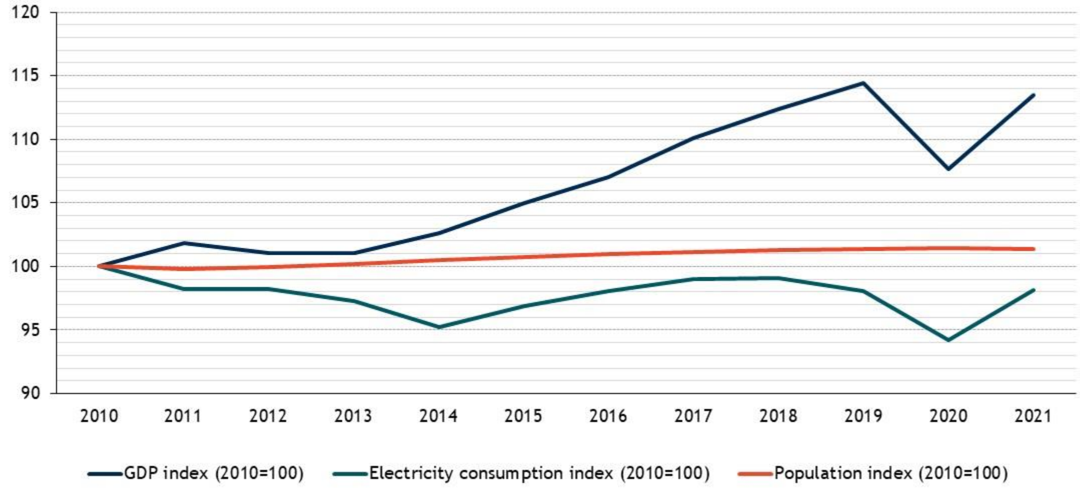


Figure 7: Electricity consumption, population and economic growth in the EU27
Source: Eurostat

On the **supply side**, the variable costs of the marginal power generation technology in the merit order (including electricity imports as a competing alternative) of a particular market determine wholesale prices – see **Box A**. Therefore, the structure of the electricity generation park and its changes can provide important indications about drivers of price trends. Figure 9 shows the changes in EU27 electricity generation mix between 2010 and 2021. Between 2010 and 2019, the fossil fuel share decreased from 46% to 37%. During the COVID-19 pandemic, lower overall electricity demand led to lower production from fossil sources, increasing the renewables share further to 36% in 2021. In 2020-2021, fossil fuel shares in the electricity generation mix dropped to 34% and 29%, respectively. As economic activity recovered as pandemic measures eased in 2021, demand and fossil generation rebounded towards previous levels.

Box A – Relationship between wholesale electricity prices and gas prices

Electricity wholesale auctions in Europe generally rely on a merit-order curve for price discovery and market clearing. The merit order curve orders prices for generation based on marginal cost, where renewable and nuclear options generally have low costs, with coal and gas turbine plants following, and ending with high-cost oil-burning or gas-fired 'peaking' plants. Due to the current market clearing mechanism, electricity prices are determined by the auction's clearing price driven by the marginal technology. This technology was previously coal, whilst in a few timeslots with higher demand it became gas. Increased carbon emission costs in recent years have driven coal prices and their market prices higher, while lower gas prices led to lower market prices for gas plants. Consequently, marginal technologies in many markets have slowly transitioned to gas generation. This is especially true for times of market scarcity, where gas plants have become the common high-cost "balancing" unit.

This relationship between electricity prices and gas prices has strengthened in the past years. Compared to prior years, most (80%) gas plants in the EU procure gas via futures contracts. Thus, the prices of gas futures, for example at the Dutch TTF hub, drive the price of electricity markets in many timeslots, and, often, average prices as well. The Russian invasion of Ukraine has demonstrated that a strong link exists between electricity prices and gas futures prices. We witness this connection very well on Figure 8, which shows the increase in gas prices followed by a large increase in European electricity market prices. The economic recovery from the COVID-19 pandemic also drove up gas and electricity demand, placing further demand-side pressure on market-driven prices.

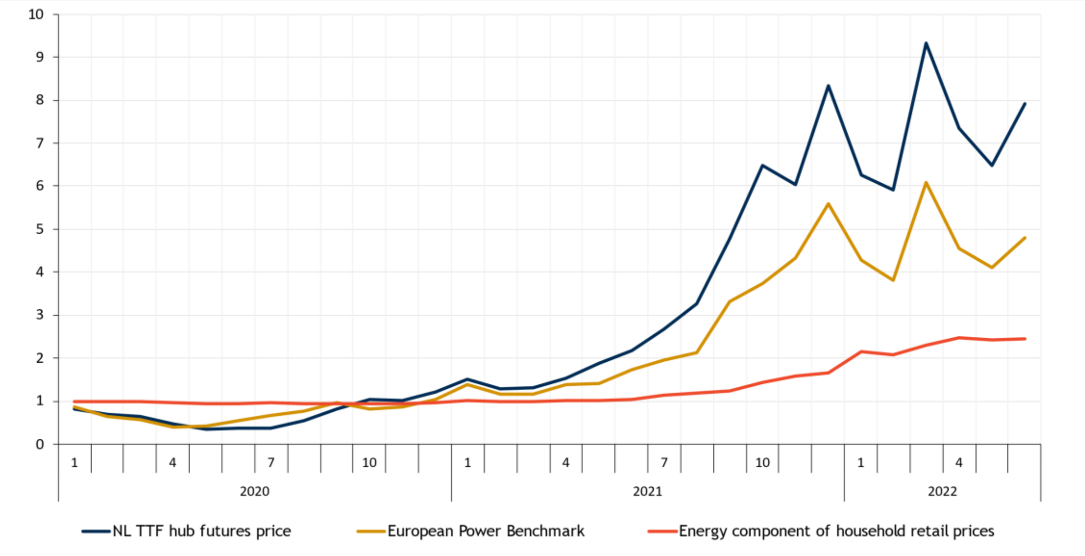


Figure 8: Day-ahead gas prices (NL TTF hub futures), day-ahead electricity prices (European power benchmark) and average energy component of household retail prices development since 2020 (index 1 = average 2019 price)

Note: Data from VaasaETT is used for the household retail prices, similar to Figure 15, which shows higher costs increases than Eurostat data.

The connection between gas price and electricity price is not equal across Europe. By 2020, most gas (96%) in CWE was already purchased via futures contracts, and thus electricity prices have been heavily exposed to gas price fluctuations. However, in Mediterranean countries (53%), Scandinavia and the Baltics (66%), and Southeast Europe (84%), a larger (but minority) share is traded via indexes tied to oil prices (which have increased less than gas futures). Therefore, the exposure of electricity prices in these regions to gas price fluctuations has been weaker.

LNG imports have historically been expensive compared to hub prices of gas in Europe, and therefore in markets with good pipeline connections they have played a relatively small role. However, LNG imports have become both a necessity (due to Russian pipeline supply disruptions) and more economically competitive in recent years, reaching 40% of European imports in September 2022 (see Figure 51). In the past, global LNG delivery prices typically set an upper bound for gas futures, and thus indirectly an upper bound for electricity prices. However, this assumed secure gas supplies, with few disruptions. In the current situation, the disruptions and uncertainties around available gas supplies have led to new ceilings being reached.

Renewable electricity sources

Various EU and Member States-level policies support the continuous growth in renewable energy generation (Figure 9). Various instruments such as certificate schemes, feed-in tariffs or feed-in premiums have incentivised further deployment of wind and solar power generation sources. In addition, the falling investment costs of renewable technologies and higher carbon emission costs (due to EU ETS and other carbon pricing schemes) have also increased the amount of interest in new renewable energy projects, which come to rely less and less on public financial support. Renewable energy projects are either set up by end-users to cover part of their consumption, or by utilities / project developers that hedge their price risks by concluding long-term power purchase agreements (PPAs). PPAs are signed typically either with industrial electricity consumers or with utilities that re-sell the electricity to consumers (see also Section 6.8).

While renewable energy is becoming cheaper, fossil fuel-based electricity has become more expensive, due to the increasing cost for carbon emissions and the recent price increases for fossil fuels. This means that in a growing number of markets, renewable energy technologies are able to compete with conventional technologies without any subsidies. As the subsidy levels in some national support policies are linked to the actual electricity market prices, such as the schemes in the Netherlands and Belgium, the public subsidies are now close to zero. The recent electricity price increases, whilst very harmful for consumers and businesses, improved the business case of renewable energies and reinforced their important role in reducing GHG emissions and energy import dependence, and increasing energy supply security on the medium and long term.

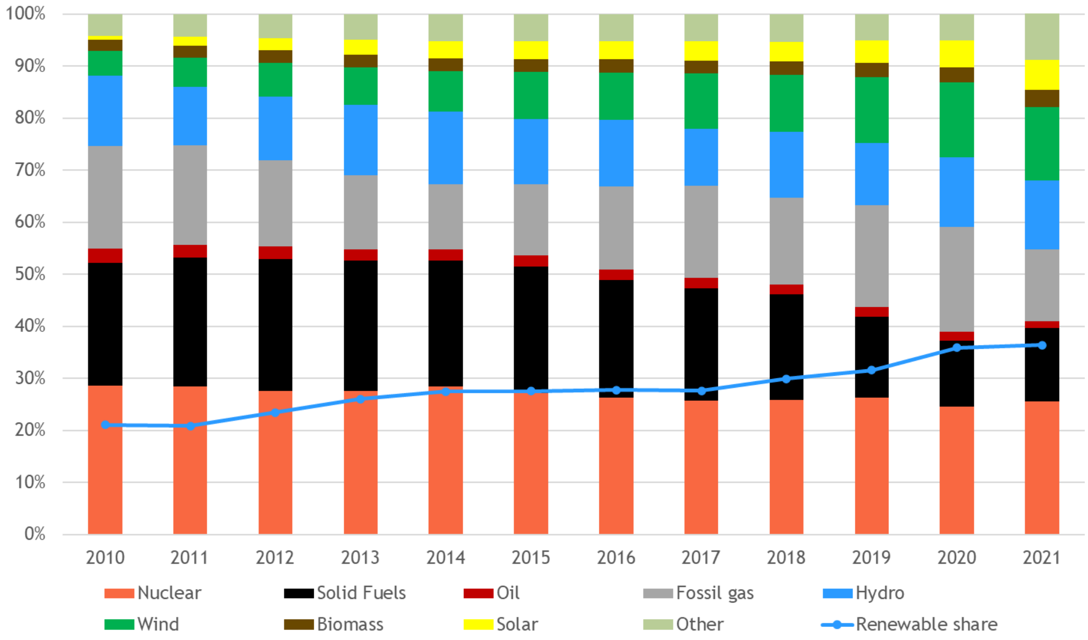


Figure 9: Electricity generation mix in the EU27
Source: Eurostat. Based on gross generation

Coal

With regard to the use of coal for power generation, the absolute consumption of coal in the electricity sector was lower in 2021 than in 2019. However, the relative share of coal/solid fuel use for electricity generation was increasing in 2021. Moreover, from January to May 2022, coal use increased in absolute volumes by 11% compared to the first 5 months of 2021, due to very high natural gas prices that made gas-to-coal switching attractive, even with the carbon emission surcharge. This price-led switching was reinforced by national policy changes, with a number of Member States providing temporary reprieves for coal-fired power plants that would normally close to meet the climate goals. Amongst others the Netherlands, Germany, Austria and Italy delayed scheduled closures of coal-fired capacity and/or have temporarily allowed their use.

Figure 10 provides a more detailed look at the power generation mix and its changes within the last 4 years, including data from early 2022. Seasonal variations can be observed, with electricity use peaking in winter (additional lighting and electric heating demand). During the summer of 2020 and 2021, the share of renewable energy sources in the power generation mix showed a significant spike, while in the winter months their share was lower: increase in wind energy production is accompanied by lower solar generation and higher absolute electricity demand. The harsh winter of 2021 led to higher electricity demand, mainly covered by a significant increase in fossil fuel shares. Lower power demand during the lockdown saw the share of coal diminishing in 2020, but coal-fired power generation has bounced back, and is increasing into 2022. Finally, a decline in nuclear power – both in absolute and relative terms - can be observed from the end of 2021 into 2022 due to decommissioning of power plants (e.g. in Germany) as well as exceptionally high planned and unplanned unavailability, mainly in France where in September 2022, 32 of all 56 plants were off-line for maintenance or technical reasons.[7]

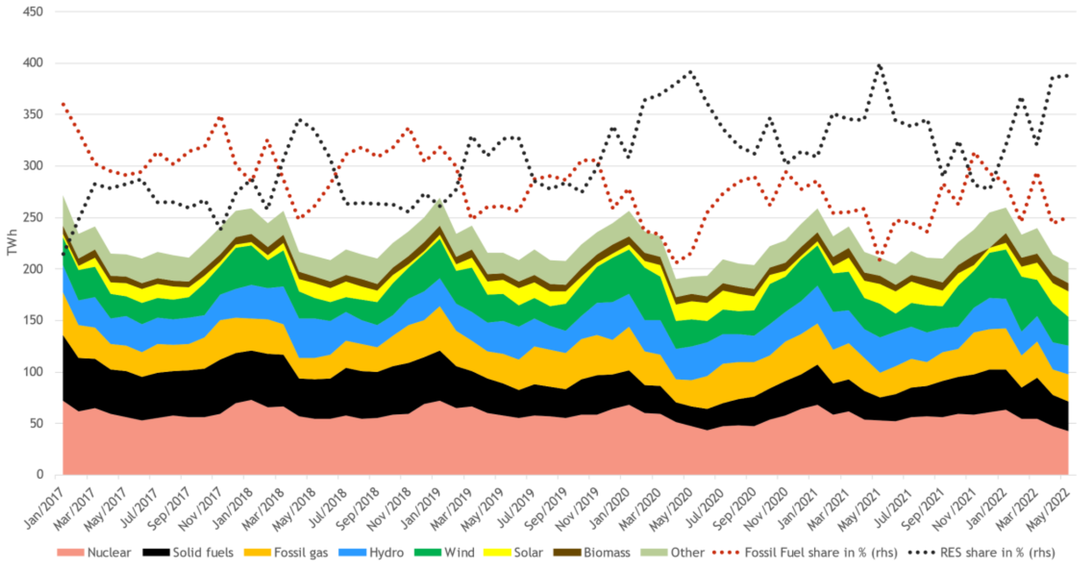


Figure 10: Monthly electricity generation in the EU27 and the shares of renewables and fossil fuels
Source: Eurostat

The variable costs of each generation technology, which play a crucial role in determining wholesale prices, differ greatly. Wind energy farms, solar PV installations, nuclear and hydro power plants have low variable generation costs. Coal-, gas- and oil-fired generation technologies have much higher operational costs (due to their cost for primary energy use and carbon emissions – see Figure 12), therefore these are mostly used if the output of the plants with low variable costs is not sufficient to cover the demand. They usually provide ancillary services and flexibility to the electricity system and set the clearing price in the spot market when they are the marginal unit in the merit order.

Increasing electricity generation from variable renewable energy sources (wind, solar) and other low marginal cost technologies started to push fossil fuel plants out of the merit order during an increasing number of hours. This dragged wholesale spot prices to lower and in some cases even to negative levels.

In Figure 11, monthly coal, gas and emission allowance prices and the EPB are indexed to 2008 values so that relative changes can be seen compared to their 2008 level. The figure shows that up until 2020 the power and fuel price indices roughly halved compared to their 2008 levels, while CO_2 emission prices also decreased significantly from 2008, but increased gradually from 2017. However, all indices have increased significantly since 2020.

7 EDF(2022). List of outages.

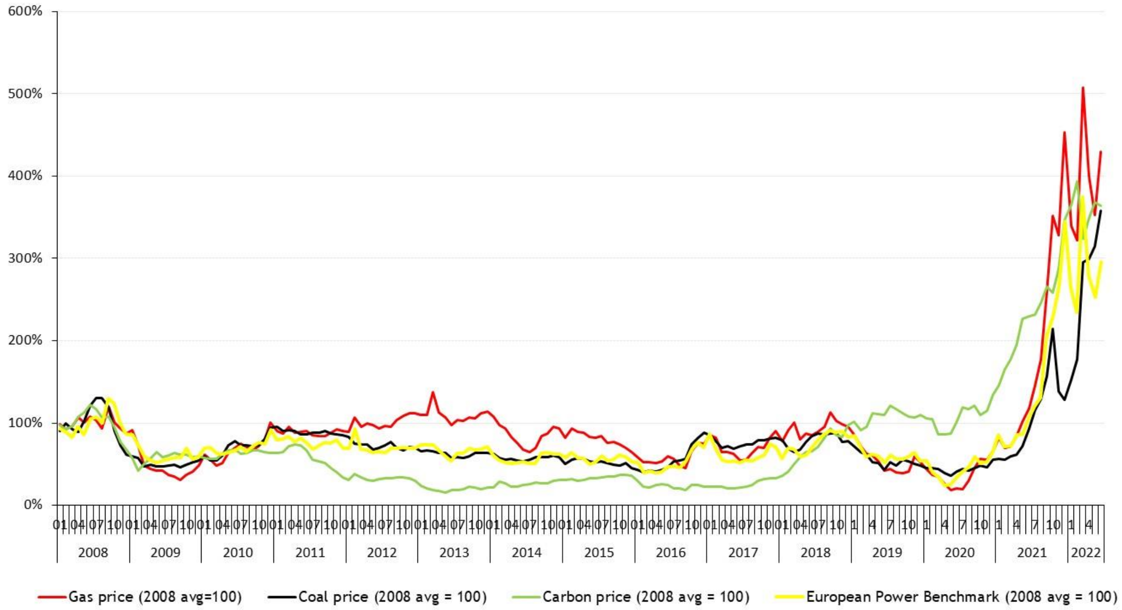


Figure 11: Monthly average day-ahead coal, natural gas and carbon price indexes, indexed to the 2008 average price
Source: S&P Platts

The staggering increases in the gas price since 2021 (up to 1100% in June 2022 compared to the 2020 prices during the Covid-19 lockdown) were accompanied by similarly high increases in the electricity price (EPB). This indicates the role of gas as main driver for the recently increasing electricity prices. Since around 2016, gas and electricity prices increasingly changed in parallel, indicating that gas became the main fuel driving electricity prices, following the large-scale coal-to-gas switching that took place most notably in the Netherlands, Greece, Germany, Portugal and Spain. From the summer of 2021, gas prices soared, also causing an increase of electricity prices, only somewhat dampened by the replacement of gas with coal in power generation. Following the Russian invasion of Ukraine, we witnessed an even stronger correlation between gas and electricity prices.

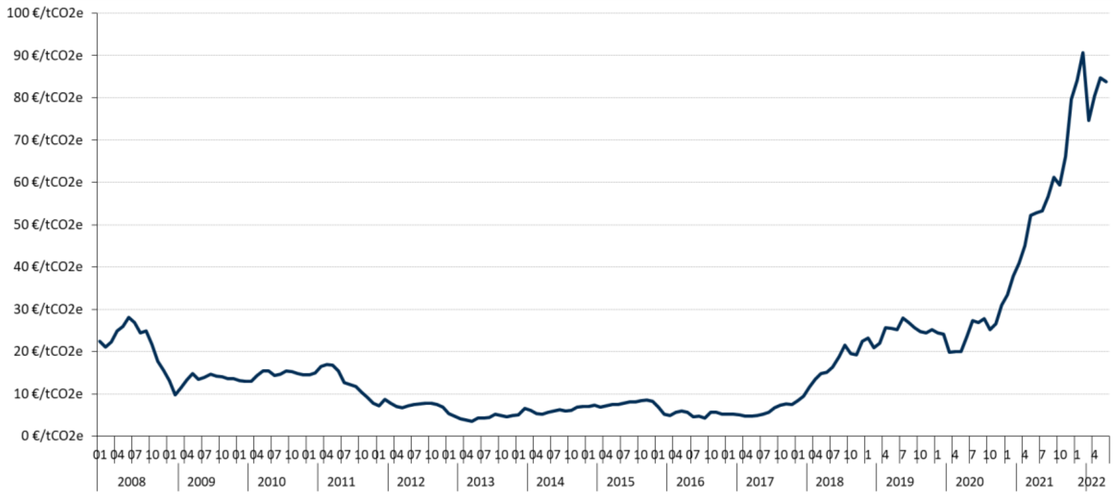


Figure 12: Monthly average EU ETS carbon prices in EUR/tCO_2e
Source: S&P Platts

Emission allowances

After a period of low prices between 2011 and 2016, CO_2 emission allowance prices (Figure 12) have embarked on a rising trajectory since 2017. Between 2018 and 2020, allowance prices fluctuated around

25 EUR/tCO_2, which was already significantly higher than in the 2011-2017 period. Starting from Q1 of 2021 the emission allowance prices significantly increased in anticipation of tightening of the EU ETS cap as part of the 'Fit for 55' policy package presented in July 2021. In the second half of 2021, allowance prices continued to increase to all-time high levels and from December 2021 until June 2022, the allowance price fluctuated around a level of 80 EUR/tCO_2. This carbon price increase also partially correlates with the increasing electricity prices especially during the last quarter of 2020 and a considerable part of 2021.

The carbon price has a particular influence on the electricity generation mix and prices in countries and regions that heavily rely on lignite and/or coal generation. The balance between the cost of emission allowances and the cost of gas was driving the switch from coal-to-gas for electricity generation in the years before 2021. However, since 2021, it is increasingly the gas price and security of supply considerations that were driving this dynamic.

Increased integration of European wholesale electricity markets, supported by EU and national policies, could help reduce EU electricity prices in the future. Initiatives such as European Single Intraday Coupling (SIDC), which since June 2022 links intraday markets of more than 23 countries[8], should bring about more efficiencies thanks to improved liquidity and increased cross-border electricity trade. Other initiatives, such as flow--based cross-border capacity allocation and enhanced availability of cross-border transmission capacity for trading purposes, could also contribute to this objective.

At EU level, electricity trade with third countries (except Norway as it is integrated already in the Nordpool market, and Switzerland as a neighbour with significant interconnection) does not influence significantly wholesale market prices as extra-EU electricity imports or exports are negligible compared to the total consumption of the EU27 (i.e. around 1.5%-2% of the total[9]). However, for some regions the situation is different (e.g. Baltic states and Italy), as they source significant amounts of their supply from abroad (see Figure 13), including from third countries.

Figure 13 shows the net electricity flow positions in European regions. As electricity normally flows from areas with lower prices to higher-priced ones, net exporter regions have in general lower wholesale prices compared to net importers.

- Central Western Europe is normally the main exporting region thanks to its diverse generation capacities, including large nuclear generation base, competitive prices and a central geographical position. However, due to the high planned and unplanned unavailability of the nuclear power plants in France, starting in the fourth quarter of 2021 and continuing into 2022, net exports of CWE dropped to around zero.
- The Nordic regions are generally electricity exporters, following a seasonal cycle driven by hydropower and seasonal refilling of reservoirs. Since 2021 there were consistent net exports in the Nordic region as other renewable generation has also increased, generating higher surpluses for export.
- Up until June 2022 the Baltics, Italy and CEE remained net importers.
- SEE and Iberia shift regularly between net imports and exports, depending on the local power generation circumstances. Since 2022, Iberia is consistently a net exporter to France, due to

[8] ENTSO-E (2022) SIDC Implementation
[9] Based on data from Eurostat [NRG_TI_EH]

lower electricity prices resulting from a temporary cap on gas prices in the peninsula ('Iberian exception').

- A notable change, resulting from the specific market conditions in 2022, was the British Isles becoming, for the first time in more than a decade, a net exporter during April to (at least) June 2022. This can be explained by soaring electricity prices, which have made coal-fired power generation competitive, and the UK able to fill part of the supply gap mainly in France left by (temporary) nuclear shutdowns.

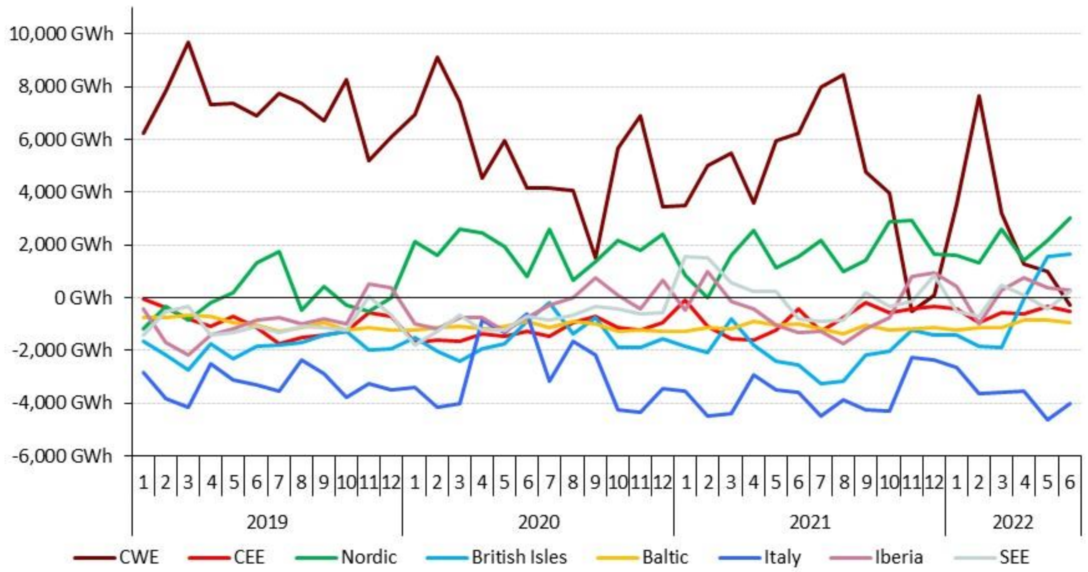


Figure 13: Net electricity flow positions of individual European regions
Source: ENTSO-E

2.1.4 International comparisons

Comparing the average electricity prices in the EU27 with wholesale prices of Europe's most important trading partners can provide a useful insight into how energy cost differentials can have an impact on the competitiveness of European energy-intensive industries with a high international exposure. Electricity bills are one of the factors determining international competitiveness.

Figure 14 below shows a comparison of wholesale electricity prices in the EU with key global trade partners (USA, UK, Japan and China) from 2008 up until 2022. The figure shows that:

- since 2008 wholesale electricity prices in the US have been mostly lower than in the EU27 (with a small exception in 2014 and then in early 2020)
- prices in Japan increased significantly after the 2011 nuclear accident at Fukushima and the subsequent national nuclear shutdown and remained significantly higher than in the EU until 2016. Between 2016 and 2020, the prices were somewhat comparable though prices remained higher in Japan, while there was a large peak in Japanese prices in Dec 2020/Jan 2021, due to cold weather, a shortage in LNG supplies and failures in the market mechanism[10]. In both markets, electricity prices were driven by global prices for LNG and have followed similar upward trajectories during 2022.
- Wholesale electricity markets are still being developed in China, but proxy prices (for large industrial consumers) have been relatively stable, with a slight continuous decline between 2017

[10] Koichiro (2021). The Price Surge in the Japanese Wholesale Electricity Market in January and the Lessons for Market Design

and 2020. Data beyond 2020 is not available, although upwards price pressures in 2021 and 2022 are understood to be strong as coal prices have increased[11].

- Electricity prices in the UK have closely tracked the EU average over time, typically being a little higher than the EU average. Their similarity is unsurprising with most of the same market drivers at play as well as large interconnection capacity (both electricity and gas) between the EU and UK.

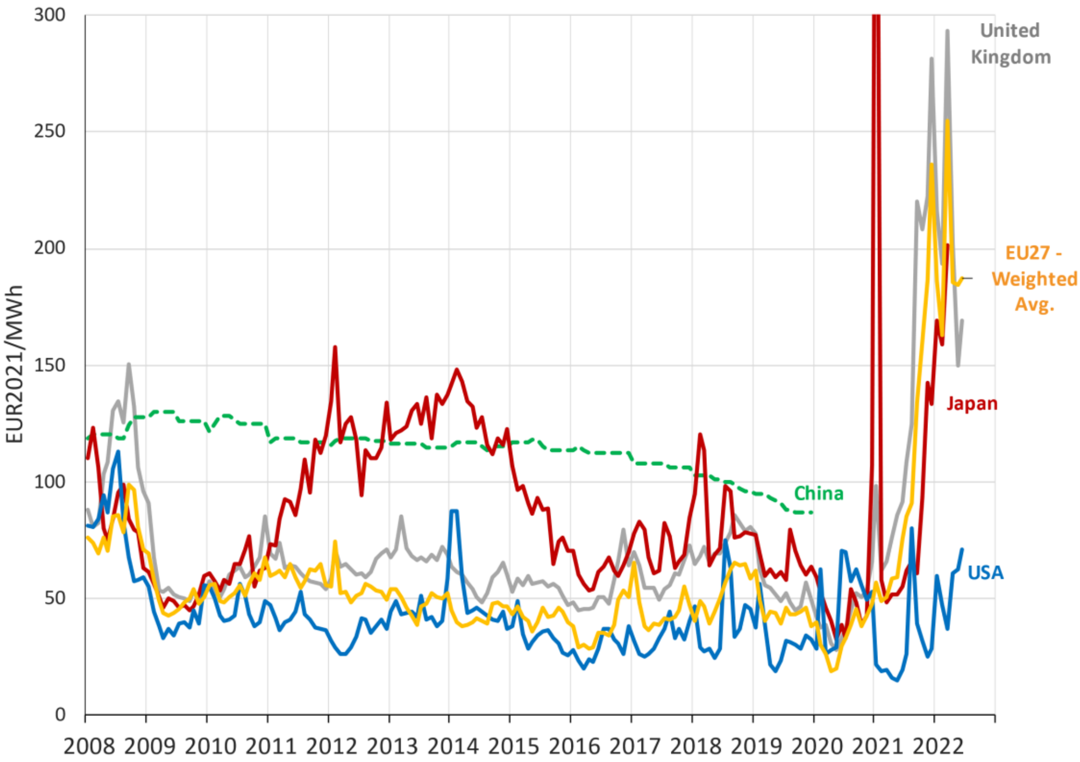


Figure 14: Comparison of monthly average day-ahead wholesale electricity prices in the EU with global trade partners (USA, UK, Japan, and China)[12]

Figure 15 below shows wholesale electricity price trends in the other G20 countries: Australia, Brazil, Canada, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa and Türkiye. Consistently low electricity prices have been observed in Canada and Russia between 2008 and 2022, the former driven by abundant hydropower and nuclear (these two combined provide more than 80% of the electricity mix), the latter by artificially low (subsidized) prices. Prices in Brazil and South Korea are very volatile, with high peaks between 2012 and 2015.

The figure clearly shows that none of the countries has experienced a price spike as high as the EU27 in 2021 – 2022. However, price spikes are evident in many (but not all) of the other G20 countries, most notably India, South Africa, Türkiye and South Korea. Prices in other countries have not spiked in similar ways, which mostly correlates with countries that are largely self-sufficient in their fuels for electricity production.

[11] Integral (2022). China Raises Cap on Electricity Price: What has Changed and Possible Impact for Business

[12] Note that price series for 2022 in this section are all presented in nominal prices, as deflators are not yet available.

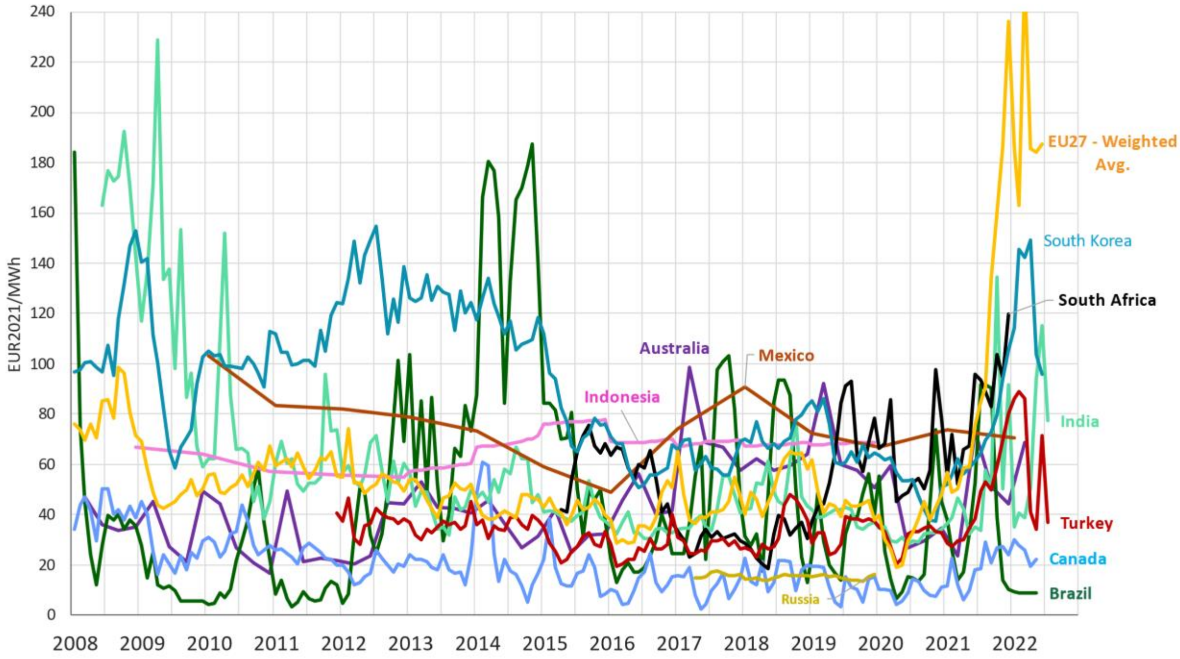


Figure 15: Comparison of average monthly day-ahead wholesale electricity prices in the EU27 with global trade partners (Australia, Brazil, Canada, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa and Türkiye).

Box B: Most recent day-ahead wholesale electricity price developments in the EU and internationally

Whilst standardised price data extending the series used in the rest of this section is not available yet for all countries for 2022, the price movements in 2022 are of particular interest given the continuing large movements. Alternative price series can help to provide insights into price changes in the EU and internationally in this period. Extracts from the IEA Real-time electricity price tracker[13] are presented below, which chart electricity price fluctuations over the last year 29th Aug 2021 to 29th Aug 2022.

These provide data for all EU MS except Cyprus and Malta and show how prices first spiked in many Member States around Dec 2021-Jan 2022 and then again at the start of March as Russia invaded Ukraine. In many Member States, the crisis has further evolved to higher peaks in July and August 2022, with prices up to 600 EUR/MWh in some countries. Prices at the end of August 2022 were above 370 EUR/MWh in 18 MS, and lower only in Finland, Estonia, Poland, Ireland (as of June 2022), Portugal, Spain and Sweden. This is higher already than the 230 EUR/MWh wholesale price peak illustrated as the EU average at the end of 2021.

The EU prices stand in significant contrast to prices in other G20 countries (except for the UK). Whilst prices in Japan, Australia and Argentina have also exceeded 200 EUR/MWh in 2021, prices in Australia have since then dropped below 100 EUR/MWh and in Japan below 200 EUR/MWh. Only in Argentina does it appear that prices may approach the levels of countries worst affected in the EU. Prices in the US and Mexico have more than doubled since February 2022, but they remain around 100 EUR/MWh, in stark contrast to most of the EU. Prices in Türkiye whilst increasing, also remain under 200 EUR/MWh, though also a consequence of government intervention/subsidies on the gas market.

[13] IEA (2022). Real-time electricity price tracker.

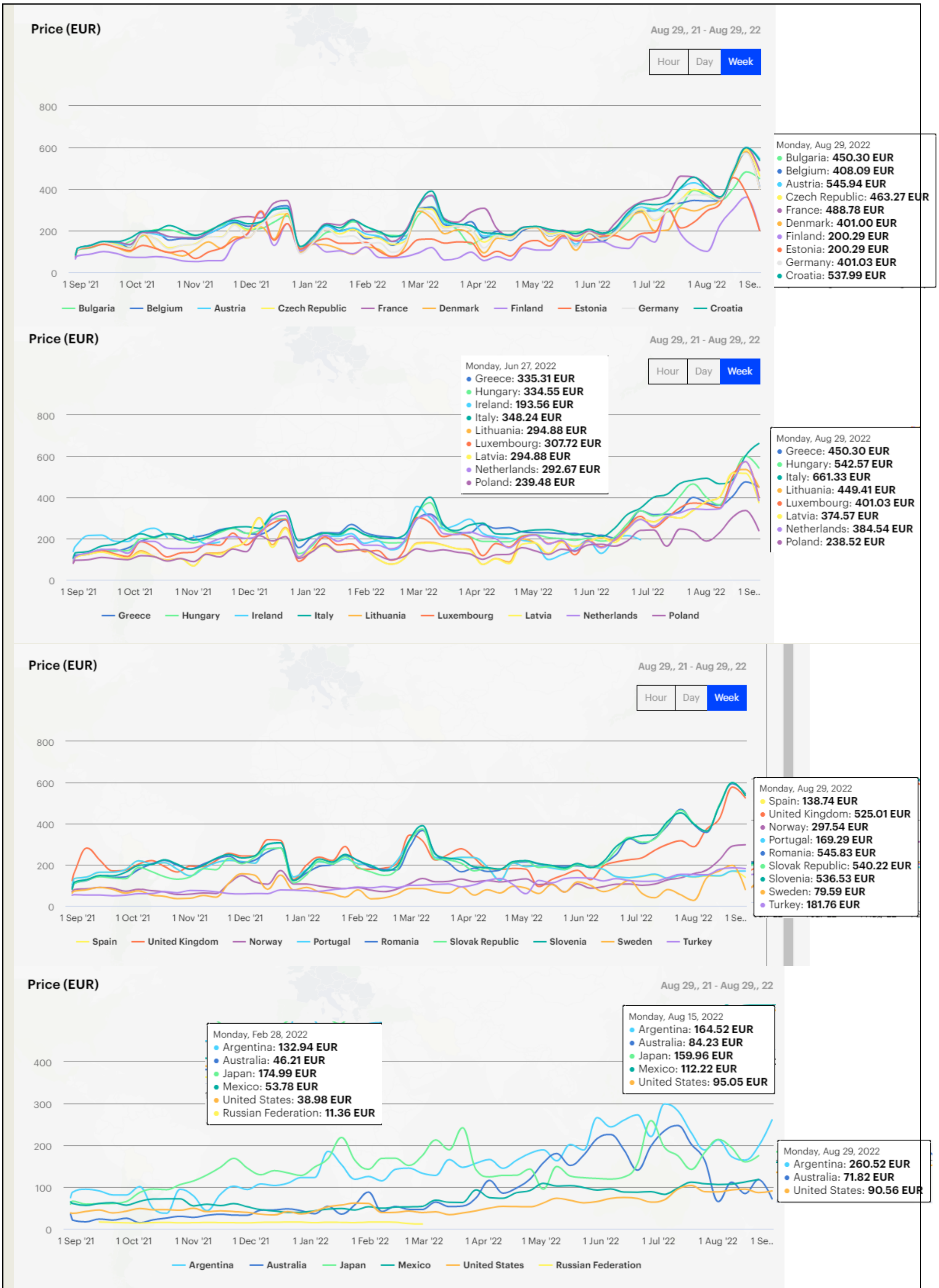


Figure 16: Extracts from the IEA Real-time electricity price tracker on August 29th 2022.

2.2 Retail prices

Main Findings

- Retail electricity prices for household consumers increased between 2019 and 2021, driven mainly by rising wholesale prices (as discussed above). In the case of households, the average EU27 retail price went up by 8% (+16 EUR/MWh) to 231 EUR/MWh in 2021.
- Data for the first half of 2022 suggests retail prices are following the wholesale price trend with a delay, with average household prices increasing to 311 EUR/MWh (+32%). Significant (43%) tax reductions have helped to mitigate this increase, with average taxes around 20 EUR/MWh lower by mid-2022 than in 2021.
- Fast developments in the wholesale electricity market led to household electricity prices being lower than the wholesale price in most EU markets. This deficit is an important factor in financial difficulties and bankruptcies of some electricity suppliers.
- Mid-size industrial companies (Band ID) experienced a 15% (+16 EUR/MWh) increase in the average price to 124 EUR/MWh in 2019. Industrial retail prices jumped significantly in 2021, and have continued to increase sharply from an average price of 124 EUR/MWh in 2019 to 191 EUR/MWh by June 2022. Industrial prices appear to respond more quickly than household prices to movements in wholesale markets (as discussed in 2.2.2).
- The spread of prices for EU households remains similar and significant, with the retail prices in 2021 ranging from a high of 321 EUR/MWh (Germany) to a low of 100 EUR/MWh (Hungary). From late 2021 into the first half of 2022, this price spread has grown significantly.
- The amount of electricity taxes and levies paid by households in the EU27 per MWh has stabilized since 2017. However, for industrial enterprises taxes and levies have increased since 2010. Following a slight (4%) decrease in 2021, these stood at an average of 37.7 EUR/MWh. The role of the tax component remains important (at 30% of total costs) for industry. This is explored in more detail in Chapter 8.
- On the international level, retail prices for households in the EU remain higher than almost all G20 countries. Only prices in Australia, the UK and Japan are at a similar level.
- Industrial prices are increasing as well, but price increases are limited in some countries (especially China and the USA). This indicates a worsening of the EU's global industrial competitiveness, as EU prices were already amongst the highest before the energy crisis.

2.2.1 Household electricity prices

This analysis of the prices paid by household electricity consumers is based on the weighted EU27 average for the DC band (covering an annual consumption of 2 500 to 5 000 kWh), available from Eurostat. A comparison of reporting countries based on a most representative band is also included. In this case, all Member States (and selected non-EU countries) are represented by the consumption band, which accounts for the largest share in their total household consumption. Therefore, they are represented by the price of the consumption band in which the most electricity was sold, irrespective of the number of consumers in the band.

Evolution of household electricity prices

EU household electricity retail prices in the DC band increased by 22% between 2010 and 2021 (see Figure 17 **[left]**), with recent wholesale price increases expected to drive further increases in 2022 and potentially beyond. In absolute terms, the average EU27 retail price increased from 215 EUR/MWh in 2019 to 231 EUR/MWh (+16 EUR/MWh) in 2021. The increase of end-user prices was driven by two components: in Energy and supply (+16 EUR/MWh) and Network costs (+3.6 EUR/MWh), whilst taxes and levies declined during this period (-3.1 EUR/MWh). The increase in the energy and supply component shows that wholesale price increases were slowly being incorporated in retail prices since (the end of) 2021, which further continued in 2022 (see Figure 26).

When looking at the retail price composition between the cost of the energy, network costs and taxes and levies (see Figure 17 **[right]),** the taxes and levies category saw its share in the total bill decrease from 40% in 2017 to 37% in 2021. Further analysis of this component is provided in the following sub-section. As the energy prices were decreasing between 2010 and 2020, the share of energy and supply costs in the total bill was also decreasing. However, as the wholesale prices increased in 2021, the share of the energy component has increased to 37% of the total bill in 2021. Most importantly, the energy and supply cost levels in 2021 exceeded all recorded values since 2010.

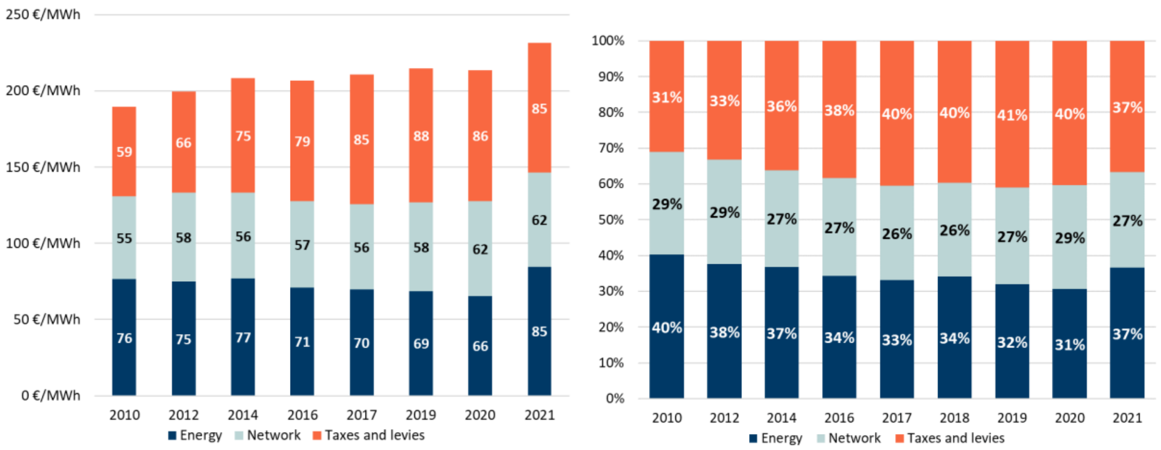


Figure 17: Evolution and composition (left) and relative composition (right) of the EU nominal household price (DC band)
Source: DG ENER in-house data collection, Eurostat

Composition of taxes, levies, fees and charges

In order to understand how Member State policies and fiscal instruments impact household retail prices, the category of taxes, levies, fees and charges is broken down into six subcomponents: VAT, renewable energy taxes, capacity taxes, environmental taxes[14], nuclear taxes and other. Note that only policies and mechanisms that directly influence retail prices are considered, and not all tax subcomponents are applied in all EU Member States. The following chart displays an evolution of EU27 averages. More details about energy taxes are in chapter 8.

Figure 18 shows that taxes and levies associated with renewable energy support policies have declined since 2019 from 26 EUR/MWh to 24 EUR/MWh in 2021, while the capacity taxes continued to gradually increase over time. Since 2010, capacity taxes have increased by 288% and reached 3.9 EUR/MWh in 2021 (although still a minor part of the tax component). Environmental taxes and levies have followed an increasing trend (+49%) since 2010, but their amount has slightly decreased to 17.9 EUR/MWh in 2021 after peaking at 19 EUR/MWh in 2019. The elimination of the EEG surcharge in Germany in 2022[15] is expected to drive further reductions in the environmental taxes and levies component in the next few years.

[14] This category includes general energy taxes, which are typically classed as having an environmental purpose
[15] German Federal Government (2022). Renewables levy abolished

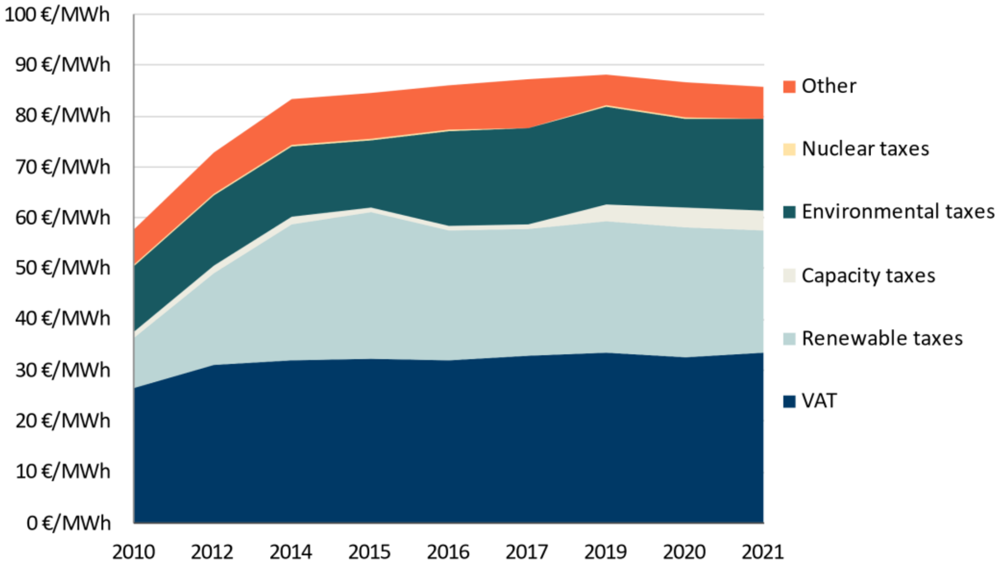


Figure 18: Evolution of taxes, levies and charges in the electricity bill for EU households since 2010 (DC band)
Source: DG ENER in-house data collection, Eurostat

Between 2019 and 2021, the structure of the taxes and levies component showed minor changes: a downward shift in the environmental taxes and renewable energies contribution (both -1%), while VAT and capacity tax increased (both +1%) (Figure 19).

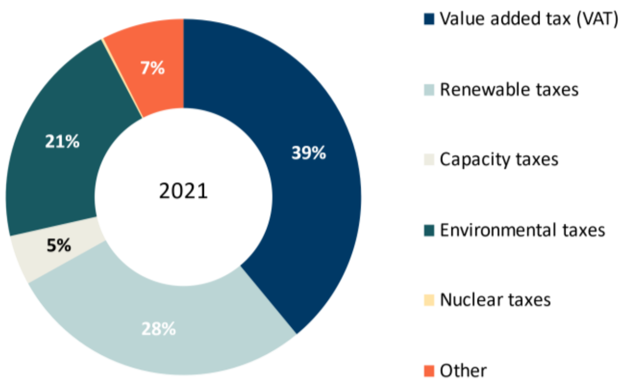


Figure 19: Composition of the taxes and levies component of household electricity prices in 2021 (DC band)
Source: Eurostat

This next section presents a brief description of the individual components.

Value Added Tax

VAT is applied on household electricity bills in all reporting countries. The EU VAT Directive explicitly allows Member States to apply reduced rates to electricity. As a result, VAT rates range from 5-6% in Greece and Malta to 25-27% in Denmark, Sweden and Hungary. Most common rates are around 20%. However, since October 2021 and continuing in 2022 many countries use (temporarily) lower VAT rates as part of compensation measures for high energy prices. VAT accounted for 38% of the tax component, making it the largest subcomponent, and overall, it accounted to 16% of the total retail electricity bill for households. Since VAT is based on the value of all other elements in the bill, even if VAT rates decrease but other elements increase, the absolute amount of VAT revenues increase.

Environmental taxes

This sub-component includes any manifestation of excise duty, environmental, greenhouse gas emission, transmission and distribution taxes, excluding VAT. Their common characteristic is that revenues from these taxes are not normally earmarked to energy, climate- or environment-related policies. In other words, revenues flow into the central state budget regardless of their source. Minimum excise duty levels on energy products are harmonised at EU level and are defined by the Council Directive 2003/96/EC22. Environmental taxes were collected by 20 Member States in 2021. They made up 21% of the taxes and levies component, representing the third largest item after VAT and renewable energy taxes. The average amount of environmental taxes paid by households in the EU27 rose by 39% in the period 2010-2021.

Renewable energy and energy efficiency taxes

This sub-component includes any support to renewable energy, energy efficiency and combined heat and power generation (CHP). Renewable energy taxes are not collected in five Member States. In Finland and Malta, the renewable energy support scheme is not financed through an explicit levy but from the state budget. France has been following the same example since 2016. In Hungary, household electricity consumers, unlike their industrial counterparts, are exempted from renewable energy surcharges, whilst no green levies are imposed on Bulgarian households. It is important to note that even in these cases, electricity consumers still indirectly contribute to the support of renewable energy as taxpayers. In several countries, renewable energy is supported also from other sources than taxes on consumer bills.

On average, EU27 household paid 24 EUR/MWh for renewable energy taxes in 2021. This figure is equal to 28% of the taxes and levies component and to 10% of the EU average total electricity bill. The average amount of renewable energy taxes paid by households in the EU27 rose significantly from 10 EUR/MWh in 2010 to 26 EUR/MWh in 2014 because many countries implemented similar taxes to subsidize the fast growth of renewable energies; after 2014 these charges stayed more or less stable until 2021.

Capacity taxes

This category includes taxes, fees, levies or charges related to ensuring adequate capacity for the generation, storage and demand response, taxes on electricity distribution, stranded asset costs and levies for the financing of energy regulatory authorities or market operators, and taxes related to coal industry restructuring. Capacity taxes were imposed by 11 Member States in 2021. The impact of these charges remains limited, at around an average 1.7% of the overall electricity retail bill, although the impact is higher in the countries with the highest capacity taxes (up to 7.2% of retail bill in Slovakia and slightly lower in Germany and Poland).

Nuclear taxes

This category includes taxes, fees, levies or charges relating to the nuclear sector, including nuclear power plants' decommissioning, inspections and fees for nuclear installations. Nuclear taxes are collected in Belgium, Italy (which closed its last nuclear power plant in 1990) and Slovakia. Their impact on the electricity retail bill is negligible at EU level.

Other charges

This category includes all other taxes, fees, levies or charges not covered by any of the previous five categories, such as support for district heating, local or regional fiscal charges, island compensation or concession fees relating to licences and fees for the occupation of land and public or private property by networks or other devices. At 6.4 EUR/MWh in 2021, the absolute value if this subcomponent decreased slightly compared to 2010. Its share in the total retail bill amounted to 3% in 2021.

Figure 20 presents the breakdown of the taxes alongside the energy and network cost components, providing additional detail compared to Figure 17. Network and tax components stay relatively stable in absolute terms and the largest variation has been the result of changing/rising energy component costs, especially in 2021 (and 2022, although no precise data is available yet).

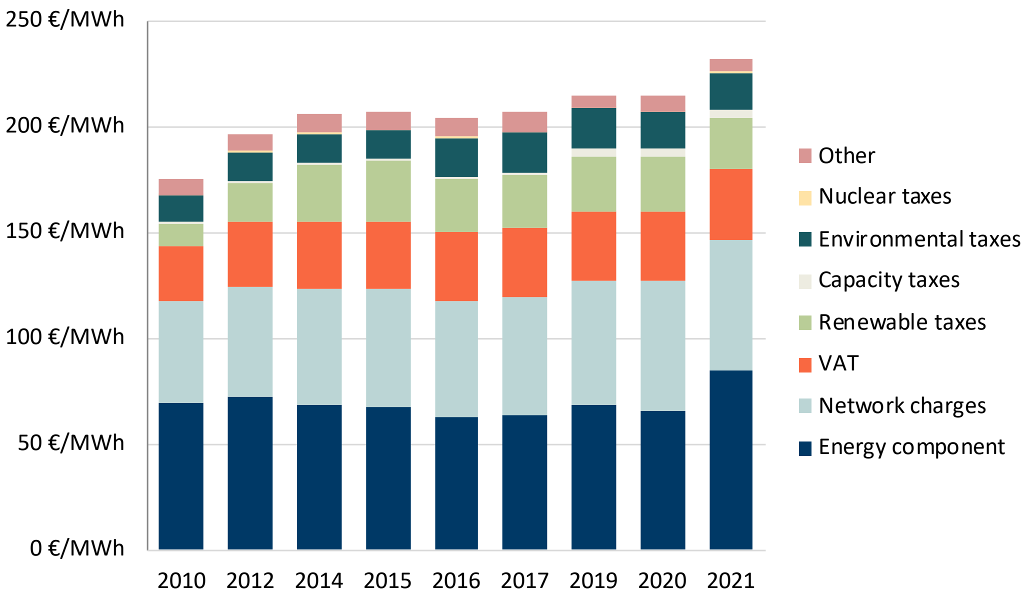


Figure 20: Breakdown of nominal household electricity prices (DC band), expanded tax component breakdown
Source: DG ENER in-house data collection, Eurostat

Situation in individual Member States

Figure 21 below presents household retail prices and their composition in individual Member States in 2021. Germany reported the highest price of 326 EUR/MWh, overtaking Denmark (where prices declined from 295 EUR/MWh in 2019 to 260 EUR/MWh in 2021). Hungary (100 EUR/MWh) had in 2021 slightly lower prices than Bulgaria (105 EUR/MWh) which was previously the Member State with the lowest price. In total, 21 Member States reported prices lower than the EU27 weighted average in 2021, indicating the strong influence on the average of large Member States with high prices such as Germany and Spain.

One notable element is the reduced share of energy taxation in the Netherlands in 2021, stemming from (temporary) tax measures to reduce energy costs for households. Other member states have since then taken similar temporary tax relief measures, but they have not been accounted for yet in the data.

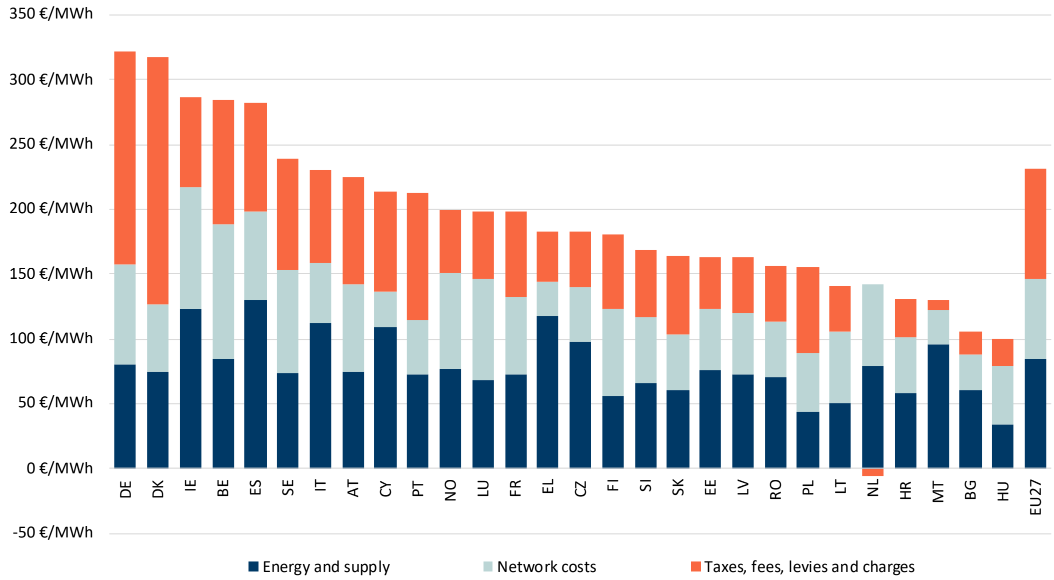


Figure 21: Household electricity prices in 2021 (most representative consumption band).
Source: Eurostat.

The composition of household prices in 2021 shows that the proportion of energy supply, network costs and taxes in the overall price is highly variable between Member States. Figure 22 shows that although energy and supply costs tend to represent the largest share of the overall price, the shares of the different components are highly variable. For example, in Germany and Denmark the costs of energy and supply are much lower than the costs of taxes, fees, levies and charges. In countries such as Malta and Greece, the cost of energy and supply represents more than 60% of the total bill. Network costs contribute the least in Bulgaria, Denmark, Portugal and Italy. In Belgium (105 EUR/MWh), Ireland (94 EUR/MWh) and Sweden (80 EUR/MWh) network costs were highest in 2021. The lowest taxes and fees component is seen in Malta. Across the EU27, the share of taxes and levies in the overall household electricity price has decreased by 4%, while network costs increased by 6% and energy and supply increased by 23% between 2019 and 2021.

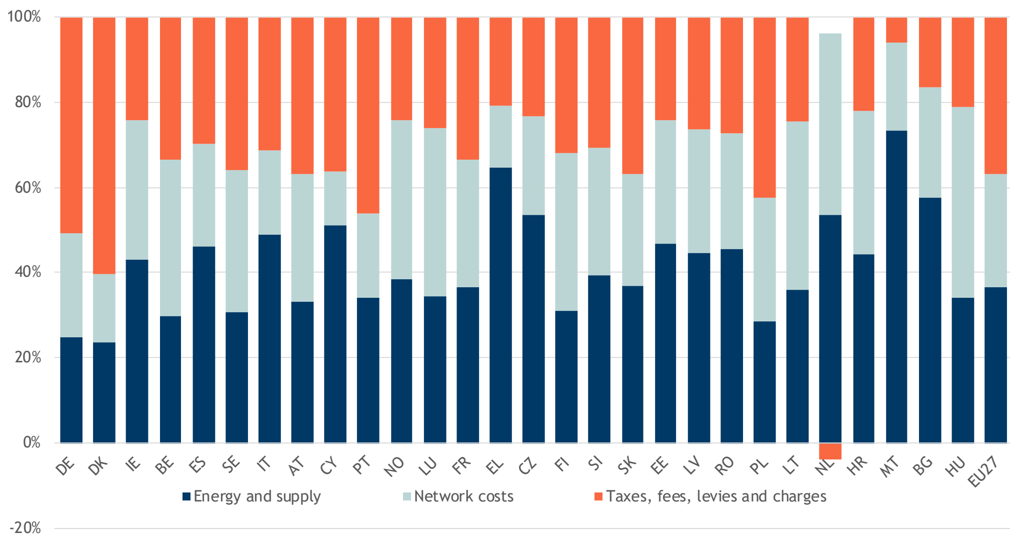


Figure 22: Composition of household electricity prices in 2021 (most representative consumption band, in % proportion of overall price)
Source: Eurostat

The costs of the energy component have seen remarkable increases and shifts in 2021 in comparison with 2019. Most notably, average EU27 energy costs have increased from 68 EUR/MWh to 85 EUR/MWh (and have risen further in 2022). While before 2021 energy costs in island systems were generally the highest (Ireland, Cyprus, Malta), in 2021 the highest costs were found in Spain (where energy costs almost doubled from 67 EUR/MWh in 2019 to 130 EUR/MWh in 2021), Ireland and Greece (118 EUR/MWh). The very high retail prices in Spain are the result of rising wholesale prices leading to higher retail prices without much delay for consumers with a so-called Voluntary Price for small Consumers (PVPC) contract. In other Member States, the coupling between wholesale and retail prices is less direct as most retail consumers have annual contracts with variable or fixed (wholesale prices based) or regulated prices. Complete data for 2022 is not available yet, but it is clear that the recent price developments on the wholesale markets will continue to increase the energy component and hence total retail prices.

Figure 23 depicts the difference between the energy component of household retail prices and the average day-ahead baseload price in the wholesale markets of the respective countries in 2021. This analysis provides us additional insights into how wholesale and retail prices correlate in Member States. In general, many factors besides the day-ahead electricity prices - shown in Section 2.1 - influence the cost of energy for energy suppliers, and therefore the retail prices they offer to households. These factors include the forward wholesale prices in the previous year(s), hedging strategies, consumption profiles, structure of customers, balancing costs, various forms of price regulation, exchange rates.

In 2019, the energy component of retail prices was higher than day-ahead wholesale prices in all countries, which is explained by additional costs (e.g. balancing and administrative costs) and mark-up made by retailers. However, in 2021 this completely changed: retail prices were in 2021 lower than day-ahead prices in all countries, except in Spain, Sweden and Greece. The largest differences between the retail and wholesale spot prices can be seen in markets with strong retail price regulation, most notably Hungary (-79 EUR/MWh) and Croatia (-56 EUR/MWh).

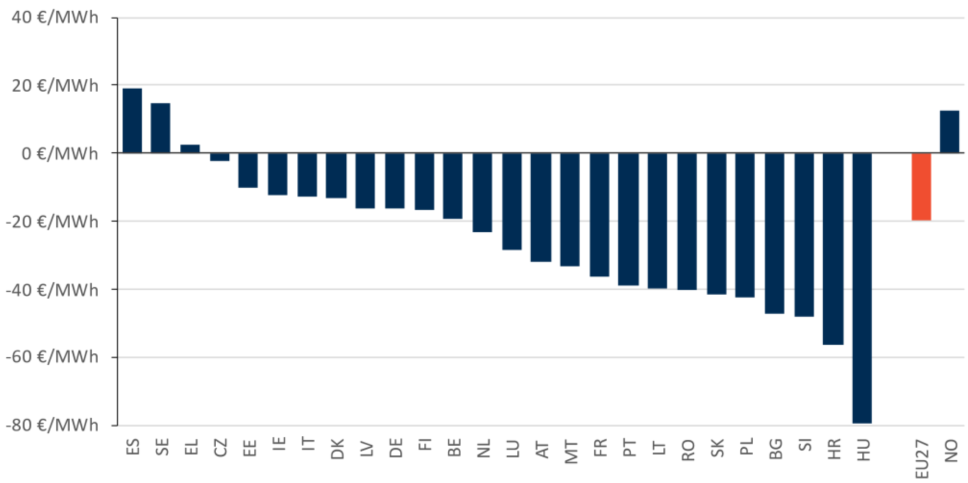


Figure 23: Difference between the energy component of household retail prices and average day-ahead baseload prices in individual markets in 2021 (DC band)
Source: Eurostat, S&P Platts, ENTSO-E

The consequences of these negative gross margins will vary per energy supplier for the reasons noted above. In the most severe cases, the negative margins have led to bankruptcies of energy suppliers. Particularly vulnerable are small- and medium-sized suppliers that have limited or no own power generation assets, and that did not (sufficiently) hedge their price risks via forward contracts. Retailers with sufficient liquidity are able to withstand (limited) periods with negative margins, although they have to raise their retail prices (taking into account national market regulation) to cover their costs, especially for new contracts. Therefore, average retail prices in 2022 have been further increasing as gradually more households have their contracts renewed at higher rates and this trend is expected to continue well into 2023.

Box C - Definition of the most representative band

Household electricity consumption is broken down into 5 bands in the Eurostat methodology. The most representative band is the band with the highest share in total consumption; in other words, the price at which most electricity is sold. While the DC band is used as main point of reference for comparative analyses, a few Member States register only a small proportion of consumption in this category. Household consumption varies across countries as it is determined by factors including household size, climatic conditions (availability of sunlight and need of light, heating and cooling needs), and the extent to which electrification is used for heating or the number of efficient electrical appliances in typical households.

To analyse prices in a comprehensive manner, reporting in the most representative band in each market is also included. The selection of consumption bands is based on the previous iteration of this report where this concept was introduced.

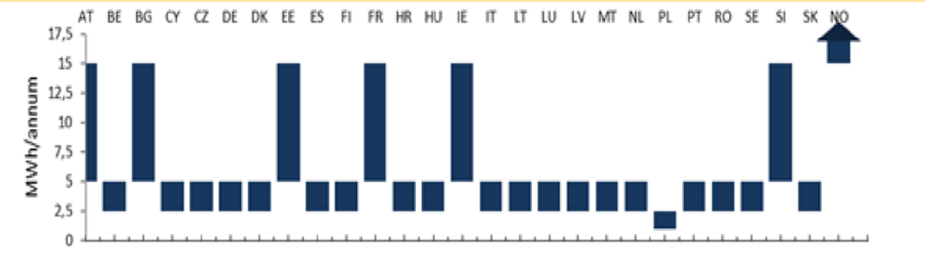


Figure 24 explores the household prices in the most representative bands, which in most but not all cases remains the DC band. In Ireland, the DD band is the most representative, and prices were 15% lower for the DD band than for the DC band in 2021. Other countries with notable differences in their most representative band compared to DC bands include France, Estonia, Slovenia, Bulgaria (DD band) and Poland (DB band). The largest difference is observed in Norway, which had in 2021 significantly lower costs in its most representative DE band than in the DC band. Average household prices in Norway were in 2021 as low as 136 EUR/MWh. These observed differences between the household prices for the DC band and the most representative band are in line with those reported in 2019 and indicate a consistent trend.

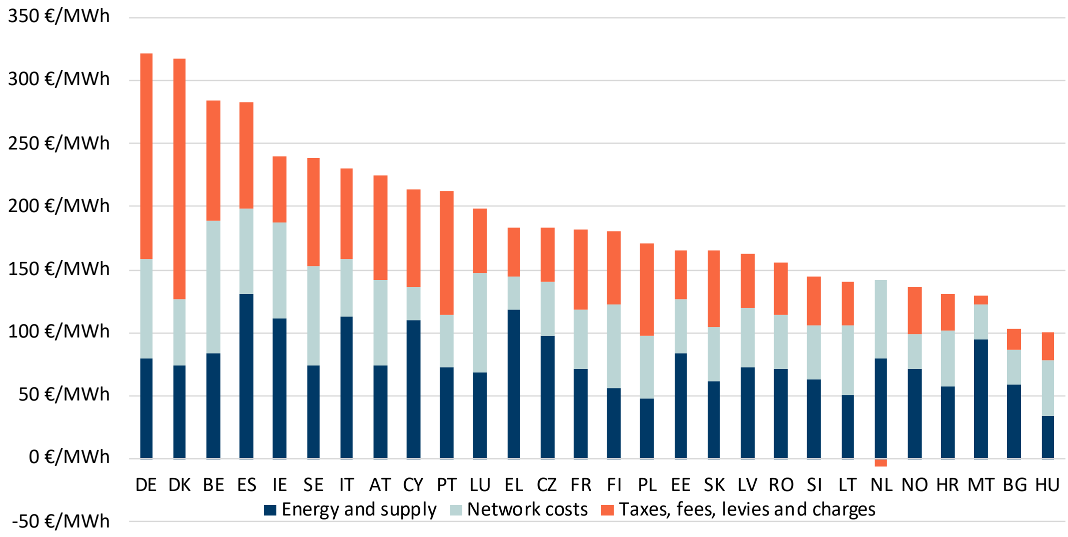


Figure 24: Household electricity prices in 2021 (most representative band)
Source: Eurostat

Recent developments in household electricity prices

More recent data is now starting to become available, for example in Figure 25, which shows average prices for the first half of 2022. This figure shows a significant increase from 235 EUR/MWh in 2021 to 311 EUR/MWh (+32%) in the first half of 2022. The increase is almost entirely caused by a doubling of the energy and supply component of the price. It is also notable that the energy tax component has decreased in this period from 47 EUR /MWh to 27 EUR /MWh (-43%) as (temporary) policy measures in MS have reduced tax levels to partially mitigate price increases of the energy component.

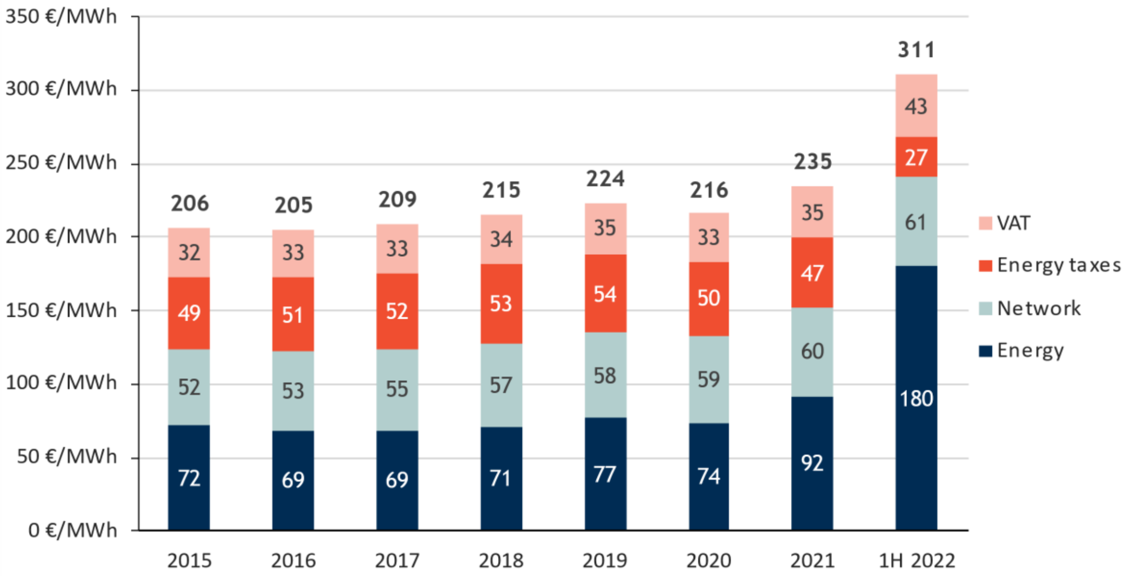


Figure 25: Average household retail electricity prices for EU27 (excl. CY & MT)
Source: VaasaETT for the latest retail prices. Other parts of the report rely on Eurostat, which can lead to (slightly) different results.

Country level data is also available for the first semester of 2022 from Eurostat (see Figure 20). Whilst the component level data is not yet available, the total price data already provides insights into the price developments in the first half of 2022. EU average electricity prices increased from 219 EUR/MWh in June 2021 to 253 EUR/MWh in June 2022, an increase of 34 EUR/MWh (+15%). The figure also shows that prices have spiked in particular in Denmark, Belgium, Italy and Spain over the last 12 months. However, major increases can be observed across many more MS, which are pushing the EU average retail price up. There is some divergence in the EU average from the previous figure, which was based on alternative data; however, the overall trend is clear.

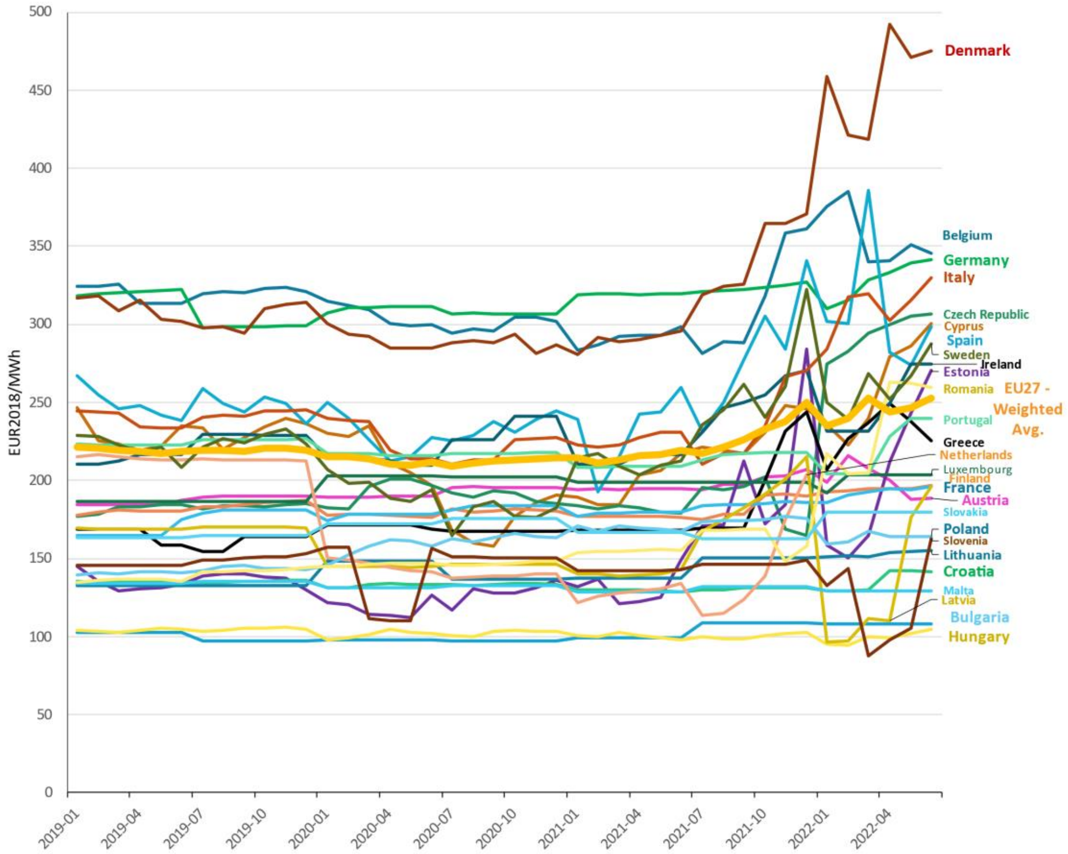


Figure 26: Average Household retail electricity prices in the EU27, Jan 2019-Jun 2022.16
Source: Eurostat.

2.2.2 Industrial electricity prices

The following section analyses prices paid by non-household electricity consumers at EU and Member State levels, examining prices of the Eurostat band[17] ID covering annual consumption of 2 000 - 20 000 MWh. This band can be considered representative of mid-size businesses across many segments of the economy. Price trends in the IF band (annual electricity consumption between 70 000 - 150 000 MWh) are also analysed, which is more representative for the situation of large enterprises and energy-intensive industries.

[16] Note: Semester data of Eurostat is converted into monthly data using countries' monthly HCIP data. This method is used for all monthly electricity and gas retail data in this report. A similar method is also used for data from Japan, UK and China in the 'international comparisons' sections.
[17] Bands refer to energy consumption levels. Band DC: household consumption between 2500 to 5000 kWh; Band ID: industrial consumption between 2 000 and 20 000 MWh; Band IF: 70 000 MWh to 150 000 MWh

Box D - Sectoral split of electricity consumption

Households accounted for 29% of the total EU27 electricity consumption in 2020, the most recent year for which data are available. This was slightly higher than observed in 2019, where they accounted for 27%. This is linked to the COVID-19 pandemic and the lockdown measures, which obliged many people to work from home for long periods. The share of electricity consumed by industrial users dropped from 37% to 36%, reflecting the reduced production volumes due to the pandemic. Similar to 2019 observations, commercial establishments and public institutions kept their shares relatively unchanged at 27%. The same applies for the transport sector, which continues to account for 2% of the total electricity consumption, primarily for rail transport, although it is unclear how electricity consumption for electric vehicle charging has been taken into account.

Evolution and drivers of industrial electricity prices in the EU

Figure 27 shows that industrial electricity prices in the ID band increased at an average annual rate of 2% during the last decade, overall showing an increase from 96 EUR/MWh in 2010 to 124 EUR/MWh in 2021. Since 2019, industrial electricity prices increased by 14%, from 108 EUR/MWh in 2019 to 124 EUR/MWh (+16 EUR/MWh) in 2021. This is the highest 2-year increase in prices observed within the past decade.

Due to the exclusion of VAT and other factors related to tariff calculations, industrial electricity prices are more influenced by the energy component compared to households and hence, more driven by developments in the wholesale market. The energy component, despite a small dip in 2020, increased by 24% (+12 EUR/MWh) in 2021 compared to 2019. Network charges also contributed to higher overall bills; they increased by 14% (+3 EUR/MWh) since 2019 and reached in 2021 their highest level since 2010 at 23.3 EUR/MWh. The lowest increase was observed for the levies and taxes component, which only saw an increase of 1.6% (+0.6 EUR/MWh) between 2019 and 2021. This small increase is in contrast to the small decrease in taxes and levies (-3 EUR/MWh) identified for household retail consumers, as shown in Figure 17.

In 2021, the energy component represented 51% of the total bill. Network charges' share remained relatively unchanged in 2021 at 19%. A substantial decline in the share of taxes and levies is observed, which in 2021 accounted for 30% of the total electricity price compared to 34% in 2019.

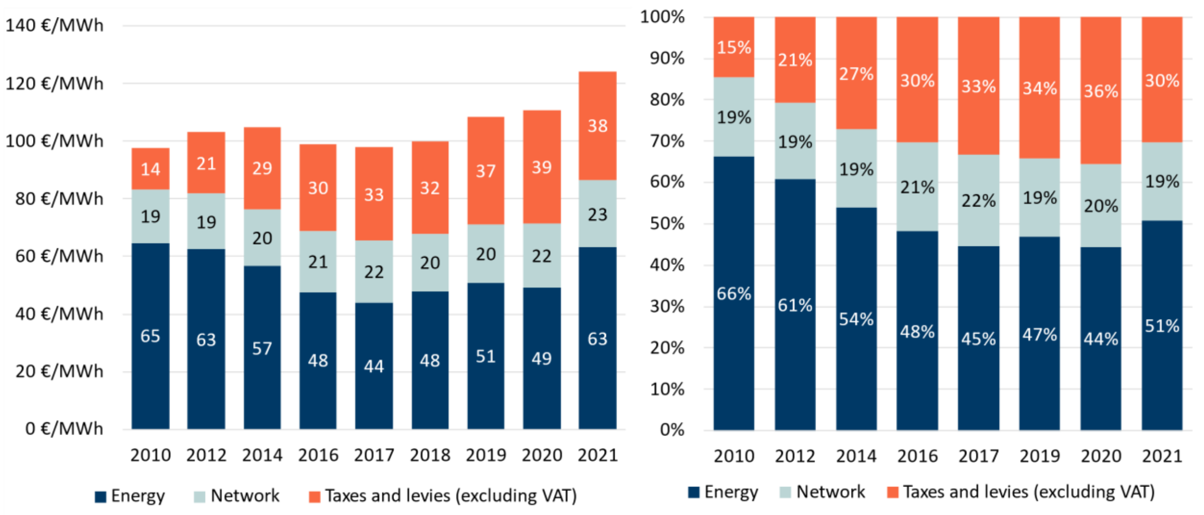


Figure 27: Evolution and composition of the EUR 27 industrial retail prices (ID band; medium-sized enterprises), absolute (left), share (right)
Source: DG ENER in-house data collection, Eurostat

Situation in individual Member States (Band ID)

Overall, the industrial retail prices in the EU27 have converged, becoming less spread out over time. The driving factors behind this convergence include increasing wholesale markets' integration and greater cross-border competition between suppliers, leading to lower variations in the energy and supply component of prices. The highest overall industrial electricity prices in 2021 were seen in Cyprus, Germany, Greece, Italy and Ireland, which all had prices exceeding 140 EUR/MWh (Figure 24). The price in Germany is heavily driven by the tax and levy price component. In Cyprus, Greece, Italy and Ireland the price is more driven by high energy and supply component costs.

Total retail prices increased between 2019 and 2021 in all Member States except Malta, and the EU weighted average increased by 15% (+16 EUR/MWh). The largest absolute increases were observed in Greece (+56 EUR/MWh) and Sweden (+50 EUR/MWh), in the latter country this represented an 80% increase in the overall retail electricity price.

As for **network costs**, the trends have changed significantly since 2019. While previously Slovakia, Ireland and Germany reported the highest values, in 2021 Sweden had the highest value at 55 EUR/MWh followed by Lithuania (32.5 EUR/MWh) and Germany (31 EUR/MWh). Greece continued to have the lowest network cost component (8 EUR/MWh).

The highest **energy and supply** components in 2021 were reported in Greece (123 EUR/MWh), Ireland (117 EUR/MWh) and Cyprus (108 EUR/MWh), which were similar levels to household prices[18]. Germany had some of the lowest energy and supply (commodity) costs, which partially helped mitigate the high amount of **taxes and levies**, which were in 2021 the highest in Europe (86 EUR/MWh) and contributed significantly to the retail price in absolute and relative terms (Figure 25). Prices in Poland and Cyprus also have a significant tax and levy component. Bulgaria is notable for having an effective negative tax and levy component. In addition, many other countries grant tax reductions to energy-intensive

[18] However, in household prices Spain had the largest energy component, followed by Ireland, Greece, Italy and then Cyprus. The relationship between industrial and household prices distribution is therefore not the same between Member States.

industries. As energy intensity is not based on consumption volumes alone, but also on the share of the energy bill in the total production cost, the ID band is likely to include enterprises that benefit from such reduced tax rates.

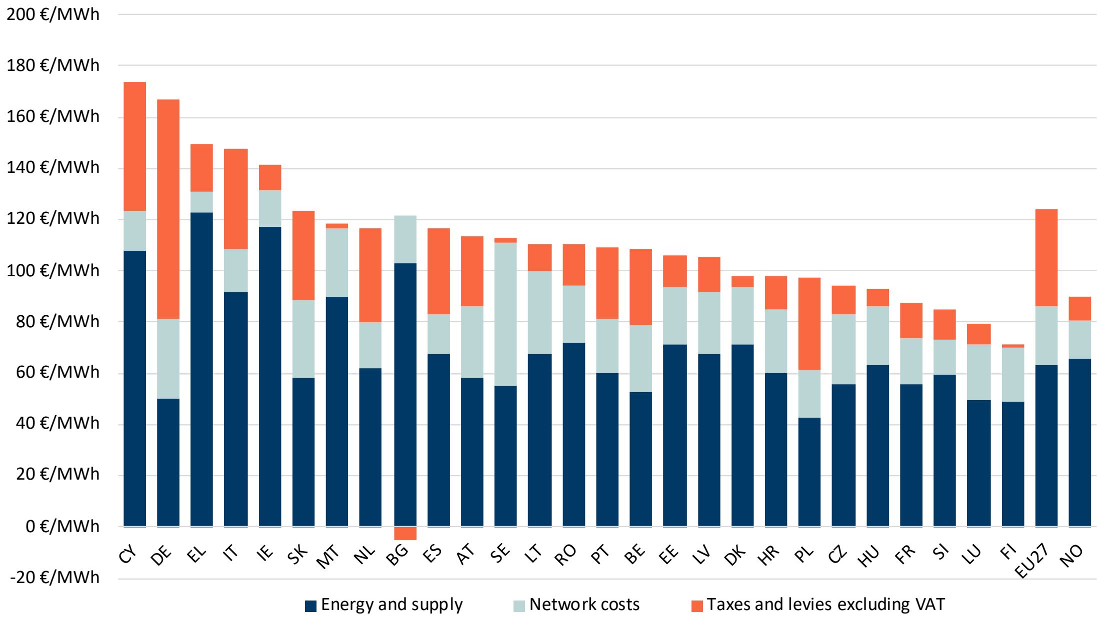


Figure 24 - Industrial retail electricity prices in 2021 (ID band; medium-sized enterprise)
Source: Eurostat

Figure 28 shows that the energy component plays a particularly significant role in energy prices in relative terms in Greece and Ireland, along with Bulgaria. Network costs play a particularly significant role in Sweden.

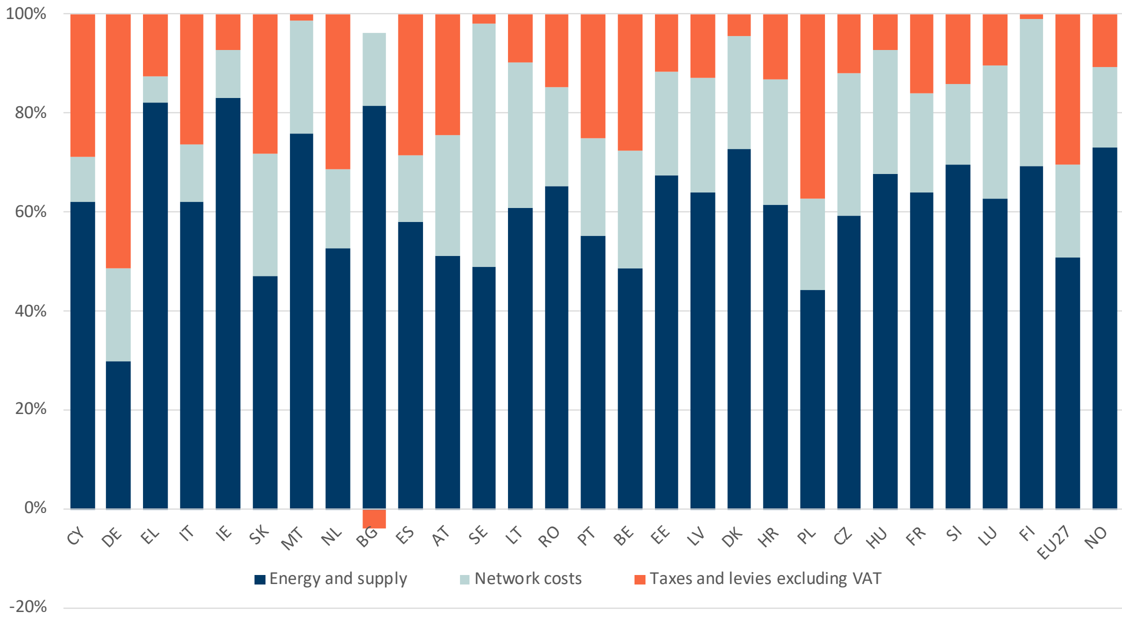


Figure 28: Relative composition of industrial retail electricity prices in 2019 (ID band; medium-sized enterprises)
Source: Eurostat

Composition of tax levies, fees and charges

The following section considers only policies that directly influence industrial retail prices for electricity. Figure 29 shows the changes in the composition of taxes, levies, fees and charges from 2019 to 2021. Similar to the overall trends in the retail prices, the tax component showed a small spike in 2020, which reduced in 2021. The tax component increased on average between 2019 and 2021, from 37.2 EUR/MWh to 38.2 EUR/MWh. However, the main drivers of this increase were increases in “other taxes and levies”, which increased by 150% (+2.1 EUR/MWh), and capacity charges, which showed a 36% (+0.7 EUR/MWh) increase in 2021 compared to 2019. The renewable tax (-0.9 EUR/MWh) and environmental tax (-1 EUR/MWh) components declined in 2021 to 93% of their 2019 level. Therefore, increases in energy supply costs as previously observed were to some extent counterbalanced by reduced taxes. In some cases, this reflects a deliberate policy choice to mitigate total price increases.

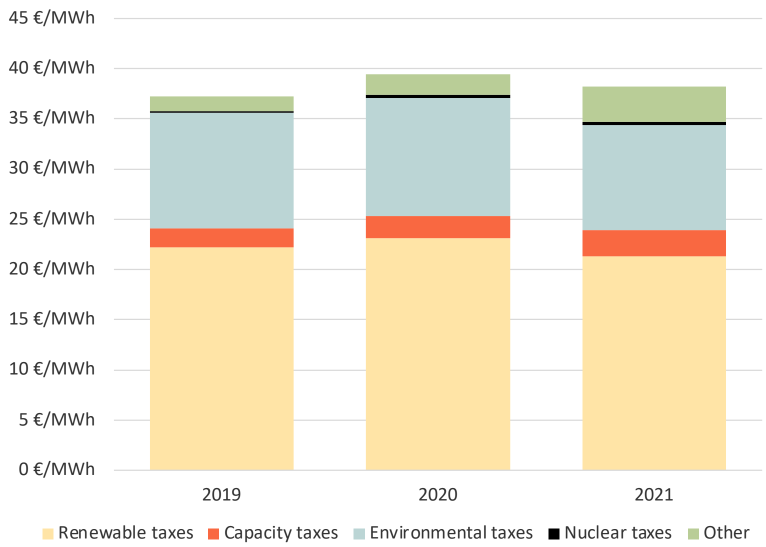


Figure 29: Comparison of taxes and levies between 2019, 2020 and 2021 (ID band)
Source: Eurostat

More than half of the tax component of industrial electricity prices was in 2021 related to support for renewable energies. However, the observed share has decreased since 2019, from 59% to 56%. Figure 30 shows that environmental taxes remain the second largest item in the taxes and levies, however, their share has also seen a significant decrease: in 2019 environmental tax made up for 31% of the tax component, while in 2021 this was 27%. Notably, taxes classified as ‘others’ showed a significant increase in their overall share, increasing from 4% in 2019 to 9% in 2021.

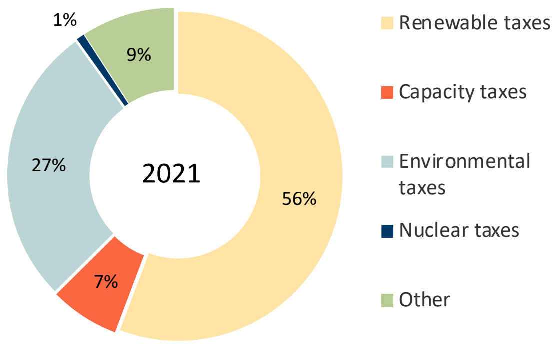


Figure 30: Composition of taxes and levies in 2021 (ID band)
Source: Eurostat

Value added tax

VAT is recoverable for industrial consumers in all reporting countries. Therefore, this report analyses industrial prices excluding VAT. Other recoverable taxes are also excluded from the price.

Environmental tax

Environmental taxes decreased by 17% between 2019 and 2021 to 7.5 EUR/MWh at EU level. They were collected in some form in all Member States with the exception of Latvia and recently also Belgium, Finland and Lithuania.

Renewable energies and energy efficiency tax

Taxes financing the support of renewable energy, Combined Heat and Power (CHP) and energy efficiency measures increased by 17% between 2019 and 2021 to 14.5 EUR/MWh at EU level. Renewable energy taxes accounted for 14% of the total retail price in 2021. Renewable energy taxes were not imposed in Finland, France and Malta. In Finland and Malta, the renewable energy support scheme is not financed from a levy on electricity consumption but from the central state budget. France has been following the same example since 2016. Therefore, in these three countries, the direct cost of supporting renewable energy is zero for industrial consumers. In Hungary, industrial consumers are subject to a renewable energy surcharge, while households are exempted.

Capacity tax

Charges related to security of electricity supply or the financing of regulatory authorities were collected in 12 countries in 2021, up from six in 2008. The impact of security of supply related charges remained limited, below 2% of the average EU27 price.

Nuclear tax

Nuclear taxes are collected in Belgium, Italy (which closed its last nuclear power plant in 1990) and Slovakia. Their impact on retail prices at EU level is negligible.

Other charges

The absolute value of the residual subcomponent increased on average from 0.7 EUR/MWh in 2019 to 1.5 EUR/MWh in 2021. Its share in the total retail price amounted to 1% in 2019.

Situation of large enterprises and energy-intensive industries

This section analyses retail prices for the IF band, which contains consumption levels between 70 to 150 GWh per year, thereby capturing the largest consumers of electricity found mainly in the energy-intensive industry. Industrial electricity prices in the IF band have increased by 30% from 2020 to 2021. Figure 31 shows that the energy component is the largest contributor to the overall increase in the price: 44% increase since 2019 from 46.7 EUR/MWh to 67.5 EUR/MWh. Unlike in past years, where rising wholesale prices were compensated by falling taxes, 2021 showed an overall increase in all components of industrial prices. Taxes as well as network charges increased by 10% and 16%, respectively. As such, 2021 showed an overall increase in industrial electricity prices as a result of significantly increasing wholesale prices reaching the highest levels in more than a decade.

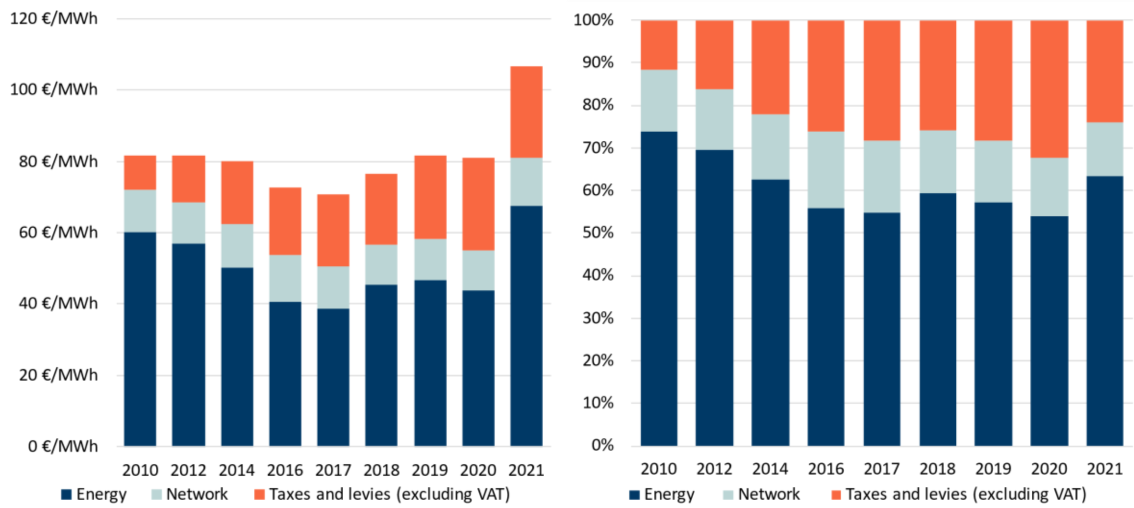


Figure 31: Evolution and composition of the EU27 industrial retail prices (IF band)
Source: DG ENER in-house data collection, Eurostat

Situation in individual Member States (Band IF)

Figure 32 shows the level of electricity prices in 2021 in different Member States, where the island of Cyprus reports the highest prices (154 EUR/MWh), followed by Ireland (141 EUR/MWh), Germany (139 EUR/MWh) and Italy (123 EUR/MWh). The EU27 weighted average in 2021 was 106 EUR/MWh. In total, 18 Member States reported prices below the EU average, indicating that the larger economies have higher electricity prices and therefore significantly drive the EU average price to a higher level. The average price of the 18 Member States below the EU average amounts to 86 EUR/MWh. In comparison to band ID, the retail prices in the IF band are more spread out than in previous years, especially towards the higher price end.

As with the industry prices in the ID band, Germany enjoyed relatively low energy component prices (49 EUR/MWh), but because of the high tax component (77 EUR/MWh), prices for industry were still relatively high. Denmark, which previously had the highest taxes and levies (125 EUR/MWh in 2019), showed an overall reduction in rates (4.3 EUR/MWh reduction in 2021). The lowest tax values were recorded in Malta (1.5 EUR/MWh) and Finland (0.6 EUR/MWh). As for the network costs, Norway (4.8 EUR/MWh) reported the lowest values while Sweden reported the highest amount (58 EUR/MWh), which was double that of the second highest cost level reported in Denmark (27 EUR/MWh).

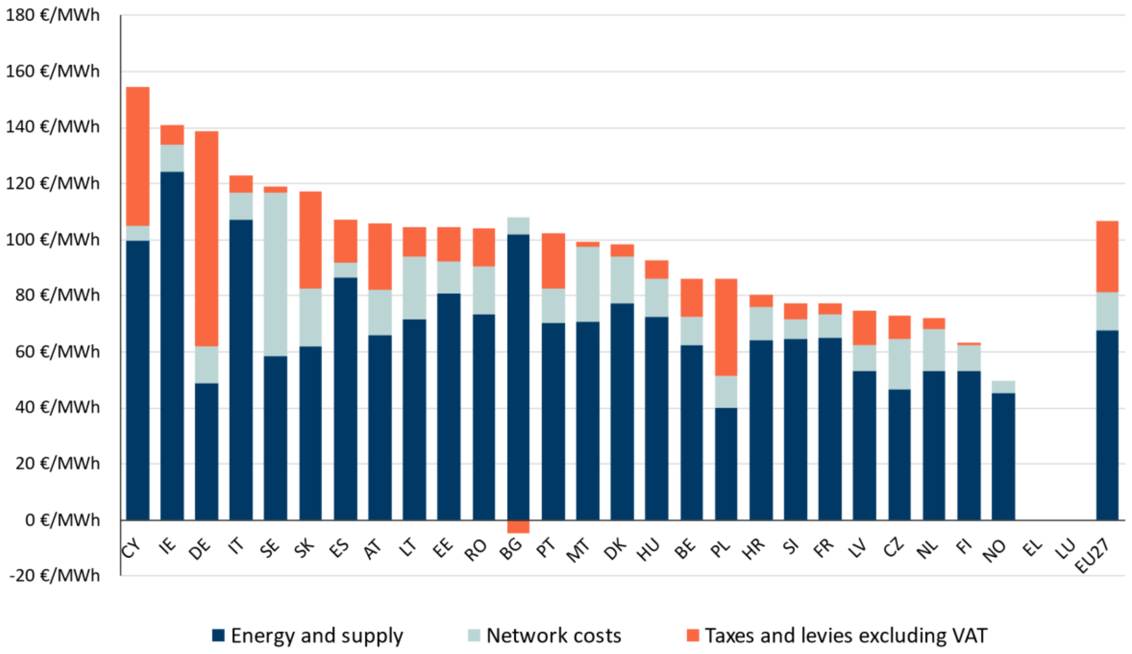


Figure 32: Industrial electricity retail prices in 2021 (IF band)
Source: Eurostat. Data for Greece and Luxembourg are either unavailable or confidential
Note: Bulgarian industrial consumers received a 55 EUR/MWh for two months in 2021, contributing in total to a negative tax component.[19]

Figure 33 shows that similar to prices in the ID band, the main driver of recent retail price changes is the energy component, while the tax component had a limited impact (not taking into account announced support measures for industry in 2022, which in some cases would lower taxes). The share of both components in the overall price ranges from 88% to 35% for energy (in Italy and Germany, respectively), and 55% to 2% for taxes (in Germany and Sweden, respectively).

[19] Euractiv (2021). Bulgaria to compensate companies for expensive electricity.

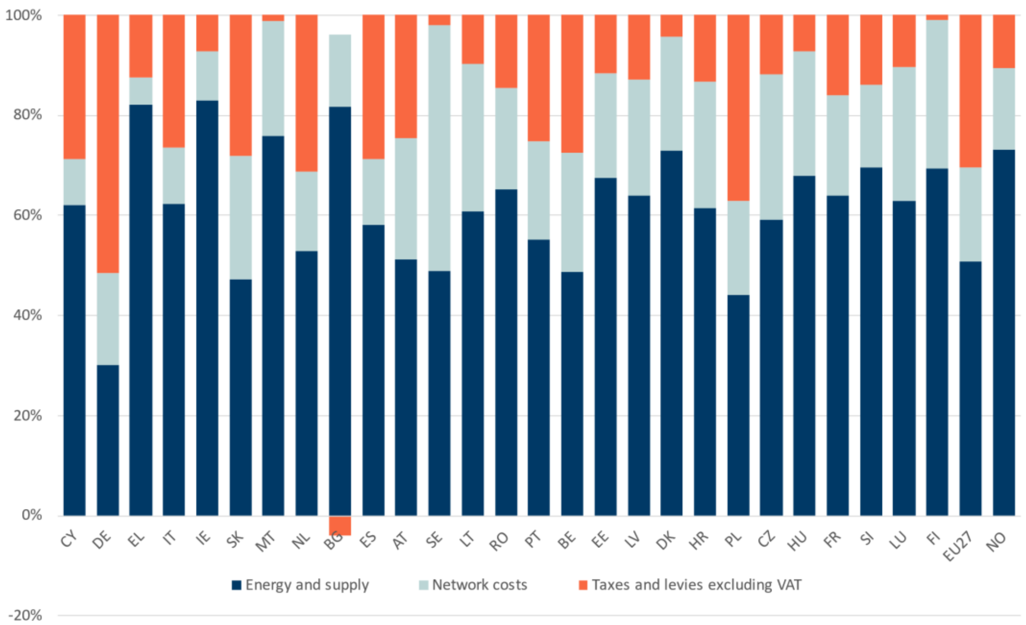


Figure 33: Relative composition of industrial retail electricity prices in 2021 (IF band; energy-intensive industry)

Source: Eurostat. Data for Greece and Luxembourg are either unavailable or confidential.

Recent developments in industrial electricity prices

Country level data is also now available for the first semester of 2022 from Eurostat (see Figure 34). Whilst the component level data is not yet available, the total price data already provides insights into the price developments in the first half of 2022. This shows that prices started to increase around July 2021 and have spiked in particular in Italy, Romania, Greece, Ireland and Cyprus, where prices are above 250 EUR/MWh. However, major increases can be observed across many more MS, which are pushing the EU average retail price up. Only in Finland, prices are notably flat.

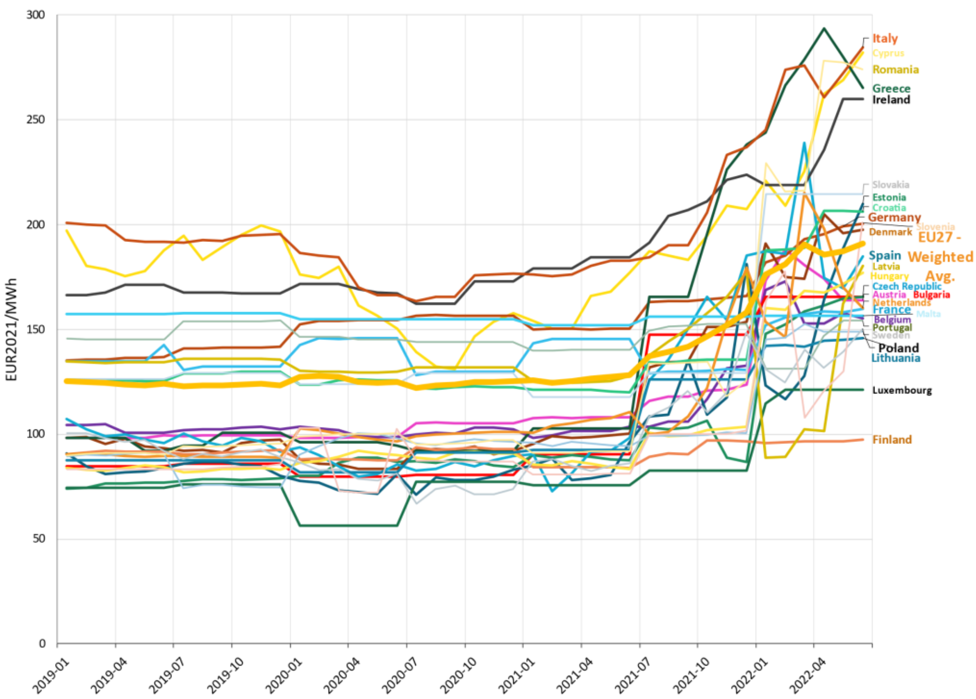


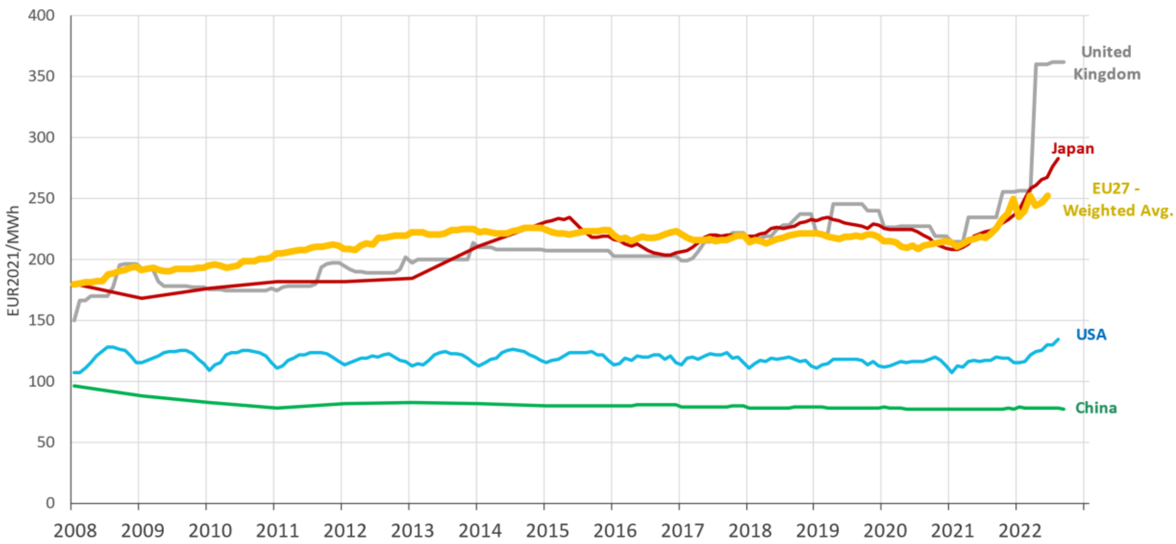
Figure 34: Average industrial retail electricity prices in the EU27, Jan 2019-Jun 2022
Source: Eurostat.

2.2.3 International comparisons

Whilst in the past wholesale electricity prices in the EU were often comparable to those in G20 countries, this price convergence did not always translate into comparable retail prices. Typically, EU prices were higher than in all G20 trading partners as a result of relatively higher levels of taxes and levies which, among other things, provide financing for the development of renewable energy, for energy efficiency measures and for other climate-related policies. Higher taxes have brought about higher retail prices but have also enabled the EU to become the leading force in combating climate change. However, as presented in section 2.2.3, EU wholesale electricity prices have now diverged from most of the G20 as the EU is, more than most other large economies, dependent on fossil fuel imports (especially gas), and therefore the energy crisis hits the EU particularly hard compared to its international trading partners. This section provides an overview of how the changes on the global energy markets have translated into retail electricity prices.

Household electricity prices

The two figures below show comparisons of household retail prices of EU27, China, Japan, the United Kingdom and the US as well other G20 countries (Australia, Brazil, Canada, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa, South Korea and Türkiye). Both graphs show that EU27 average prices generally are significantly higher than in the majority of the other countries displayed, with the exception of Japan, the UK and Australia, which have comparable or higher prices. From the figures, it is apparent that the impact of the energy crisis on wholesale prices has not yet fully translated into an increase in average retail prices in the EU, although further price increases are likely to follow.[20] Retail prices can also be seen to be increasing in Japan and the UK, following a similar, or in the case of the UK higher, trend than the EU. In 2022, retail price increases can also be observed in the US, Korea and Türkiye, however prices in China have not changed, these being fixed by government. In the case of Türkiye, in addition to higher energy prices a further driver is the significant depreciation of the Turkish Lira in this period due to ongoing economic and currency crises in Türkiye, which has resulted in increased prices being passed to Turkish households.



[20] Even though average prices have not yet increased significantly, for many individual households' prices could have increased significantly.

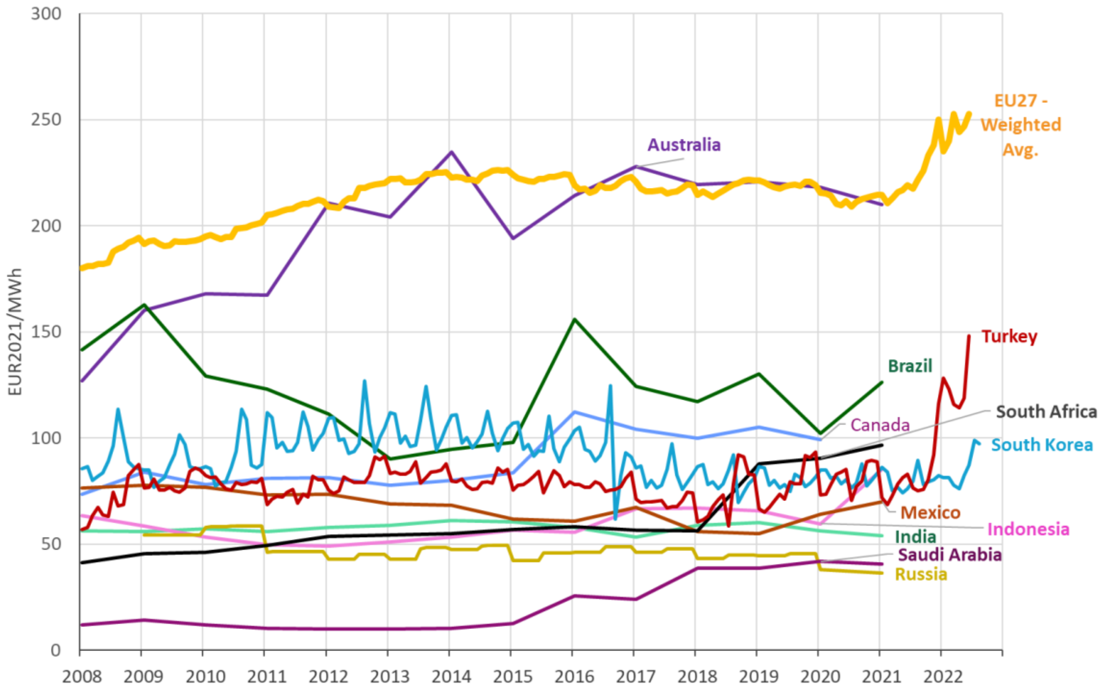
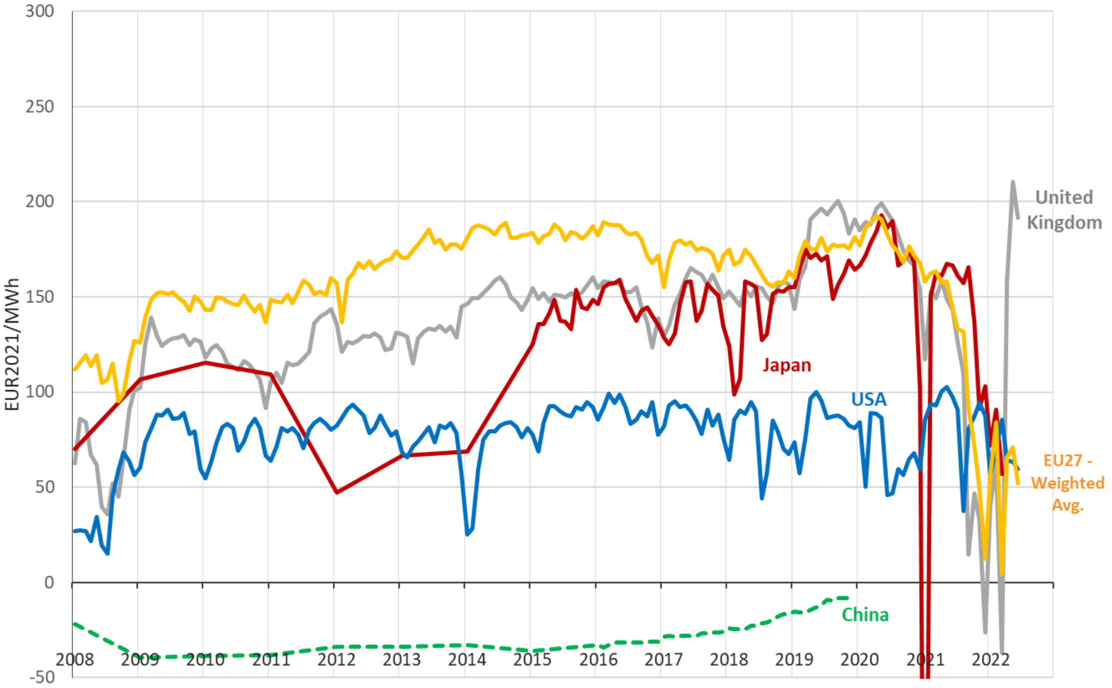


Figure 35: Household retail electricity prices in EU27, USA, UK, China and Japan and household retail prices in EU27 and other G20 countries, 2008-2022, EUR2021/MWh
Source: Eurostat, US DoE, Enerdata (NBS, E-Stats, BEIS, KESIS), IEA

As component level data is not available for the G20 trading partners, comparing household retail prices to wholesale prices can help as a proxy to understand the price drivers in these countries. The difference between wholesale and retail prices, or the impact of the regulated part of the retail price, is larger in the EU27 than in its G20 trading partners. Retail prices are below wholesale prices in some trading partner countries, indicating that prices are subsidized and regulated at low levels: consumers pay less than the actual cost of the electricity they use.

In Figure 36, a comparison of wholesale and retail prices is presented. This highlights that the EU and UK have always had a much higher difference between retail and wholesale prices than the US and other G20 countries. Differences in taxation are understood to be a major explanatory factor. Many of the G20 countries, particularly the industrializing economies, have retail prices fixed either very close to or below the wholesale price for electricity, for example in China and Mexico. The most evident change over the last 2 years is the massive decline in the difference with the EU27 average, UK and Japanese prices, highlighting that the increases in wholesale prices have not yet fed through into increases in the household retail prices, and that as noted before, negative margins emerge. The short price spike in Japan in December 2020-January 2021 already turned this comparison negative for a very short period. The UK has also seen this indicator turn negative twice in the last 12 months; the strains this illustrates are reflected in the market, with multiple bankruptcies among small- and medium-size energy suppliers[21]. In Korea, this indicator has typically always been close to zero, and in the past sometimes negative, however, the current price crisis has turned it sharply negative in the first half of 2022 before recovering. Within the EU, recent data shows that retail prices for households in 2022 are increasing significantly, which may increase the difference, mitigating strains for suppliers but placing additional burdens on households.

[21] ICAEW (2022). Energy supplier collapses highlight bigger sector crisis



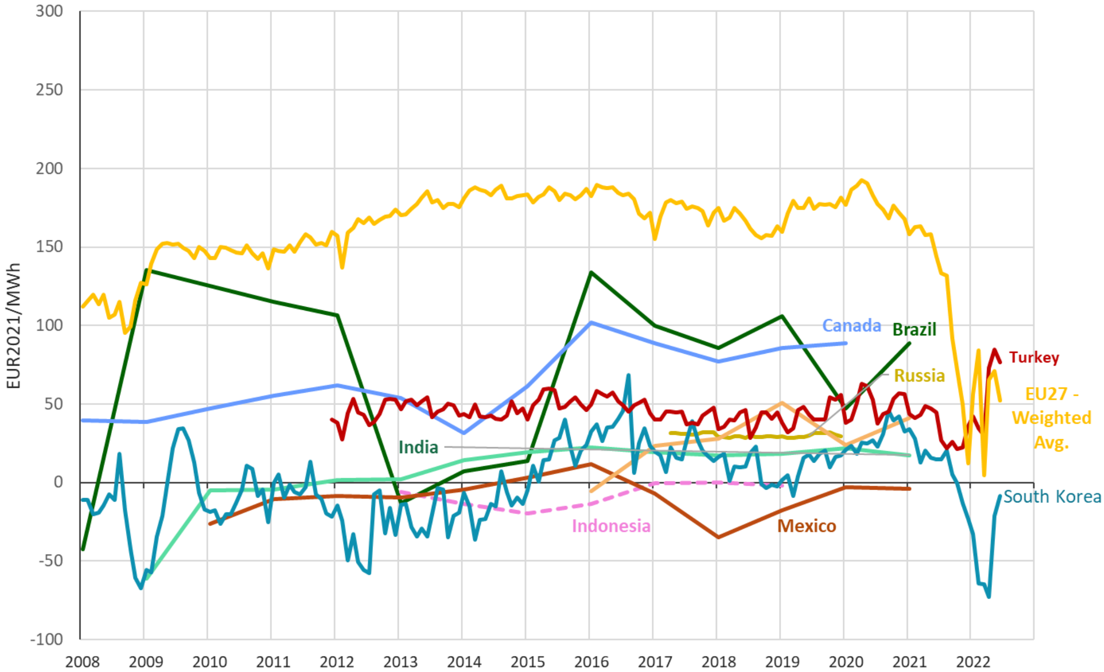
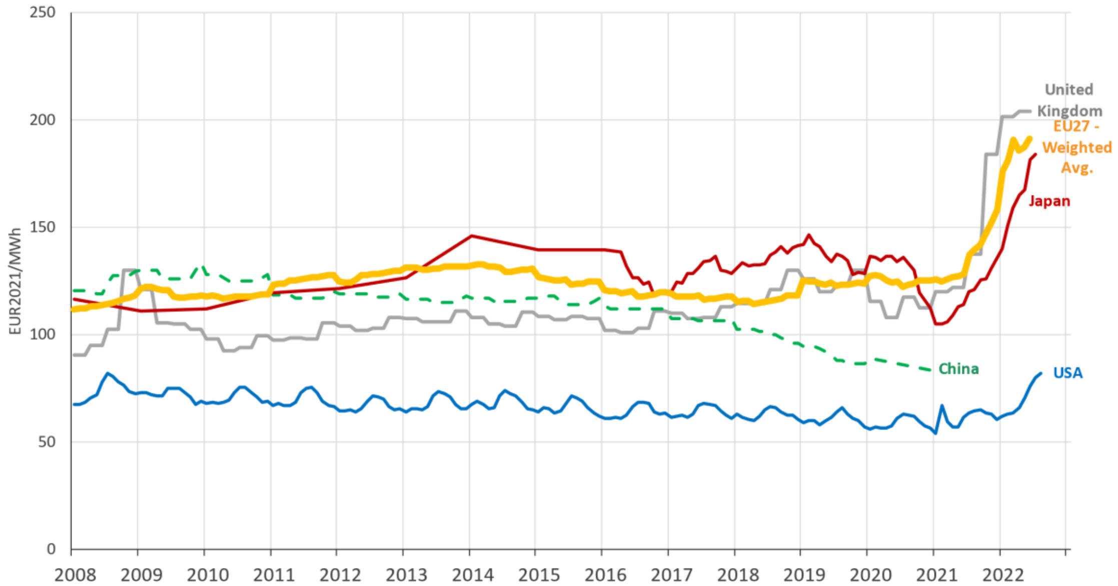


Figure 36: Difference between household retail electricity prices and electricity wholesale prices, 2008-2022, EUR_{2021}/MWh

Source: Authors calculation based on data from S&P Platts, Eurostat, US DoE, Enerdata (NBS, E-Stats, BEIS, KESIS), IEA.

Industrial prices

The figures below show the trends in industrial retail prices for the EU27 and other G20 countries in the period between 2008 and 2020/2022 (depending on data availability). In contrast to the household retail prices, the gap between industrial retail prices in the EU27 and the other G20 countries is less striking. Australia has the highest prices overall since around 2014, whilst Japan, the UK and EU27 average prices are at a similarly high level. Prices in the US are significantly lower than in the EU, as are prices in most of the rest of the G20, particularly the industrialising economies; although India and Brazil have prices only a little lower than the EU average. Since 2020, the upwards curve of EU average, UK and Japanese prices is clear. A similar trend is evident in Türkiye (as a result from both increasing energy prices, currency depreciation and inflation). In 2022, prices in the US have also started to trend upwards, as have prices in Korea, but these remain significantly below EU levels. In percentage terms, between January 2021 – June 2022 EU average prices (+231%) and US prices (+225%) have increased by very similar proportions, while in China — though detailed data is not available —price increases have been very limited.



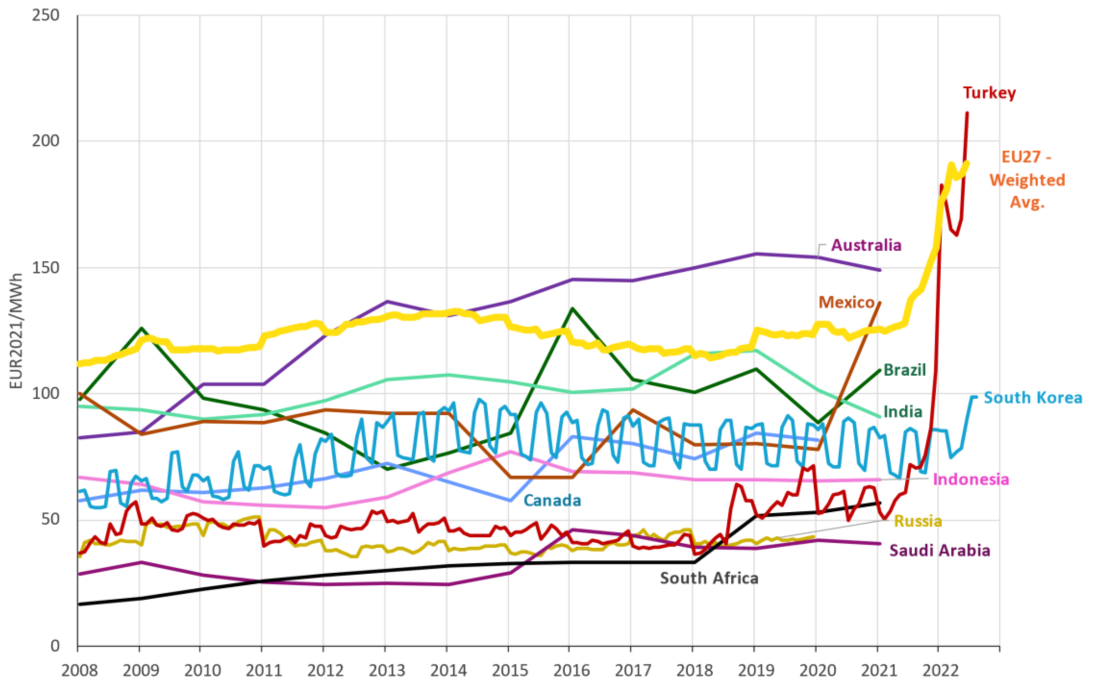


Figure 37: Industrial retail electricity prices in EU27, USA, UK, China and Japan (top) and industrial retail prices in EU27 and other G20 countries (bottom), 2008-2022, EUR_{2021}/MWh
Source: S&P Platts, Eurostat, US DoE, Enerdata (NBS, E-Stats, BEIS, KESIS), IEA.

A comparison of wholesale and retail prices for industry is presented below. This figure highlights that many of the G20 countries, particularly the industrializing economies, have retail prices fixed either very close to or below the wholesale price for electricity, for example in South Africa. The most evident change over the last 2 years is the massive decline in the difference in the EU27 average, UK and Japanese prices, each of which switched from net positive to negative in 2021-2022 highlighting the faster increase of wholesale prices than industrial retail prices in the same period. The latest data suggests these may have moved more in balance around mid-2022, as industrial retail prices adjust. The indicator in Türkiye is distorted by exchange rate movements. There appears to be no significant change in the US situation, where the difference is usually positive but occasionally turns negative.

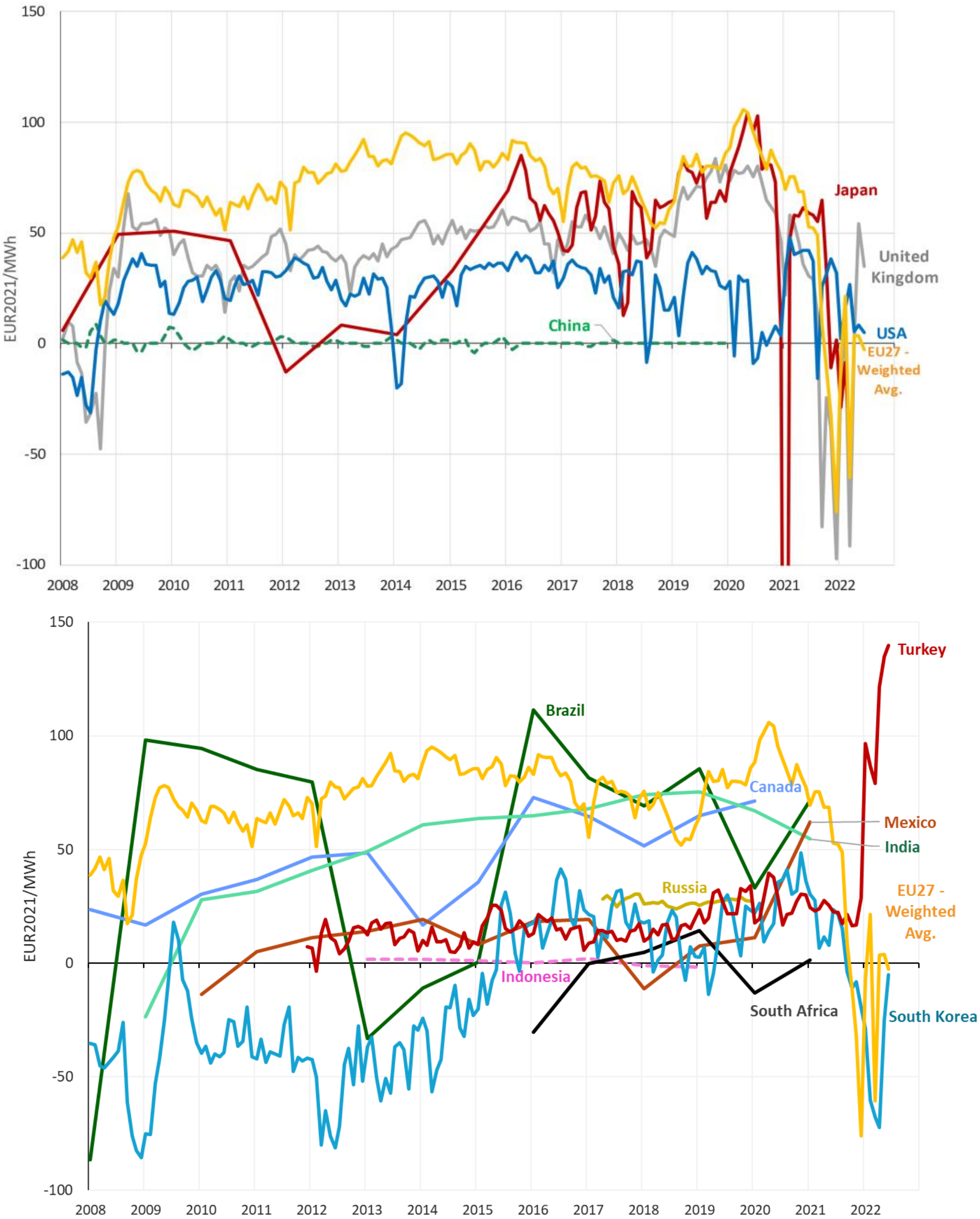


Figure 38: Difference between industrial retail electricity prices and electricity wholesale prices in EU27, USA, UK, China[22] and Japan (top) and other G20 countries (bottom), 2008-2022, EUR2018/MWh
Source: Authors calculation from S&P Platts, Eurostat, US DoE, Enerdata (NBS, E-Stats, BEIS, KESIS), IEA

[22] Note: In China most electricity is sold via bilateral contracts between generators and consumers. Hence, no real wholesale market exists and the average industrial retail price is used as a proxy for the wholesale price. As a result, in the figure retail and wholesale prices are the same in China.

3 Prices of natural gas

3.1 Wholesale gas prices

Main Findings

- In 2021, the wholesale gas price rose to historically high levels. First, prices rose mainly due to the increasing demand in relation to the loosening of Covid-19 restrictions, which led to a recovery in economic activity. Since the summer of 2021, limited spot gas supplies from Russia and increasing risks for supply disruptions combined with rising gas demand further drove prices up. By December 2021, the Dutch TTF hub prices reached 113 EUR/MWh (monthly average of day-ahead price); more than 3.5 times higher than the previous highest price since 2010.
- In early 2022, in response to further tensions with Russia following its invasion of Ukraine in February, the Dutch TTF hub prices reached a peak of 127 EUR/MWh in March and stayed very high as the war exacerbated instabilities in the energy market and restraints on energy supplies from Russia to Europe.
- Following the Russian invasion of Ukraine and significant curtailment of Russian pipeline gas supply to Europe, LNG imports have both increased in volume and also as a % of total European gas imports, in September 2022 accounting for more than 40% of the total.
- While very common in the past, oil-based gas price indexation is no longer common practice in Europe, except in some regions, particularly in the Mediterranean. Alternatively, hub pricing gained significant ground in Central Europe, Scandinavia and the Baltics: wholesale prices in these regions are increasingly aligned with Northwest European hub prices (in particular TTF), rather than with oil-indexed prices. In Europe, on average, the share of hub priced contracts increased to 80% of the total gas consumption in 2020, up from 15% in 2005.
- Compared to the global market, European wholesale gas prices are well above those in major gas producing countries (Canada, Russia, US) but in general lower than in other G20 economies, especially those which solely or largely rely on LNG imports (e.g. China, Japan, South Korea). However, the Russian invasion in Ukraine has led to an exponential increase in gas prices in Europe. This price trend is also experienced globally by other gas importing countries, especially those that are competing for the same LNG supplies. Strikingly high wholesale gas prices in 2022 were observed in China, Japan, South Korea and Mexico. Even prices in Canada (a major gas producer) have increased significantly, but to a lesser extent than in Europe.

3.1.1 Evolution of wholesale gas prices

From 2010 up until 2020, wholesale gas prices have remained close to 20 €/MWh. Extreme events (such as extreme weather conditions and supply disruptions) impacting specific regions have led to short periods of wider price ranges though.

In 2020 gas prices declined, mainly due to the Covid-19 pandemic which led to a significant reduction in industrial demand for gas, accompanied with higher shares of renewable energy sources further reducing gas demand for electricity production. As a result, in May 2020, the wholesale gas price on the Dutch TTF hub dropped to 3.4-3.5 EUR/MWh, the lowest level since the hub started trading.

Simultaneously, the crude oil market (see Chapter 7) also experienced a supply and demand shock in 2020, as the major oil producers in the OPEC+ bloc could not come to an agreement on production adjustment until April 2020. Coupled with the reduction in demand due to the Covid-19 pandemic, this led to a significant oversupply of oil and a considerable drop in oil prices, which also influenced the wholesale gas market.

In 2021, the wholesale gas price rose considerably, partially due to increasing demand in relation to the post-Covid-19 economic recovery. Additionally, colder weather conditions in spring drove up demand and the uncertainty around the commissioning of the Nord Stream 2 pipeline drove gas prices up. In addition to these 'visible' factors, Russian state-controlled Gazprom created 'artificial scarcity' in gas supply, including not refilling their gas storages in NWE and not offering spot gas deliveries on the European market. The intention behind these actions was to push up European gas prices and to influence the permitting process for Nord Stream 2[23].

In 2022, wholesale gas prices continued to increase, mainly reflecting the impact of the Russian invasion of Ukraine on natural gas trade. Russia's responses to European sanctions (which are not directly targeting natural gas) are a significant driving factor behind the price increases. Many EU countries are still dependent on Russian natural gas imports and Russia either directly cut natural gas supplies or imposed such conditions that led to gas export restrictions.

It is important to note that long-term contracts, for example for Russian imports, have gradually been adapted by replacing the oil indexation clause with gas hub-based pricing, which resulted in more competitive prices for gas consumers, especially in Central and Eastern Europe. However, this effect has been reversed as a result of the gas price crisis.

Regional wholesale price differences are largely explained by the different pricing mechanisms and the different levels of competition. In general, markets with multiple import sources (e.g. several gas pipelines and access to LNG) and several importers show a lower price level than markets with only one supply source.

[23] IEA (2022). Gas Market Report Q3 2022.

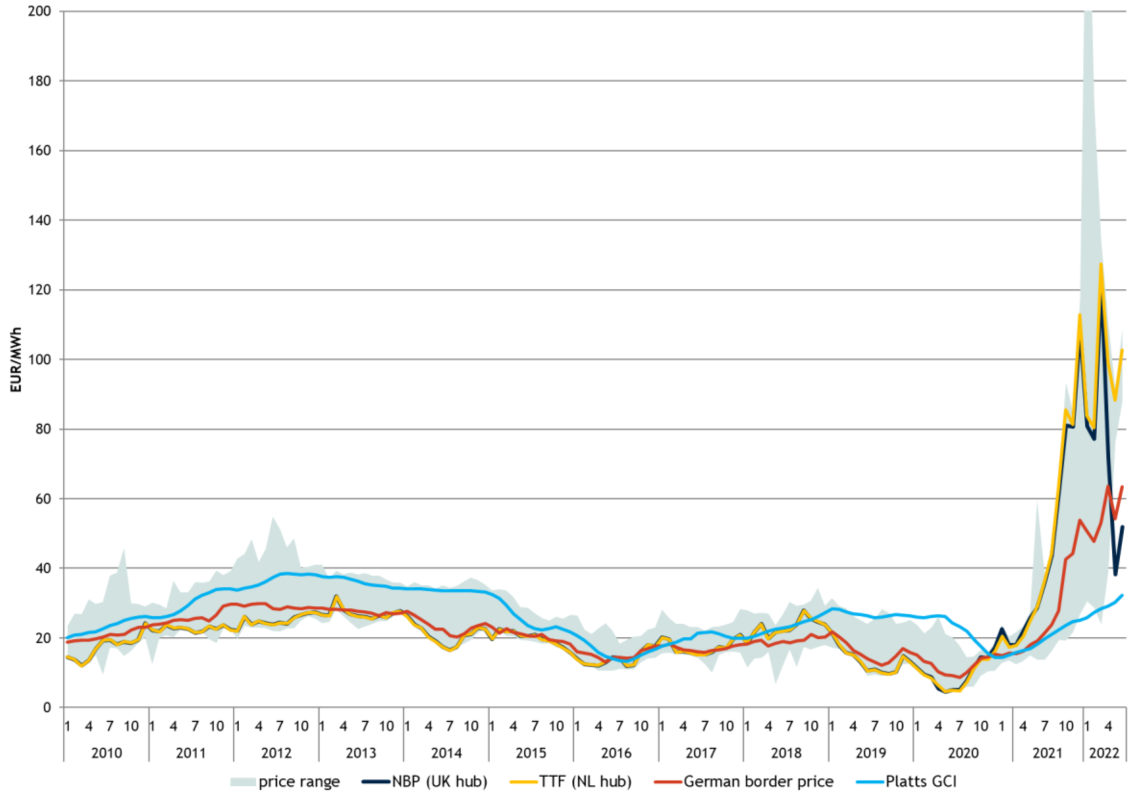


Figure 39: Selected wholesale gas prices in Europe, nominal prices.
Source: S&P Platts, EnergyMarketPrice, BAFA, Eurostat Comext

Figure 40 shows the difference between the S&P Platts North West Europe Gas Contract Indicator (GCI) and the Dutch Hub price (TTF). The GCI is a theoretical index showing a gas price linked 100% to oil. Therefore, it can help to compare gas prices on hubs with oil-indexed gas prices. From 2010 until 2020, GCI prices generally showed a premium compared with hub-based prices. Oil-indexed gas contracts were thus less favourable and helped spur a shift to hub-based prices within the EU (see Figure 41). However, since 2021 the premium of oil-indexed contracts turned into a huge discount, because of slower increase of oil-indexed contracts compared to gas hub prices. In the first 3 semesters of 2022, the average discount of oil-indexed contracts amounted to 93 EUR/MWh, with peaks up to 190 EUR/MWh in August. Typically, crude oil price changes appear in the oil-indexed contracts with a time lag of 6 months, while TTF hub prices react more instantly to market developments. This time lag is expanded by the slower and more moderate increase of oil prices compared with gas prices in 2021 and 2022. Therefore — as oil-indexed contracts slowly start incorporating recent oil price hikes — it is expected that the GCI discount will gradually decrease.

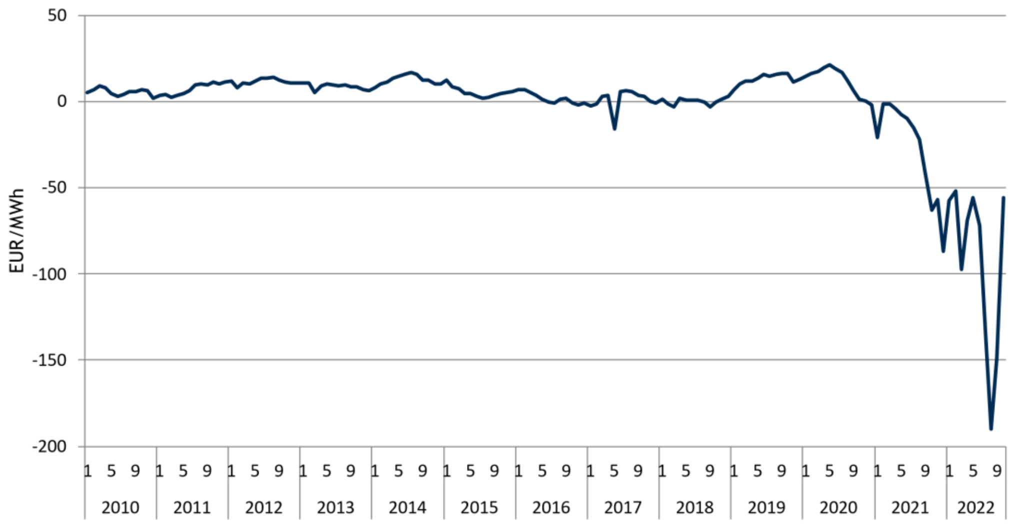


Figure 40: The difference between the S&P Platts Northwest Europe Gas Contract Indicator (GCI) and the Dutch hub price (TTF)
Source: S&P Platts

Figure 41 and Figure 42 provide an overview of the development of wholesale gas price formation over time and across regions. In Europe, the share of gas-on-gas competition rose from 15% to 80% between 2005 and 2020, but this share varies from region to region. One main driver for this development is the continuously lower hub prices than the prices of oil-indexed contracts (oil-based escalation) until 2021.

In North-Western Europe[24], gas-to-gas competition has become the general practice, with 96% of the total gas contracts (measured by consumption) in 2020, compared to 27% in 2005. In other parts of Europe, gas-to-gas competition was very limited in 2005, whereas in 2020 its share was 84% in Central Europe[25], 66% in Scandinavia and the Baltics[26] and 66% in Southeast Europe[27]. In the Mediterranean region[28], gas-to-gas competition had the lowest share in 2020, around 53%.

Simultaneously to the gradual phasing out of oil-price indexed gas contracts since 2005, the use of other forms of price formation, such as bilateral monopolies or regulated contracts (e.g. regulation of costs of service, political and social regulation, etc.) has also declined.

The world average share of gas-to-gas competition was 49% in 2020 and oil price indexation represented 19%, whereas bilateral monopolies and diverse forms of price regulation had the remaining share (32%). With its share of gas-to-gas competition of 80%, following North America, Europe is the second region in the world in terms of the penetration of hub-based pricing. In Asia and Asia-Pacific, oil price escalation is still predominant, with a share of 63% in 2020. High shares of oil-price indexation impact the gas price differential between Europe and Asia, which can be a crucial factor determining if LNG will be supplied to Europe or Asia, depending on where the bid price is highest. In Russia and other countries of the former Soviet Union (FSU), Africa, Latin America and the Middle East, price regulation was still the dominant contract form in 2020.

[24] Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, UK
[25] Austria, Czechia, Hungary, Poland, Slovakia, Switzerland
[26] Estonia, Finland, Latvia, Lithuania, Norway, Sweden
[27] Bosnia, Bulgaria, Croatia, North Macedonia, Romania, Serbia, Slovenia
[28] Greece, Italy, Portugal, Spain, Turkey

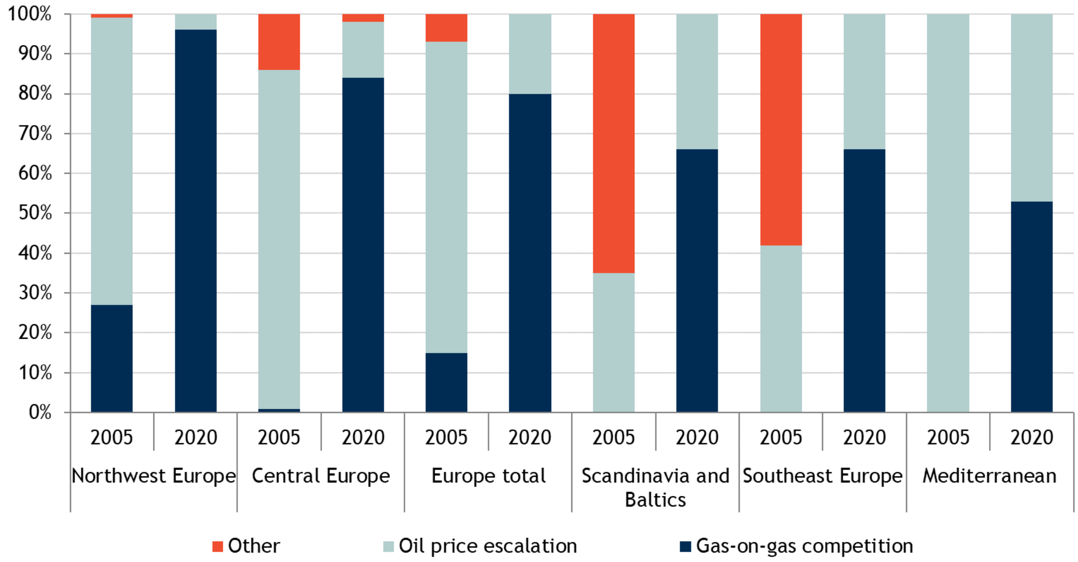


Figure 41: Price formation in Europe
Source: IGU Wholesale Gas Price Survey, 2020 Edition
Northwest Europe: Belgium, Denmark, France, Germany, Ireland, Netherlands, UK
Central Europe: Austria, Czechia, Hungary, Poland, Slovakia, Switzerland
Mediterranean: Greece, Italy, Portugal, Spain, Türkiye
Southeast Europe: Bosnia, Bulgaria, Croatia, FYROM, Romania, Serbia, Slovenia
Scandinavia & Baltics: Estonia, Finland, Latvia, Lithuania, Norway, Sweden
Other includes bilateral monopoly, netback from final product, regulated cost of service, regulated social and political, regulated below cost, no price available

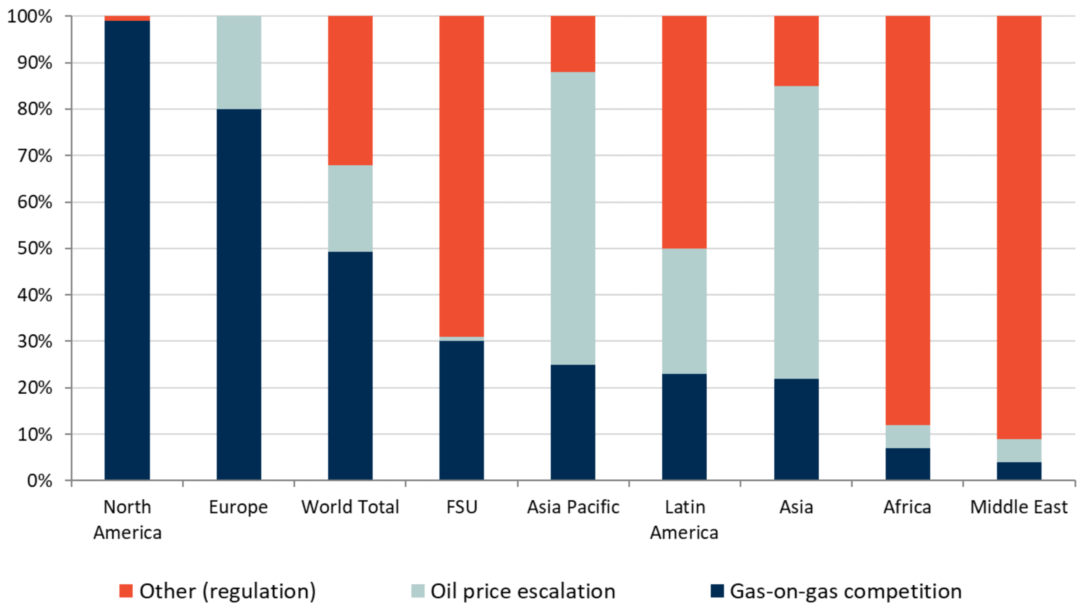


Figure 42: The role of different price formation methods in different regions in the world
Note: FSU = Former Soviet Union
Source: IGU Wholesale Gas Price Survey, 2020 Edition Other includes bilateral monopoly, netback from final product, regulated cost of service, regulated social and political, regulated below cost, no price available

The monthly average prices depicted in Figure 39 hide a high degree of daily volatility. For short periods, daily prices can reach exceptionally high levels, typically when cold snaps sharply increase demand while supply is limited by infrastructure constraints or other factors. Figure 43 shows that a few such occasions occurred over the last twelve years. Cold spells occurred in February 2012, March 2013 and January 2017, resulting in rapidly increasing demand for heating needs. This was, on several occasions, combined with lower availability of other generation sources in the electricity sector (e.g. nuclear or renewable energy sources). Generally, high price peaks occur more often at the end of winter, when gas storages are depleted.

On the other hand, extreme low prices can also occur, when demand for gas falls unexpectedly: this was the case in the first half of 2009 and in the first half of 2020, when gas demand fell due to lower industrial activity. In these periods spot prices showed abrupt falls, however, looking at quarter-ahead or year-ahead contracts, we notice that the forward prices fell less steeply, showing that such unexpected changes in demand are mainly affecting the spot market. Moreover, Figure 43 also shows that gas hubs in the EU show very similar price patterns (besides the local price spikes) and prices do not differ that much.

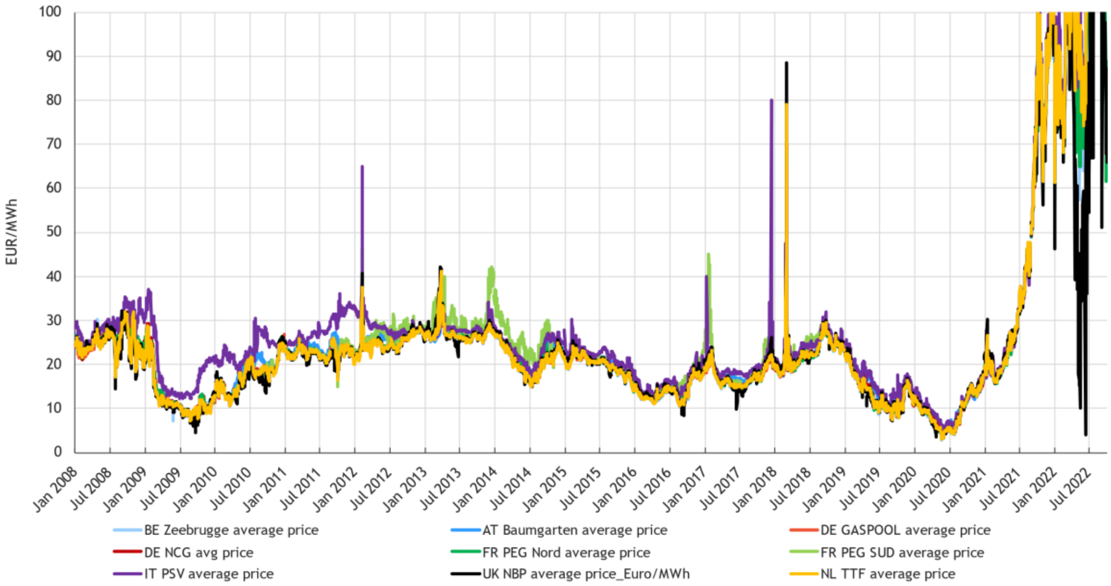


Figure 43: Daily day-ahead prices at selected gas hubs from 2008 to 2022, with y-axis going to 100 EUR/MWh, thereby not displaying many higher price levels since 2021.
Source: S&P Platts

As illustrated at the right hand side of Figure 44, price developments since 2021 are of a different magnitude than those before. This figure illustrates that on all gas hubs gas prices rose considerably and showed similar price patterns, with comparable price peaks on all hubs in December 2021 and March 2022 (after the Russian invasion of Ukraine).

However, since April 2022, day-ahead prices have started to diverge between some gas hubs. Average day-ahead prices in the period April to September 2022 were comparable on the Dutch TTF, Italian PSV, German THE and Austrian Baumgarten (between 150 and 153 EUR/MWh). However, the Belgian Zeebrugge hub (114 EUR/MWh), French PEG Nord (109 EUR/MWh) and British NBP (83 EUR/MWh) showed significantly lower prices, which is a trend not seen in the previous 10 years. This can mainly be explained by increasing LNG imports to substitute gas pipeline imports from Russia. Hubs directly connected with ample LNG import capacity (e.g. France, Belgium, the UK, and Spain) show considerably lower prices than markets that do not have direct access to LNG terminals, because transport of regasified LNG to other markets is constrained by limited gas interconnectors.

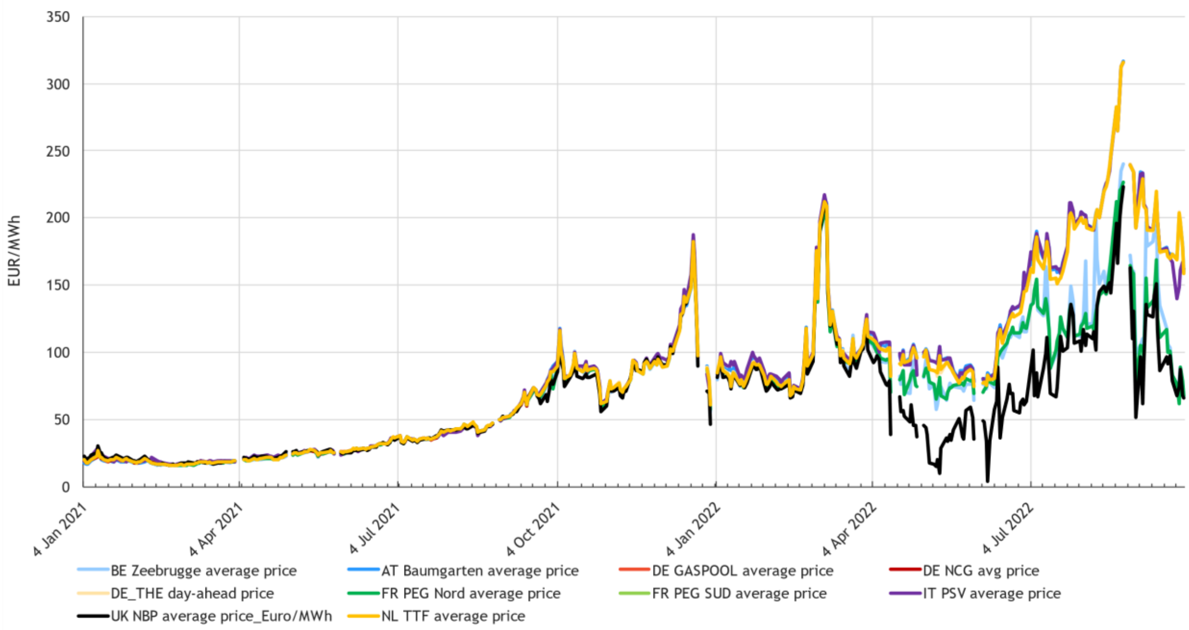


Figure 44: Daily day-ahead prices at selected gas hubs from 2021 to 2022, zooming in on recent price developments.
Source: S&P Platts

3.1.2 Factors impacting the evolution of wholesale gas prices

The development of wholesale gas prices is influenced by factors such as gas demand for power generation and industry, heating-related needs, the filling level of gas storages, the amount of pipeline and LNG imports etc. As the gas demand and prices are also affected by price developments of other fuels (in particular oil) and weather conditions, we look in this section into these impacts, and also present the latest developments of the European LNG imports.

There is obviously a correlation between oil and gas prices, which is most visible in periods of large volatility of energy commodity markets (e.g. steep price falls or hikes). However, as it was already mentioned, the gas market is now less directly influenced by oil prices, owing to the increasing role of hub pricing and LNG imports.

By definition, there is a strong correlation between oil and oil-indexed gas prices, as shown in Figure 45 which depicts the evolution of the Brent oil price and the S&P Platts North West Europe Gas Contract Indicator (GCI), a theoretical index showing what a gas price linked 100% to oil would be. Typically, there is a 6-9 month time lag in the pricing formulas used which means that oil-indexed gas prices react to changes in the oil price with a delay. For example, the steep fall in Brent crude oil prices in March-April 2020 was only reflected in oil-indexed gas prices in August-September 2020. Similarly, oil-indexed gas prices started to significantly increase again only since March 2021 while oil prices started increasing already in August 2020. This is not to be confused with hub-based gas prices. Hub gas price increases were most likely also one of the drivers for the increase of oil prices, which subsequently also influenced the oil-indexed gas prices.

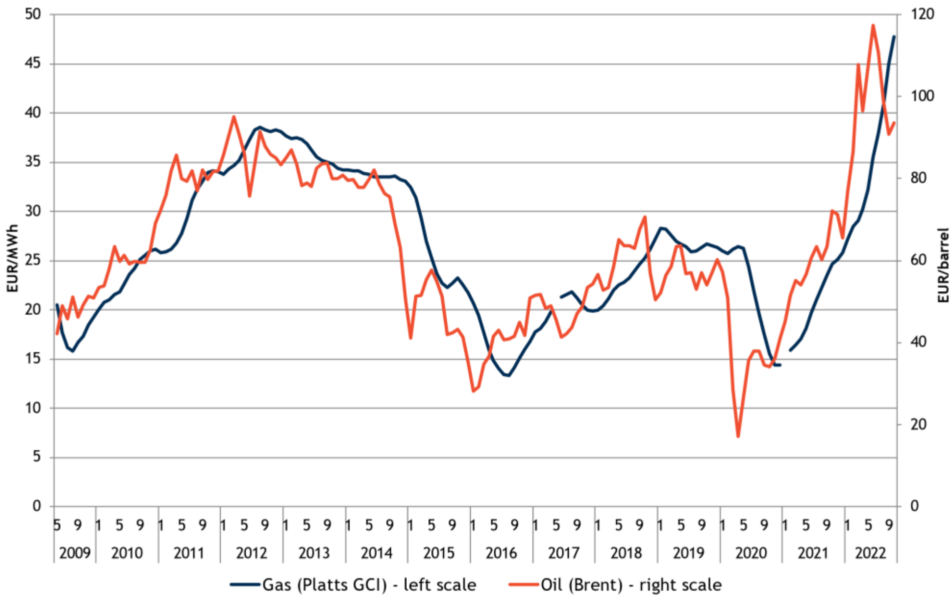


Figure 45: The monthly average price of oil (Brent) and oil-indexed gas contracts (S&P Platts GCI)
Source: S&P Platts

The correlation between oil and gas prices generally holds for European gas hub prices, as shown in Figure 46 through the example of the Dutch TTF, Europe's most liquid hub. Therefore, whilst oil-indexed prices have a diminishing role in the European market (see section 3.1.1), hub prices typically continue to be impacted by the oil price, reflecting the close relationship between the gas market and the wider energy complex, also reflecting the macro-economic situation. However, this relationship has broken down in the context of the current energy price crisis, with gas prices surpassing oil prices since summer 2021 when the current gas price crisis began. Oil prices have also trended upwards but not by nearly as much. It is unclear if the previous relationship will reassert itself in future or if the current crisis marks a more significant, permanent delinking of oil and gas prices.

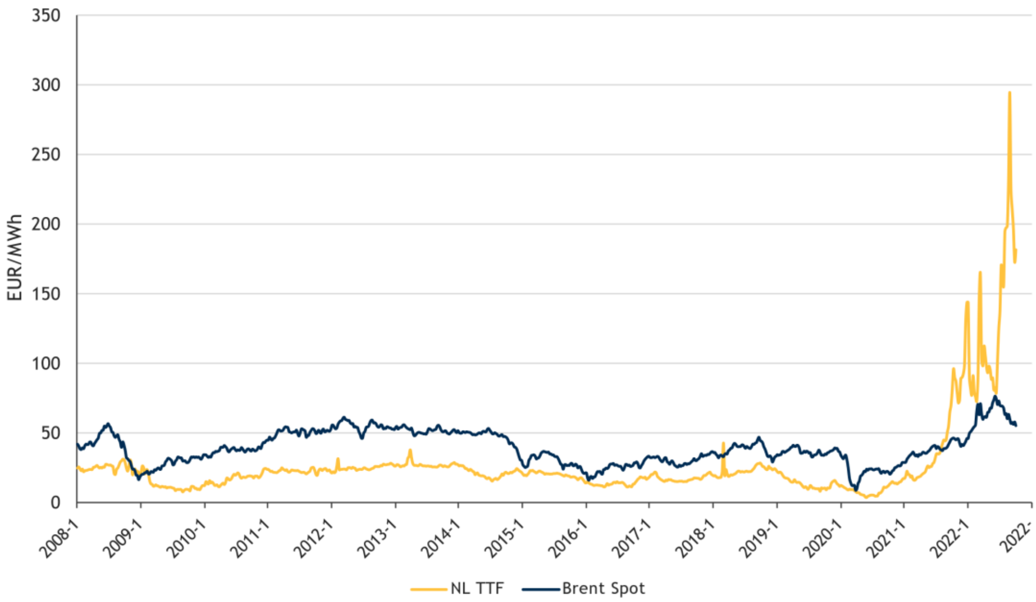


Figure 46: Daily spot prices of oil (Brent) and gas (at the Dutch TTF hub)
Source: S&P Platts

Measured in energy content, oil has traditionally been more expensive than natural gas, owing to higher energy transformation costs (and transformation losses) and lower combustion efficiency in power generation. This was the case since 2008, with some short period of exceptions when sudden falls in oil price resulted in comparable or lower costs in energy content compared to natural gas. Between the beginning of 2008 and mid-2020, the price of Brent (measured in EUR/MWh) was on average 95% higher than the price of gas at the TTF hub. In 2019, the gas price fell significantly, and this ratio rose to peak at 4.2 in mid-2020. However, the gas price crisis has completely reversed this situation, with the steep increase in gas prices at the TTF hub quickly outpacing the more moderately rising Brent oil prices and leading to oil prices being about half the price of gas in 2022 (measured in EUR/MWh); a quite dramatic example of the extreme current situation.

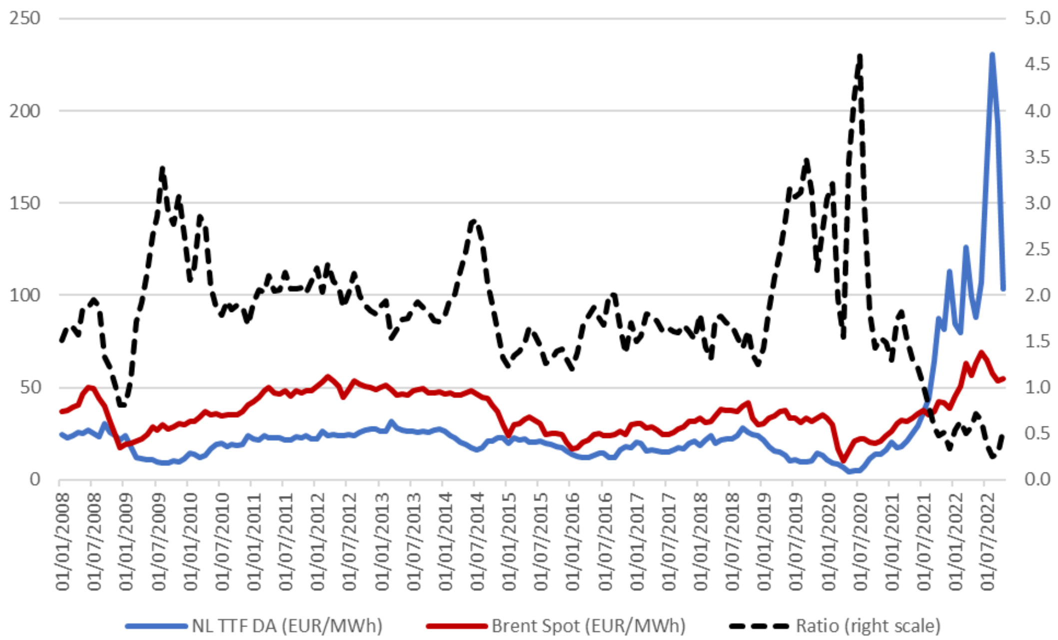


Figure 47: The monthly average price of oil (Brent) and gas (at the Dutch TTF hub), measured in €/MWh
Source: S&P Platts
Note: a conversion rate of 1.7 MWh/barrel was used for Brent

As the next chart (Figure 48) shows, there has been an increase in liquefied natural gas (LNG) imports from 2014 to 2019, to cover the gas demand in the EU. In the early 2000s, LNG imports in the EU showed a significant increase due to LNG regasification terminal investments in many European countries (e.g. Spain, Italy, France, UK, Netherlands and Belgium). However, in 2011, in the aftermath of Fukushima nuclear incident in Japan, increasing gas demand for power generation (in replacement of nuclear generation) in Japan, led to substantially increased LNG demand and prices in East Asia, developing a considerable price premium to Europe and ensuring higher profitability for LNG producers to sell their gas in Asia, rather than in Europe. Consequently, between 2010 and 2015 LNG imports into the EU plummeted. As of 2016, as a result of the sharp production increase of shale gas, the US joined the LNG exporting countries, while Russia opened a major new LNG terminal at Yamal in 2017; both contributed to increasing LNG supply on the global market[29]. This increase in LNG supply outpaced the increase in LNG demand, which resulted in decreasing LNG prices and re-convergence of different regional (US, European, Asian, South-American, etc.) price benchmarks.

[29] the key suppliers are Qatar, Australia, US and in recent years (until the invasion), Russia

From 2019 to 2021, net LNG imports into the EU declined from 86 bcm to 73 bcm, with a consequential decline of the role of LNG in total gas imports/consumption within Europe. The decline in LNG imports in 2020 and 2021 is partially explained by the decline in demand due to the Covid-19 pandemic. Additionally, several LNG shipments to Europe were cancelled and re-routed to Asia where higher prices could be found.

During 2021, LNG imports increased every month — though starting from a very low level during the Covid-19 lockdowns — and this trend has continued in 2022 (not visible in graph), to partially compensate for the decreased Russian pipeline imports and to further fill up gas storages before the 2022/2023 winter. As a result, in Q1 2022 LNG imports were 72% higher than in Q1 2021 and this trend has continued until September 2022 (source: EC Gas market report Q1).

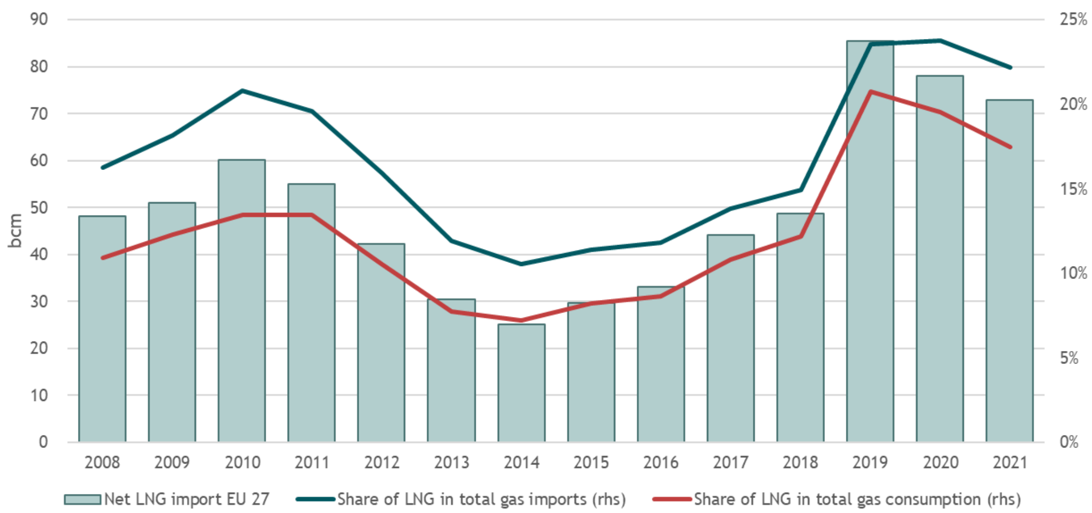


Figure 48: LNG imports and their share in the EU-27 total gas imports and consumption
Source: Eurostat

Figure 49 provides an overview of the main extra-EU import sources of LNG. From 2011 to 2016, the main LNG exporters to the EU were Qatar, Algeria and Nigeria. However, from 2019 onwards, the United States and Russia have played an increasing role.

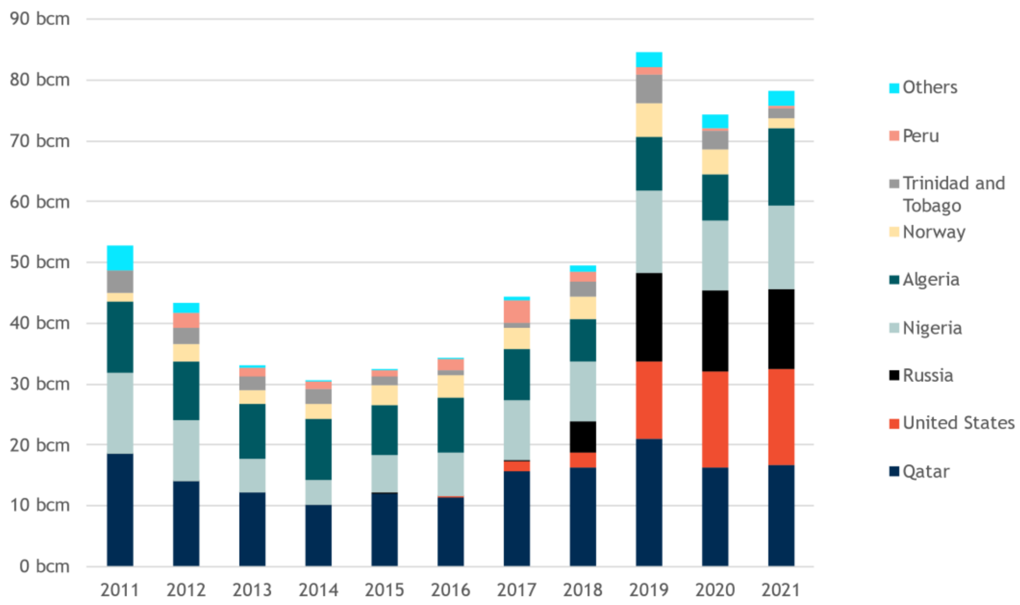


Figure 49: Main extra-EU import sources of LNG
Source: Authors calculation with Eurostat data.

The two biggest LNG importer countries in 2021 in the EU were Spain (25% of the total EU imports) and France (20%). LNG imports were also significant in the Netherlands, Italy and Belgium, having shares respectively of 13%, 12% and 11% of total EU imports. LNG imports could also be observed in Portugal (6%), Poland (5%), Greece (3%), Croatia (2%) and Lithuania (2%).

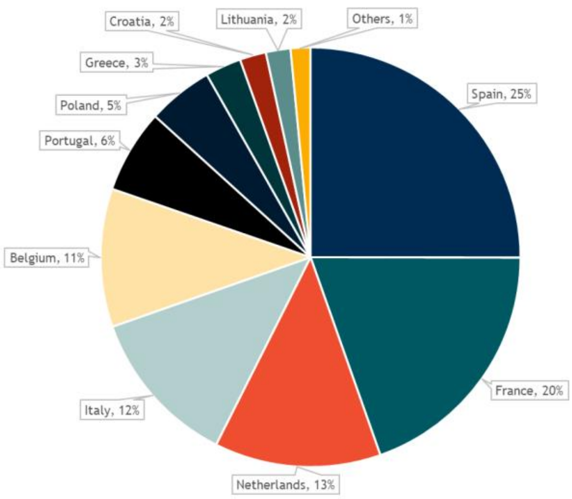


Figure 50: Main EU LNG importer countries in 2021
Source: Eurostat.

With declining pipeline imports from Russia, increased LNG imports are one of the main supply alternatives to meet gas demand. Figure 51 shows total gas imports in the EU from 2020 until October 2022. In 2022, imports from Russia have steadily declined which has also led to decreasing total imports.[30] However, the decreasing imports from Russia are (partially) compensated by a steadily increasing LNG supply during 2022. The share of LNG in total EU gas imports jumped from levels below 30% (from June 2020 to Dec-2021) to 40 to 45% in September 2022. In addition, the graph shows that LNG supply has

[30] Bear in mind that this graph only shows imports. Local production and re-export of gas is not included.

increased in 2022 compared to 2021, but during 2022, the LNG import level has stayed steady. This is the result of most LNG import terminals currently operating at full capacity, making it impossible to further scale-up LNG imports in the short-term.

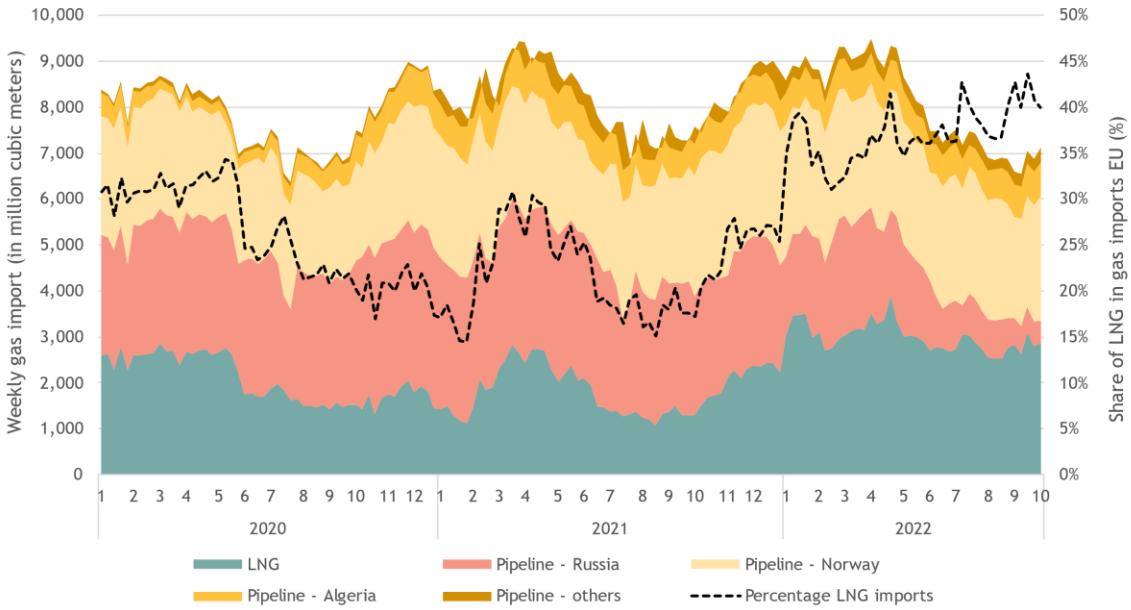


Figure 51: Weekly natural gas imports to the EU from 2020 until September 2022 from the main pipeline export countries as well as LNG.
Source: ENTSO-G, via Bruegel data extract.

3.1.3 International comparisons

Comparing European gas wholesale prices with those in the EU's main trading partners provides insights into how energy costs can influence the international competitiveness of energy-intensive industries, which are also trade-intensive. Even though energy prices are only one element of the energy costs of industries, besides consumption and efficiency data, they make an important part of such analysis.

A comparison of EU, US and Japanese prices provides an insight into comparative developments in prices, the absolute prices and ratio between the prices is presented below in Figure 52 and Figure 53. These show that the EU and Japanese prices typically move in close to tandem, with Japanese prices a fraction higher than EU prices. This is with the exception of one period from 2011 to 2014 where Japanese gas prices were significantly higher compared to the EU and US prices as a result of the Fukushima nuclear accident and the impact this had on power generation in Japan. US prices have consistently been lower than both since 2010 as a result of the US shale gas revolution resulting in abundant domestic gas supply and limited export capacity, leading to low prices in the US. As US LNG export capacity grew since 2018, the EU TTF price started to converge to the US Henry Hub, reaching parity around summer 2020 at the peak of the pandemic.

However, since summer 2020 prices already began to diverge again and since summer 2021 this divergence accelerated as the EU (and Japanese) prices both increased rapidly for reasons discussed earlier. As a result, EU-US prices have diverged to their highest ever historic levels (in this timeframe) with US prices between 3-10 times less than EU prices. The ratio relationship with Japan has also been affected, from Japanese prices typically being higher than EU prices in the past, but since 2022 the reverse being true, with Japanese prices now being lower. Exchange rate movements are not an explanatory factor – as the yen has devalued more strongly against the US dollar than the Euro has in the last year – which would actually support the opposite trend. The main explanation is the severe impact on European supplies of the Russian invasion leading to a supply squeeze, and a price premium willing to be paid in the EU compared to Japan to secure LNG supplies.

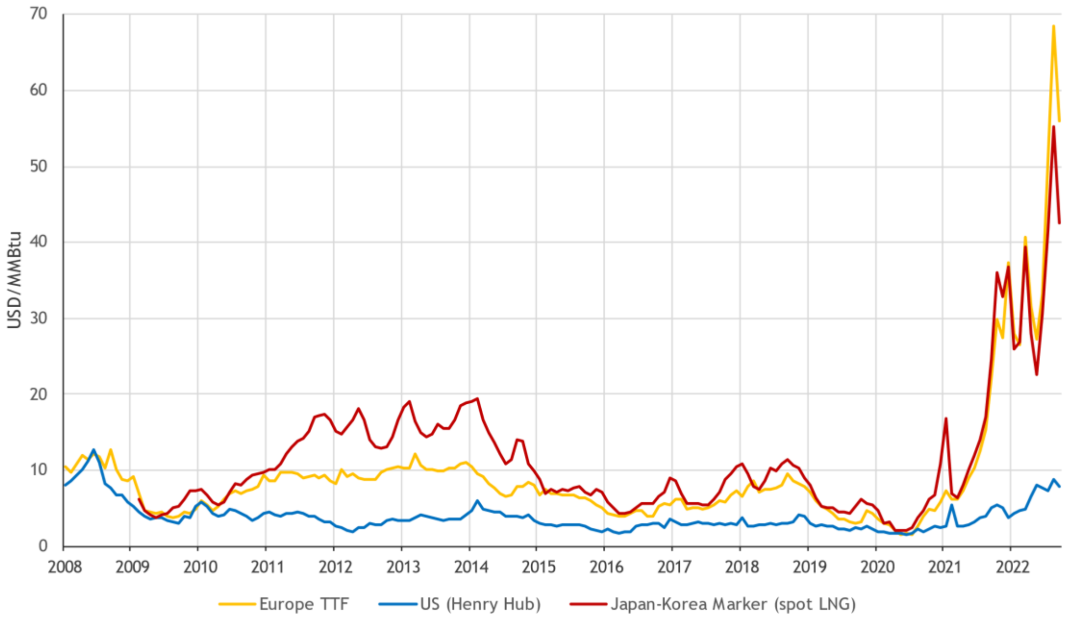


Figure 52 - Comparison of European, US and Japanese day-ahead wholesale gas prices.
Source: S&P Platts.

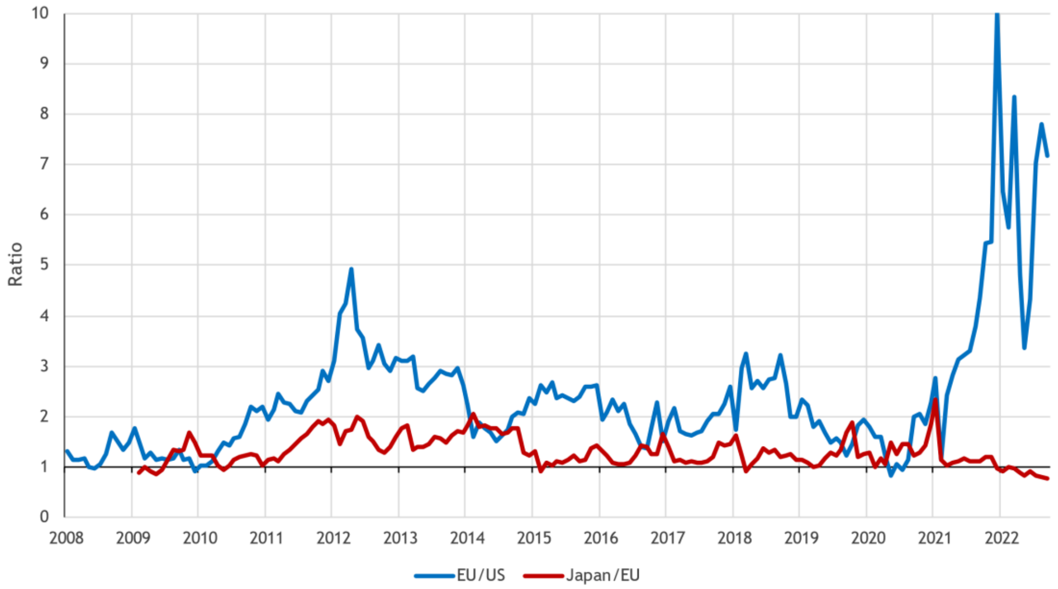


Figure 53: The ratio of European, US and Japanese wholesale gas prices
Source: S&P Platts.

Figure 54 and Figure 55 provide a comparison of the EU27 weighted average wholesale gas prices with those of the EU's major trade partners. The disparity in prices from 2011 to 2014 between the US and the other countries is due to the reduction in crude oil prices in 2014-2016 (as wholesale gas prices were more closely indexed to oil prices in many regions). Starting from 2021 onwards, gas prices have increased exponentially in many countries, in addition to the EU, also in China, Japan, the UK, South Korea, Mexico and Indonesia. Gas prices in the non-EU countries are closely tied to global LNG prices, and in the UK, the gas prices are very closely aligned with the EU prices due to market integration. The gas price increases had emerged already during 2021 and continued into 2022 with the Russian invasion of Ukraine. Wholesale prices in non-producing countries tend to be more volatile; this was also evident in 2021-2022.

In countries where gas is produced at large scale, such as Canada, Russia, Australia and the US, wholesale gas prices are much lower than in non-producing countries. Amongst these major producers, prices in Australia and Canada have increased in 2021, and have also increased in the US as domestic supplies tightened due to increased exports. Price increases in each of these countries are much lower than in the most affected countries. Price increases in Russia have been very limited.

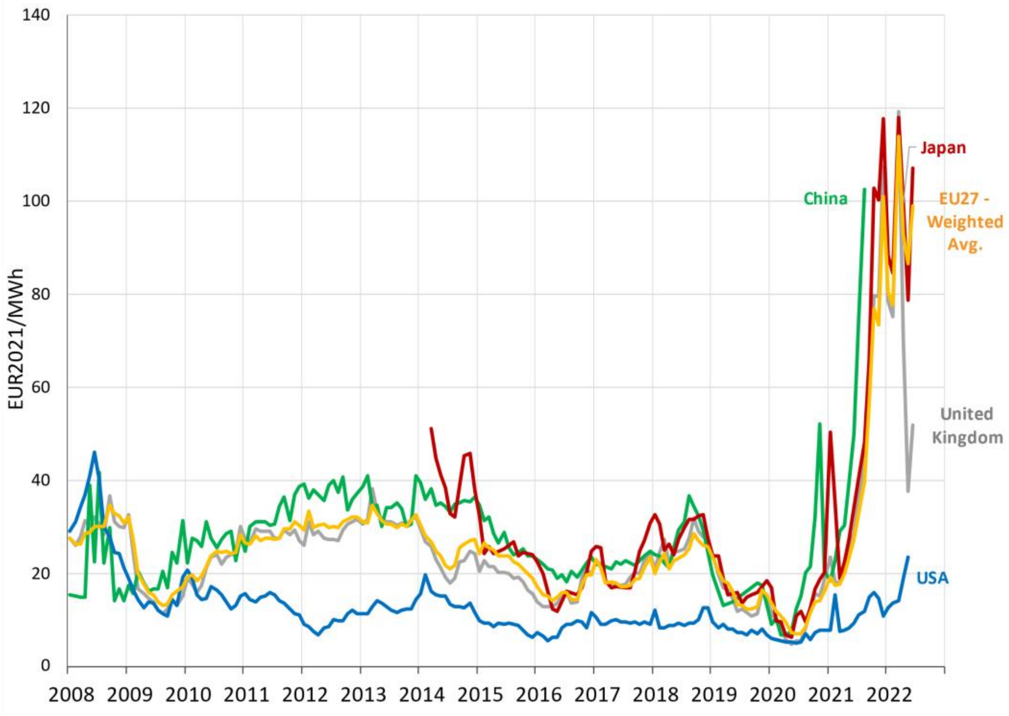


Figure 54: Day-ahead wholesale gas prices in the EU (weighted average), China, Japan, UK and the USA
Source: S&P Platts, World Bank, Energymarketprices.

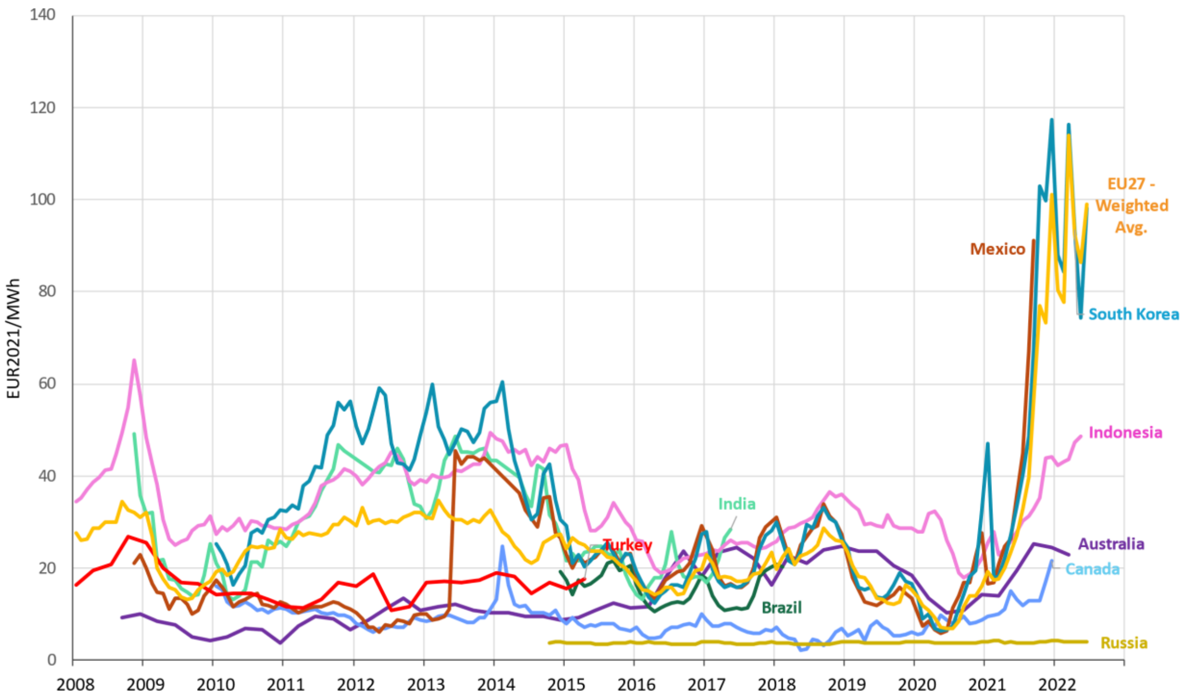


Figure 55: day-ahead wholesale gas prices in the EU (weighted average) and major G20 trading partners
Source: S&P Platts, World Bank, Energymarketprices, IMF, Enerdata (SPIMEX, AER).

3.2 Retail prices

Main Findings

- Natural gas retail prices are mainly determined by the development of wholesale gas prices, albeit with a time lag (see also section 3.4). Thus, retail gas prices in 2021 did not (yet) increase with the same magnitude as wholesale prices, representing both the time lag before changes in wholesale prices are incorporated in retail prices as well as recent policies aimed at mitigating retail price increases for (lower income) households.
- Households on average pay a higher price for gas than businesses: retail gas prices were 68 EUR/MWh on average in 2021 in the EU, whereas in the same year, medium and large industrial gas consumers had to pay 42 EUR/MWh and 41 EUR/MWh, respectively.
- Retail gas prices for household consumers increased by 1.8% annually from 2010 to 2021, whereas the price for medium-level industrial consumers increased by 2.6% annually and by 4.8% annually for large industrial consumers. The inflation rate in the EU, measured by the Harmonised Index of Consumer Prices, amounted to 1.5% annually in the same period.
- The **energy component** (i.e. commodity price) of household prices increased by 0.5% between 2010 and 2021 annually, whereas for industrial consumers, it went down by -0.4% for I3 consumers and went up by 3.3% for I5 consumers annually.
- **Network charges** increased for all the three consumer types: for households network charges went up by 2.0% annually, whereas for medium and large industrial customers they rose respectively by 2.3% and 1.0% annually between 2010 and 2021.
- The **tax component** for both households and industrial customers increased significantly, by 3.6% annually for households, while for medium and large industrial customers by 15.6% between 2010 and 2021.
- The impact of taxation on natural gas prices is gradually increasing. Taxes made up 34% of household bills, 30% and 22% of the bills for medium and large industrial customers, respectively.

- For households and industrial consumers, the share of VAT and environmental taxes are the highest within the total taxation elements. Contrary to electricity, renewable energy-related taxes have a much lower importance in the taxation of gas.
- In 2021, the ratio of the most expensive and the cheapest gas price within the EU27 was 3.5 for household customers[31], whereas for medium and large industrial customers it amounted to 3.2 and 2.6, respectively. This difference in household prices is further exacerbated by differences between countries in the speed with which changes in wholesale prices are incorporated in retail prices. In 2021, the impact of rising wholesale prices was still limited for households, but in 2022 this will further lead to differences between Member States, also depending on the level and type of price regulation or temporary policies that aim to reduce household energy bills in 2022.
- Looking at the international comparison of retail gas prices, industrial prices follow wholesale prices more quickly and completely, whereas in the case of household customers, retail prices in some countries are lower than the wholesale prices, reflecting both potential lags in adjustment, and also subsidies for household gas prices.

Table 1: Key figures on the evolution and drivers of retail gas prices between 2010 and 2021

Consumer type	Household (D2)			Industrial (I3)			Large industrial (I5)		
Component	Annual growth	Share 2021	Δ Share	Annual growth	Share 2021	Δ Share	Annual growth	Share 2021	Δ Share
Energy	+ 0.5%	44%	- 6 p.p.	- 0.4%	57%	- 22 p.p.	+ 3.3%	74%	- 12 p.p.
Network	+ 2.0%	23%	+ 0 p.p.	+ 2.3%	13%	+ 0 p.p.	+ 1.0%	5%	- 2 p.p.
Taxes	+ 3.6%	34%	+ 6 p.p.	+ 15.6%	30%	+ 22 p.p.	+ 15.6%	22%	+ 14 p.p.
Total	+ 1.8%	100%	-	+ 2.6%	100%	-	+ 4.8%	100%	-

Source: Authors calculation from Eurostat.
Note: table only shows data until 2021. Wholesale price increases in 2022 increase the energy component in the price.

Scope of the chapter

Following the Regulation (EU) 2016/1952, this report analyses prices of natural gas sold to consumers that purchase gas for their own use. Therefore, prices paid by consumers that purchase gas for electricity generation in power plants or for non-energy purposes (e.g. for use as feedstock in the chemicals industry) are not considered.

Household gas prices are available for 24 EU Member States in the database of Eurostat. Data is only lacking for 3 member states with no or very limited natural gas use: gas is not used in Malta and Cyprus, while in Finland the share of gas in final energy consumption of households is below 1.5%[32].

In the other 24 Member States, gas is an important energy carrier. In 2020, natural gas accounted for 32% of the final energy consumption of households[33]. The Netherlands has the highest share of natural gas for energy consumption in households (68% in 2020), followed by Italy (52%) and Hungary (51%). In contrast, residential gas use in several Member States such as Poland (18%), Denmark (14%) and Spain (24%) is significantly lower due either to alternative heating fuels, e.g. coal in Poland, or lower heating demand.

[31] Excluding Sweden where gas is very expensive, but hardly used.
[32] Regulation (EU) 2016/1952 lays down that reporting in such countries with negligible gas use is not required. However, some countries with low gas use, e.g. Sweden, still choose to report.
[33] Source: Eurostat

3.2.1 Household gas prices

The following chapter compares natural gas prices paid by household consumers across the EU, whose annual consumption falls in the range of 20 to 200 GJ (5.56 to 55.56 MWh). This consumption band is defined by Eurostat as D2. This is the most representative consumption band in most of the EU countries.

Evolution of household gas prices

Household retail gas prices increased by 1.8% annually from 2010 to 2021. In absolute terms, the EU average price increased from 56 EUR/MWh to 68 EUR/MWh during this period. This increase is higher than the inflation rate, which averaged 1.5% annually during the same period. In 2021, Hungary reported the lowest (31 EUR/MWh) and Sweden the highest price (213 EUR/MWh, but household gas use in Sweden is negligible. The ratio of the highest to lowest price was 3.5 in 2021 (Denmark and Hungary) if we exclude Sweden because of its negligible gas use.

Composition of household gas prices

The composition of gas prices has gradually changed over time. In 2021, the energy component, which predominantly consists of the wholesale price (plus a mark-up), accounted for 44% of the final price, whereas in 2010, it accounted for 50% of the final price. In absolute terms, this component increased at an annual rate of 0.5% and reached almost 30 EUR/MWh.

The share of the network component has remained relatively stable, only increasing from 22% (2010) to 23% (2021). In absolute terms, the network part of the final price increased at an annual rate of 2.0% and added up to 15.4 EUR/MWh in 2021.

The share of the taxes component increased from 28% in 2010 to 34% in 2021. In absolute terms, taxes on household use of natural gas increased at an annual rate of almost 4% and added up to about 23 EUR/MWh in 2021.

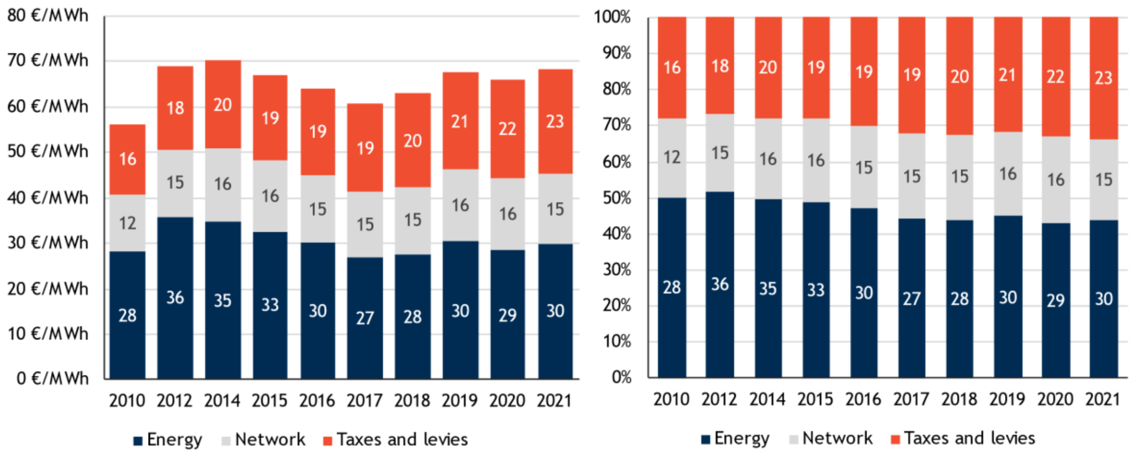


Figure 56: Composition of the EU household gas price (D2)
Source: Eurostat.

On average in the EU, natural gas taxes made up 34% of the final gas price in 2021. Although VAT on natural gas used for household purposes has remained stable from 2019 to 2021, the amount of environmental taxes has increased, from 42% in 2019 to 46% in 2021. Support costs for renewable energy, which have a relatively limited impact on household gas prices, make up 4% of the total taxes. Other taxes (i.e. capacity and other taxes) account for another 4% of the total taxes. Taking into account that total taxes represent 34% of final household gas prices, VAT, environmental taxes, renewable taxes and other taxes make up 16%, 16%, 1% and <1%, respectively. From 2019 to 2021, taxes of household gas prices increased by 8% in the EU, mainly driven by the increase in environmental taxes.

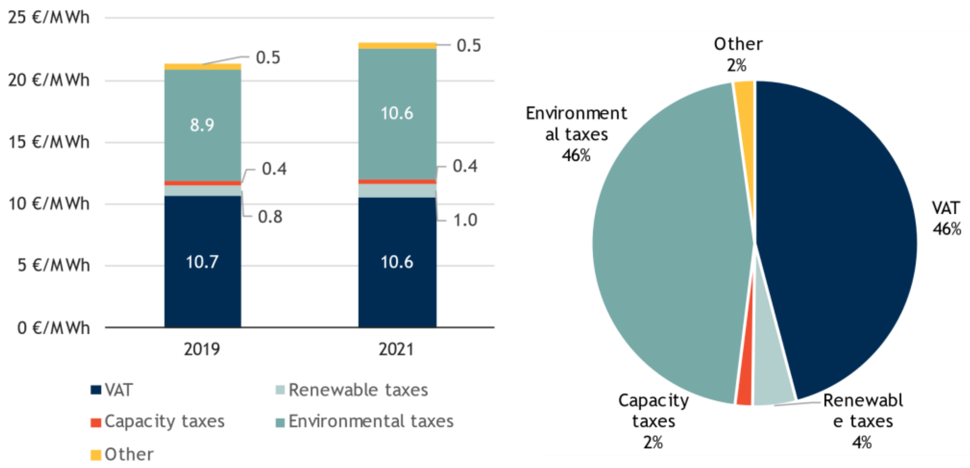


Figure 57: Change in the composition of EU taxes on household gas prices between 2019 and 2021 and the composition in 2021
Source: Eurostat.

Situation in individual Member States

In 2021, the three highest household gas prices were in Sweden (213 EUR/MWh), Denmark (107 EUR/MWh) and the Netherlands (101 EUR/MWh). The high prices each of these are partially driven by higher tax components. In Sweden, this is attributed to a carbon tax that aims to reduce greenhouse gas emissions, and a very small gas network, which leads to a higher contribution of the network costs. High household gas prices in Denmark and the Netherlands are mainly due to high tax rates on household natural gas consumption. For the Netherlands, the high tax rate however is accompanied by a fixed tax refund on the energy bill, which lowers the total tax expenditure per household. In Denmark, taxes make up 50% of the gas price, and in the Netherlands, taxes make up 61% of the gas price. The lowest taxes are in Greece, making up only 6% of the total gas price and adding up to 4.6 EUR/MWh.

The share of network costs is the highest in Spain (38%) and Slovakia (38%). In absolute terms, the highest network costs are in Sweden. The lowest network costs are in Czechia: 4.8 €/MWh and 9% of the final gas price.

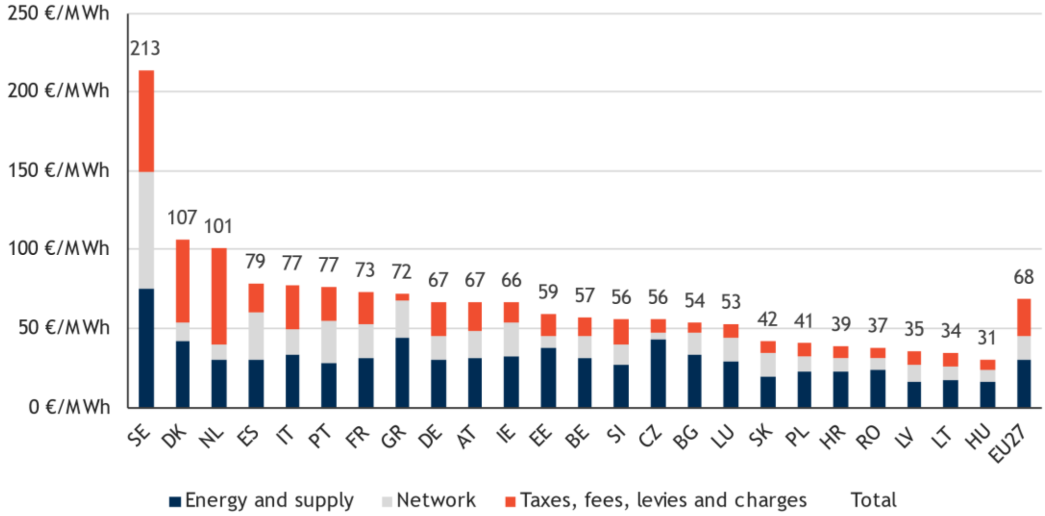


Figure 58: Average household gas prices in 2021.
Source: Eurostat.

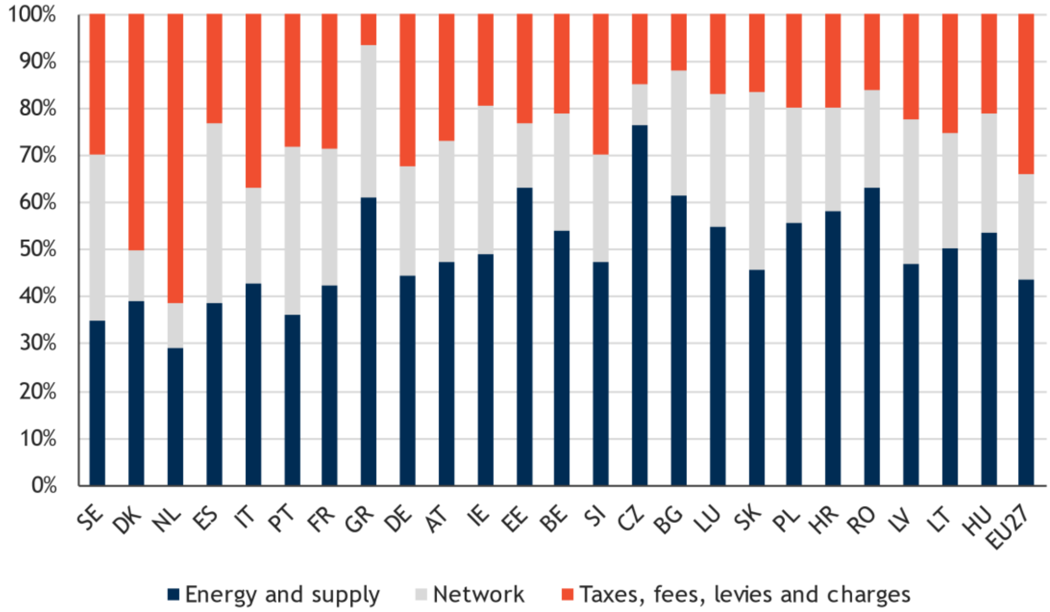


Figure 59: Average composition of household gas prices in 2021
Source: Eurostat.

Recent developments in household gas prices

Country level data is also available for the first semester of 2022 from Eurostat (see Figure 60). Whilst the component level data is not yet available, the total price data already provides insights into the price developments in the first half of 2022. EU average gas prices increased from 65 EUR/MWh in June 2021, to 88 EUR/MWh in June 2022, an increase of 23 EUR/MWh (+35%). This proportional increase is higher than the equivalent for electricity retail prices, although the price per MWh remains far lower for gas than for electricity. The figure also shows that prices have spiked in particular in Sweden, Denmark, Estonia and the Netherlands over the last 12 months. Prices have remained relatively flat in some countries, such as Hungary and Croatia, due to regulated prices.

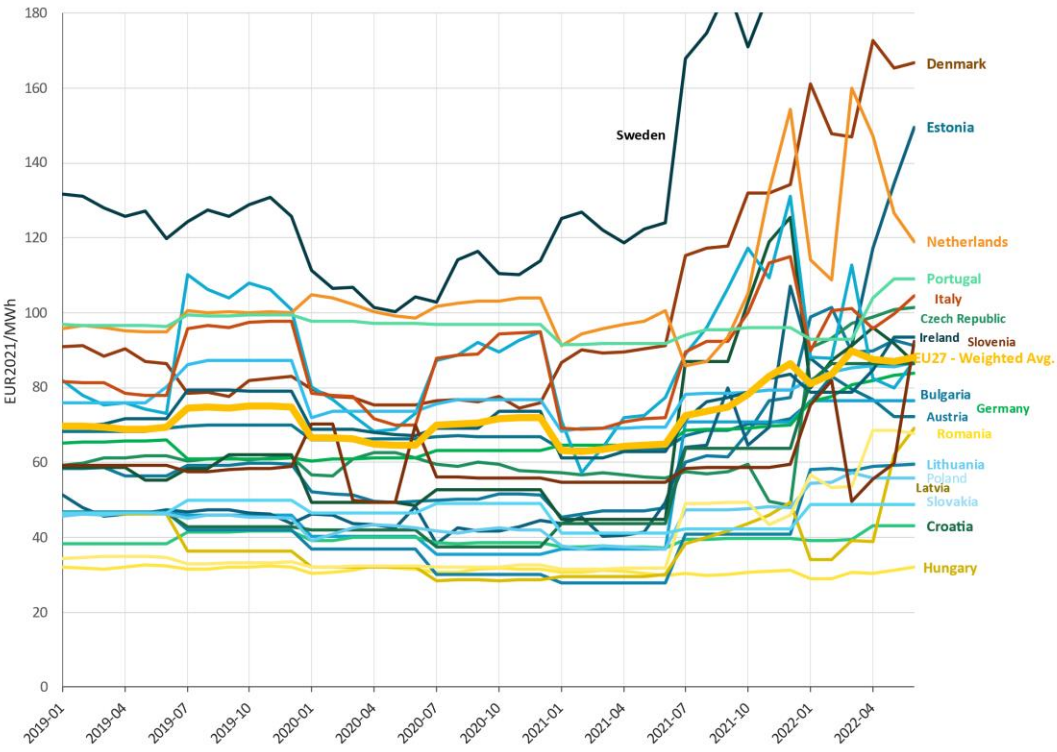


Figure 60: Average Household retail gas prices in the EU27, Jan 2019-Jun 2022
Source: Eurostat.
Note: Prices in Sweden gradually increased to 250 EUR/MWh in June 2022.

3.2.2 Industrial natural gas prices

This section compares gas prices paid by industrial consumers with medium and large annual consumption. Eurostat defined medium industrial consumption as band I3, covering annual consumption volumes between 10,000 and 100,000 GJ (2,778 MWh and 27,778 MWh). Large consumption is defined as band I5 covering annual consumption between 1 million and 4 million GJ (277,778 to 1,111,111 MWh). Medium industrial (I3) prices were available for 25 EU Member States (with the exception of Cyprus and Malta). Large industrial prices (I5) were reported by 19 EU Member States (in addition to Cyprus and Malta, no data was available for Greece, Croatia, Latvia, Lithuania, Luxembourg and Slovenia, primarily owing to data confidentiality reasons and/or limited consumption).

Evolution of industrial gas prices

For the I3 band, average prices fluctuated between 29 and 38 EUR/MWh between 2010 and 2020; average prices in the I5 band were lower at between 22 and 31 EUR/MWh. Looking at the price trend, industrial prices with medium consumption (I3) showed an annual increase (+2.6%), though lower than the average annual increase for large consumers (+4.8%). These high annual growth rates are mainly influenced by the recent increase in prices in 2021. Inflation during the same period averaged at 1.5% annually, implying that contrary to household customers, industries faced gas price changes greater than the inflation. In absolute terms, the I3 price gradually rose from 32.1 to 42.4 EUR/MWh by 2021. The I5 price increased from 25.1 to 41.9 EUR/MWh from 2010 to 2021.

In 2021, Spain and Belgium reported the lowest I3 price (34 EUR/MWh) and Sweden the highest (106.5 EUR/MWh). The ratio of the highest to the lowest price across the EU was 3.2 in 2021. The lowest price for I5 consumption band was reported by Ireland (31 EUR/MWh), whereas the highest by Denmark (80.4 EUR/MWh), implying a highest-to-lowest price ratio of 2.6 in 2021.

Composition of industrial gas prices

Over time, the composition of industrial gas prices also changed, albeit to a different extent for the two consumer types. In 2010, the first year of our observation period, the energy component accounted for 79% of medium (I3) and 86% of large industrial (I5) prices. The impact of network costs and taxes was limited. By 2021, the share of the energy component decreased to 57% for medium and 74% for large industrial consumers1.

The composition of I3 price has experienced some fluctuations in the last decade, as the share of the energy component has shrunk from 2012 to 2020. Although, the share of the energy component is still much lower than in 2010, a decrease of 22 percentage points to 57% in 2021. In absolute terms, the energy component has slightly decreased from 25.3 EUR/MWh in 2010 to 24.2 EUR/MWh in 2021. The main development in this period has been in taxes on industrial gas, which have increased from 3 EUR/MWh to 13 EUR/MWh from 2010 to 2021. This is mainly driven by environmental taxes.

The composition of I5 prices also experienced changes in the last decade, as the share of the energy component declined from 2012 to 2020. However, the drastic increase in wholesale prices in 2021 led to an upward trend of the share of the energy component. However, the share of the energy component in 2021 (74%) is still lower than in 2010 (86%). in absolute terms, the energy component has increased by 9 EUR/MWh from 2010, reaching 31 EUR/MWh in 2021, increasing by 17 EUR/MWh between 2020 to 2021. This suggests that wholesale prices are passing through more quickly to larger industrial energy consumers. Additionally, taxes on industrial gas have also increased significantly from 2 EUR/MWh in 2010 to 9 EUR/MWh in 2021. This is mainly driven by an increase in environmental taxes. It is notable that 2021 was the first year in which the difference in prices between I3 and I5 was reduced to almost parity, with a difference of only 0.5 EUR/MWh, compared to 6-13 EUR/MWh differences in other years.

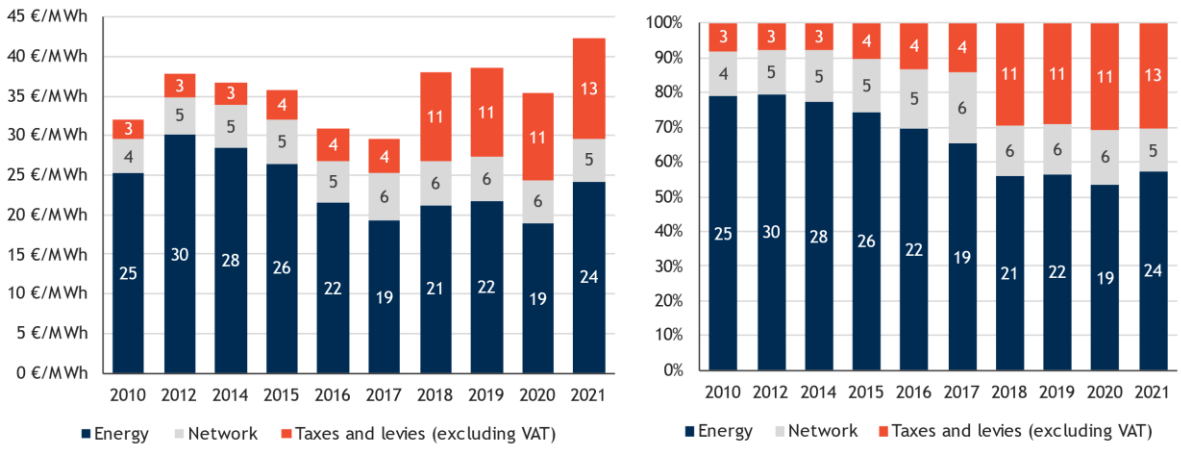


Figure 61: Composition of EU prices for medium (I3) industrial gas consumers
Source: Eurostat

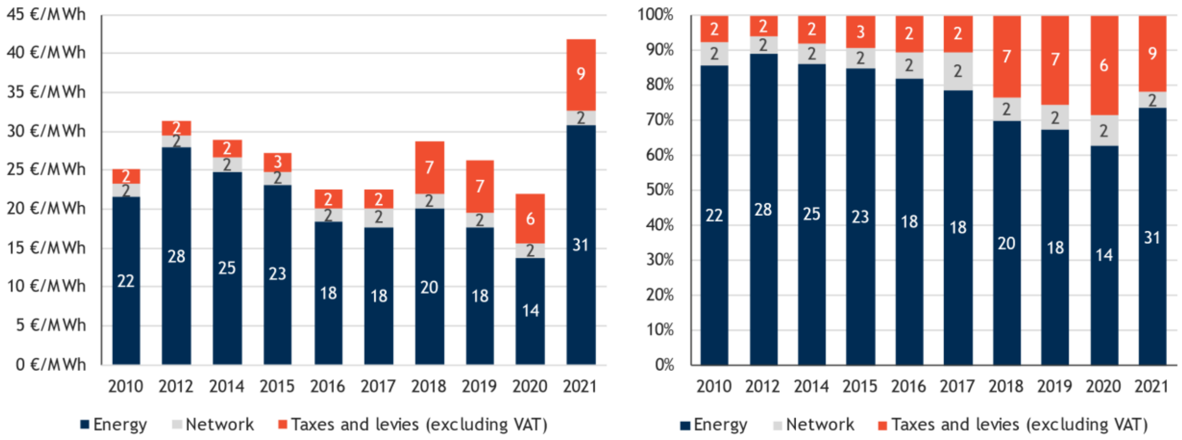


Figure 62: Composition of EU prices for large (I5) industrial gas consumers
Source: Eurostat

Natural gas generally enjoys lower tax rates (both absolute and as share of the final price) compared to electricity prices. In addition, industrial consumers benefit from exemptions and reduced tax rates in most countries. However, since 2018, the rate and share of taxes on industrial gas use has increased. In 2021, taxes constitute 30% and 22% of the total industrial gas price for medium (I3) and large (I5) industrial consumers, respectively. In comparison, taxes made up 34% of the household gas prices in the same year.

Taxes imposed on industrial gas prices consist mostly of value added taxes, which represented 52% of band I3 taxes and 67% of band I5 taxes. Environmental taxes also constitute a significant portion of industrial gas taxes: 42% of medium (I3) consumer gas taxes and 26% of larger (I5) consumer gas taxes. Renewable taxes, similarly to the other taxes (including capacity tax), represented 5-6% out of the total tax and about 1-2% out of the final retail price in 2021.

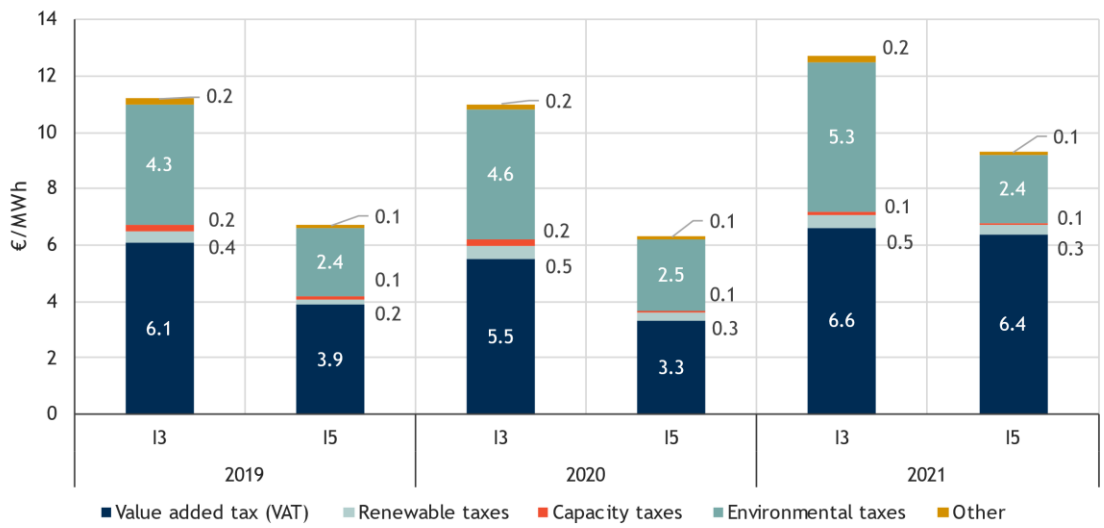


Figure 63: Composition of the tax structure of the EU retail gas prices for medium (I3) and large (I5) consumers in 2019, 2020 and 2021
Source: Eurostat

Situation in individual Member States

Industrial gas prices are mainly comprised of the energy component, which mostly comprises of the wholesale price. Consequently, industrial gas prices develop in parallel to the wholesale gas markets, although with a time lag. The recent decrease in 2020 and increase in 2021 are mainly driven by the changes in demand due to the Covid-19 pandemic, where restrictions on movement and industrial activity in 2020 first reduced demand and subsequently demand increased again in parallel with economic recovery in 2021

In 2021, the ratio of the most expensive and the cheapest retail industrial gas prices for medium-level (I3) customers was 3.2, whereas for larger industrial consumers (I5), the ratio was 2.6. Over the last few years, for both consumer groups, a slight price convergence can be observed across the EU, albeit in some countries the difference is still large (e.g. Finland and Sweden).

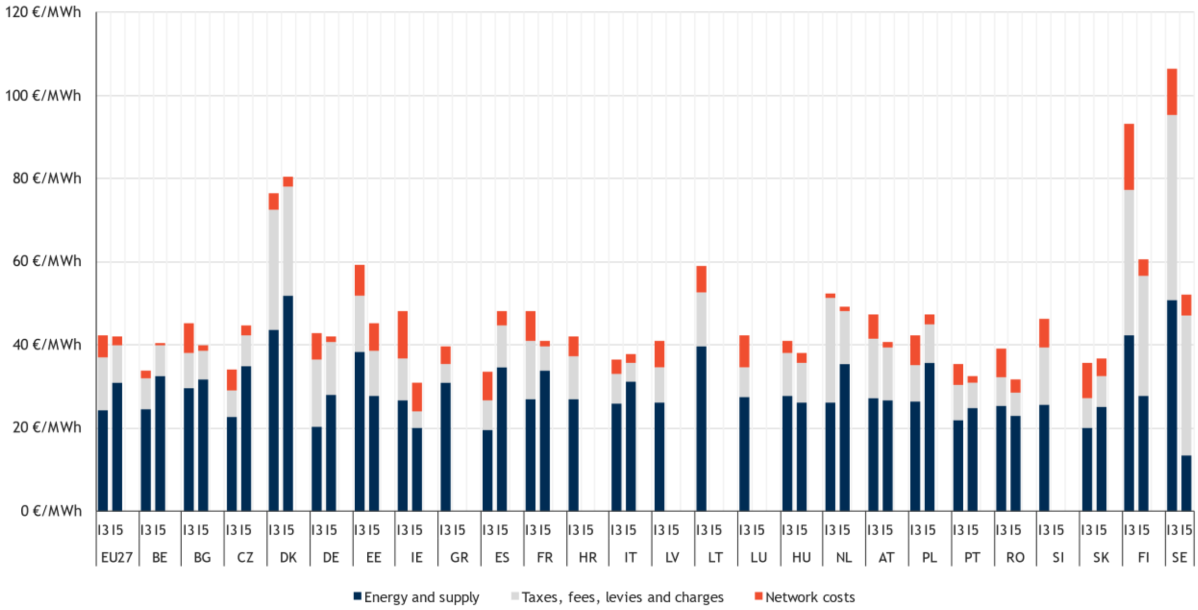


Figure 64: Comparison of Medium (I3) and larger (I5) consumer industrial gas prices in 2021 per Member State
Source: Eurostat

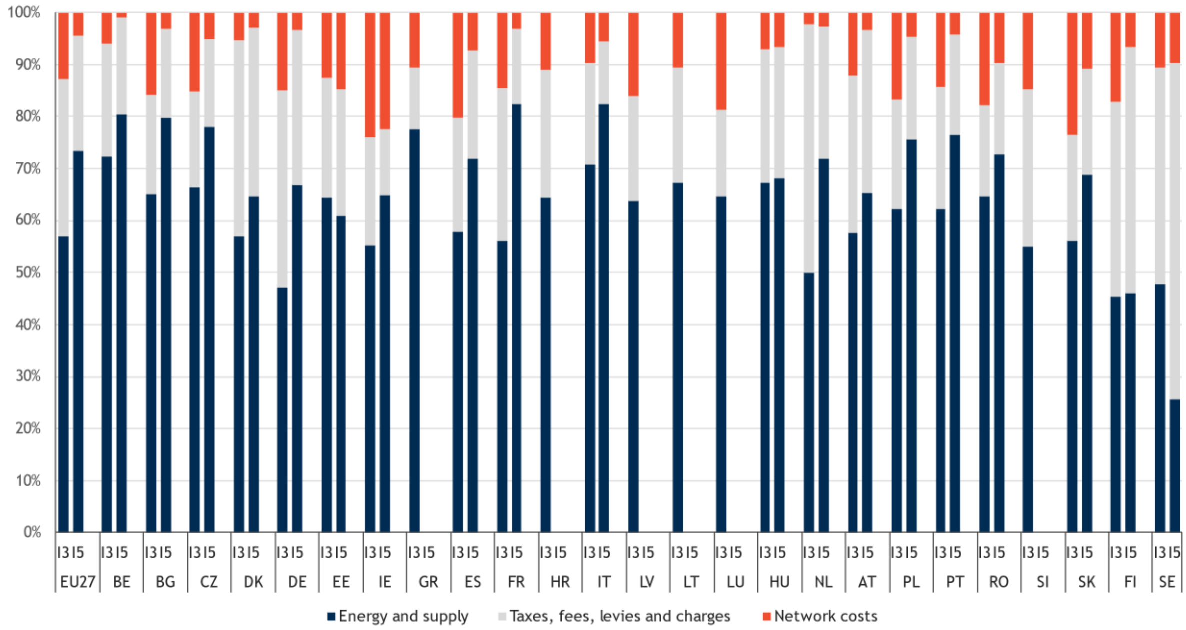


Figure 65: Composition of medium (I3) and large (I5) consumer industrial gas prices in 2021 per Member State.
Source: Eurostat

Recent developments in industrial gas prices

Country level data is also available for the first semester of 2022 from Eurostat (see Figure 66). Whilst the component level data is not yet available, the total price data already provides insights into the price developments in the first half of 2022. EU average gas prices increased from 65 EUR/MWh in June 2021 to 88 EUR/MWh in June 2022 (+35%). This increase is higher than the equivalent for electricity retail prices, although the price per MWh remains far lower for gas than for electricity. The figure also shows that prices have spiked in particular in Sweden, Denmark, Estonia and the Netherlands over the last 12 months. Prices have remained relatively flat in some countries, such as Hungary and Croatia, due to regulated prices.

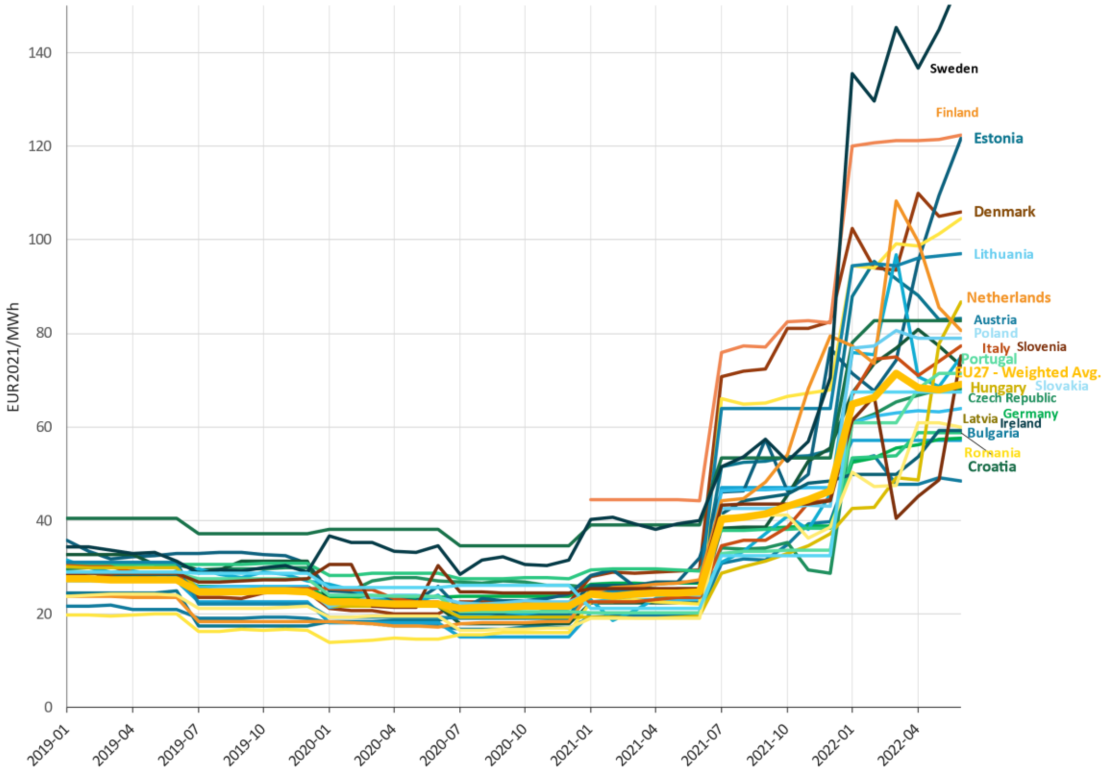


Figure 66: Average industrial retail gas prices (Band I3) in the EU27, Jan 2019-Jun 2022.
Source: Eurostat.

Figure 67 shows how both retail and wholesale prices increased since 2020 for both gas and electricity. In the figure, one can see several trends:

- Price increases for gas are higher than for electricity for all price categories (wholesale and retail).
- Wholesale price increases have seen the largest increases: up to a sixfold increase for gas compared with the 2019 average and a 4 to 5 time increase for electricity.
- Industrial retail prices incorporate rising wholesale prices faster than household prices. Among others, this is the result of purchasing strategies of industrial consumers, but also because of a higher household tax component which mitigates relative price increases.

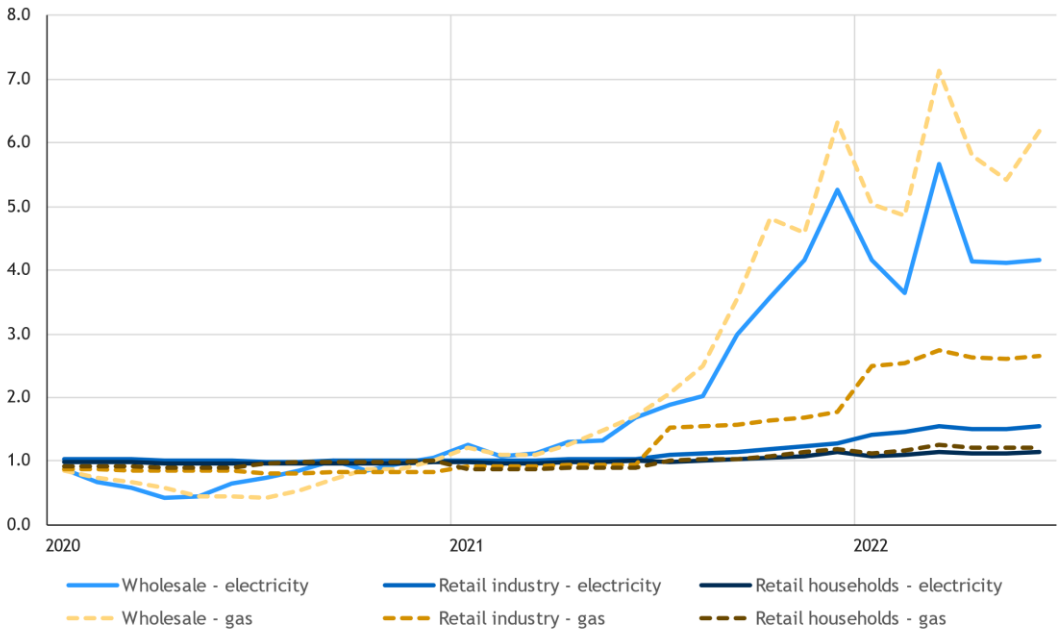


Figure 67: Indexed (2019 average = 1.0) price development since 2020 showing for electricity and gas the retail prices for households and industry, as well as the wholesale price.
Source: Eurostat, S&P Platts.

3.2.3 International comparisons

Household natural gas prices

From 2008, the EU27 average household natural gas price has fluctuated between 60 EUR/MWh and 80 EUR/MWh (Figure 68). Concurrently, household retail natural gas prices in the US and China have remained significantly lower, ranging from 20-40 EUR/MWh. Although wholesale prices are high in China, household prices remain low, indicating possible subsidisation for households. From 2008 to 2020, household prices in Japan have been higher than the EU27 average, whilst prices in the UK have been below the EU average, partially due to its own natural gas production.

Notably, although wholesale prices have starkly increased in the past year in the EU, the household increase has been much less so far, due to the lag in retail contracts and price regulation in some countries. Prices in Japan, the US and the UK have all trended upwards, Japan displaying the highest prices. In the UK, prices have started to move stepwise with changes in the recently introduced UK price cap.

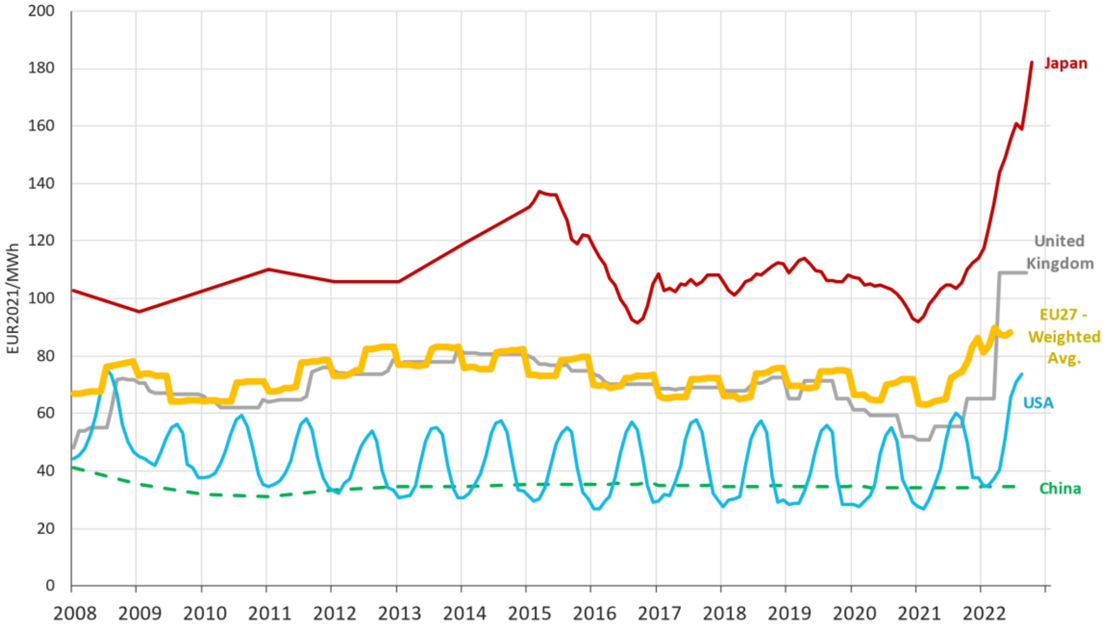


Figure 68: Household gas retail prices in EUR2021/MWh in the EU, Japan, US, UK and China
Source: Eurostat, US DoE, Enerdata (BEIS, NBS)

Figure 69 shows a comparison of EU27 average household retail natural gas prices with other major G20 trading partners. The household retail gas prices of Australia are the highest compared to the other selected countries, despite Australia not having the highest wholesale prices. Of the prices which are the most up to date (EU27 average and Türkiye), there is an emerging upward trend of household prices in Türkiye in 2021, following the same trend as wholesale prices.

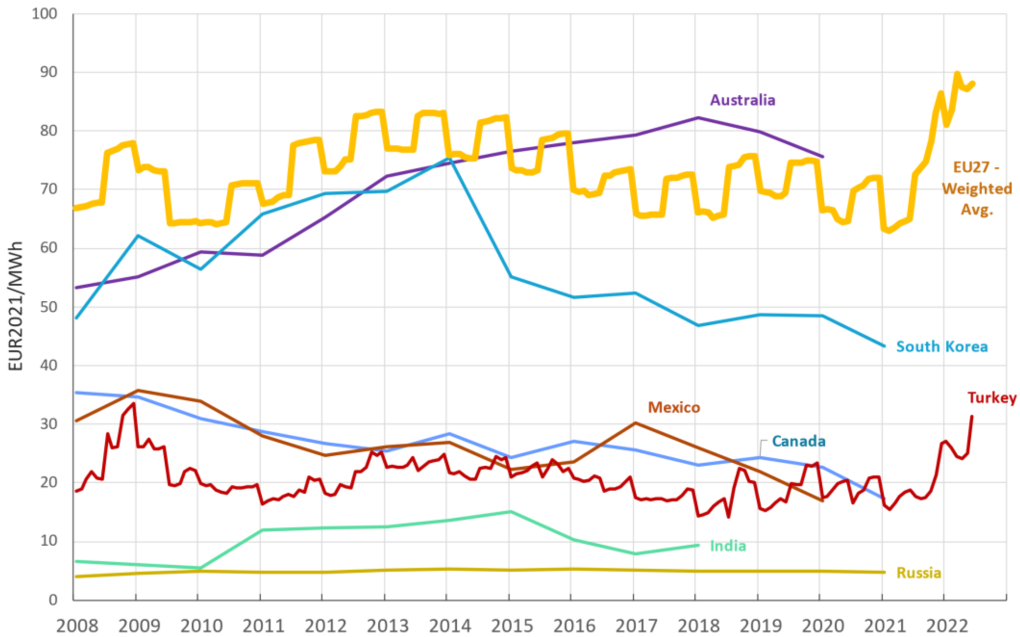


Figure 69: Household retail natural gas prices in EUR2021/MWh in the EU27 and major G20 trading partners from 2008 to 2022
Source: Eurostat, US DoE, Enerdata (BEIS, NBS), IEA

Industrial natural gas prices

From January 2021 to January 2022, the average retail industrial natural gas price has increased from 24 EUR/MWh to 45 EUR/MWh (+85%) in the EU27, and have climbed even higher in 2022. Compared to other countries (Figure 70), industrial retail gas prices in the US are significantly lower, although these also have seen an increase in 2021 and are trending upwards in 2022. Prices in the UK are very similar to the EU average although have diverged somewhat in 2022.

Industrial gas prices in gas producing countries, such as Russia, US, Saudi Arabia and Canada (Figure 71), are lower compared to non-producing countries. They are also lower in India and Mexico. In previous years, South Korea had the highest industrial gas prices, because of high wholesale prices and dependence on LNG. From Q3 2021 industrial gas prices have risen considerably for the EU27 average and Türkiye, similar to wholesale gas prices. This trend continued in 2022 in the EU and the US and in other countries.

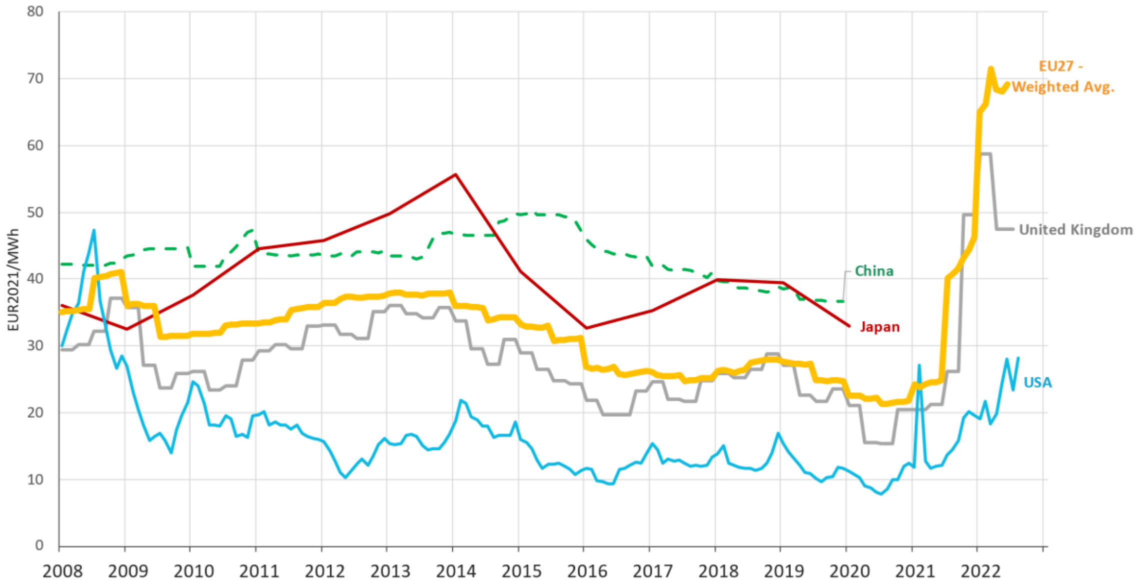


Figure 70: Retail industrial natural gas prices in EUR$_{2021}$/MWh in the EU27, Japan, US, UK and China.
Source: Eurostat, US DoE, Enerdata (BEIS, NBS)

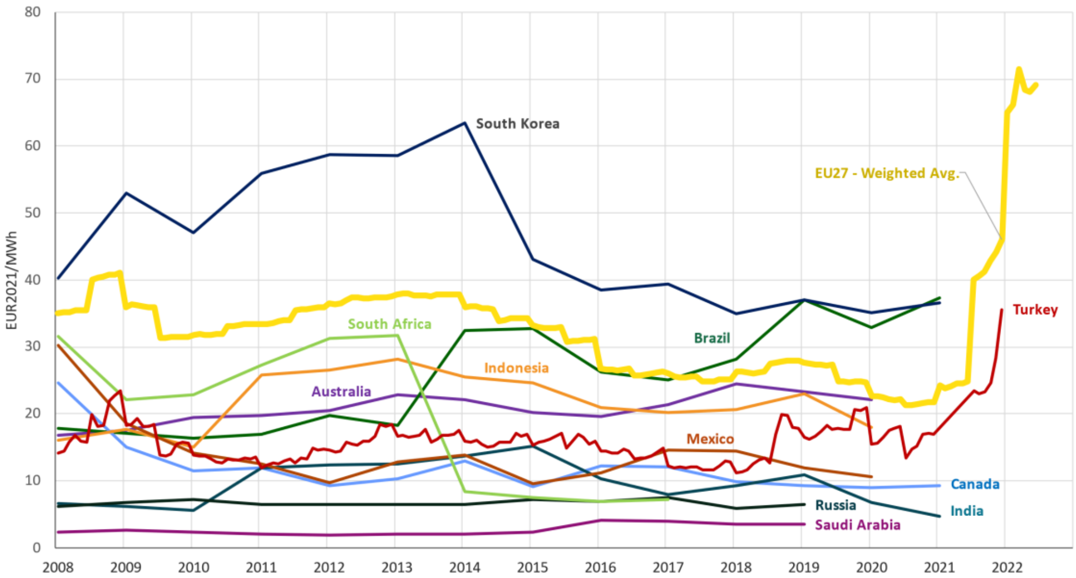


Figure 71: Retail industrial natural gas prices in EUR$_{2021}$/MWh in the EU and major G20 trading partners.
Source: Eurostat, US DoE, Enerdata (BEIS, NBS), IEA

4 Oil, coal and alternative fuel prices

Main findings

- Since the pandemic-induced drastic price reduction to <$20/bbl in March 2020, **crude oil prices** have risen substantially, peaking at more than $130/bbl in March 2022 after the Russian invasion of Ukraine. Whilst prices recently have fallen to the $80-100/bbl range in Q3 2022, they remain at historically high levels for several reasons. Competing pressures exist for future prices, with on one hand on the demand side an economic slowdown and on the supply side production cuts by leading suppliers (OPEC+). Nevertheless, oil price increases have been less significant than the increases for gas and electricity.
- **Coal prices** have also increased significantly since September 2020, from around 50 EUR/tonne to more than 250 EUR/tonne in September 2022, with price increases driven by increased post-Covid demand from China and then increased gas to coal switching in electricity generation in Europe and elsewhere.
- European and international retail prices of oil-based fuels (gasoline, diesel, heating oil) have also followed an upward trend since mid-2020. The increases were driven by crude oil prices, and an increasing influence of VAT as total prices increase. Some fuels like diesel and jet fuel endured price hikes as markets tightened due to embargos on Russia. Temporary tax breaks implemented in several Member States have slightly mitigated these rising prices.
- Alternative fuels followed the general trend with increases in prices for bioethanol and biodiesel, as well as for LPG fuels; the latter linked closely to the increasing gas price.
- Prices for electrical storage (estimated for the first time in this edition) show that Lithium-ion (Li-ion) batteries are in some use-cases now more competitive than pumped hydro storage for utility-scale electricity storage. Prices for Li-ion battery storage are declining with declining battery unit costs through increased production scale and innovation, linked to the fast growth of electric vehicles. However, this positive trend is in danger of being reversed due to recently increasing (raw) material prices.
- Prices for hydrogen have been estimated for the first time in this edition too. These estimates show that the cheapest renewable hydrogen production achieves prices of around 3 EUR/tonne (onshore wind), or 4 EUR/tonne (solar). This compares to ‘normal’ prices for hydrogen from grid electricity of 2-8 EUR/tonne, and of less than 1.5 EUR/tonne from ‘grey’ hydrogen made using natural gas through the Steam Methane Reforming (SMR) process. However, prices of the latter have spiked along with natural gas prices to more than 7 EUR/tonne, making some hydrogen from green technologies cost competitive — though still expensive —under the current exceptional high energy price context

4.1 Crude oil and coal prices

4.1.1 Crude oil prices

From a low point of 26 USD/bbl Brent on 20 January 2016, its lowest level since 2003, prices generally trended upwards until March 2020, largely driven by restricted production by OPEC and a few key non-OPEC producers, and events such as US withdrawal from the Iran nuclear deal (which prevented Iranian oil to reach global markets).

Oil prices crashed to 20 USD/bbl around March/April 2020 (the lowest since 2002) as COVID-19 lockdowns were imposed, first in China and subsequently in other countries. This led to an immediate decrease for oil demand (for transport and industry). Negotiations between OPEC members and non-OPEC members including Russia led to production adjustments only in May 2020, after which oil prices recovered to around 40 USD/bbl.

Oil prices stayed below 50 USD/bbl throughout 2020, though showing a moderate growth trend since the lowest point in March 2020. The gradual increase in prices was spurred by growing demand in regions, which reduced or lifted lockdown measures (mainly China in second half of 2020) and more optimistic outlooks on the future economic impacts of Covid-19. This even led to seven consecutive months of oil stock draws from September 2020 to March 2021 in which built-up reserves were sold. However, overall absolute demand stayed low with continuing lockdowns in the EU and other regions, most notably affecting demand for jet fuel.

2021 also saw a steady price increase from 50 USD/bbl to nearly 80 USD/bbl by the end of the year. Though the trend was generally upwards, prices were relatively volatile. Increasing global demand on the back of post-Covid recovery, combined with slow OPEC+ negotiations on increasing supply contributed to higher prices in the middle of the year. Towards the end of 2021 oil demand increased further as very high prices for other fuels (mainly gas and electricity) made switching to oil more attractive and economic recovery continued. Global oil supply increased in tandem as OPEC+ came to an agreement to unwind prior made cuts in supply, but not as fast as demand grew. As a result, crude oil prices in Q4 of 2021 reached their highest level since 2014.

At the start of 2022, oil prices increased further on the back of increasing global oil demand, increased demand forecasts and restricted supply, as OPEC+ production was consistently below their targets. Oil prices hit 100 USD/bbl in February 2022 already before the Russian invasion in Ukraine.

After the Russian invasion in Ukraine, oil prices in March rose sharply to 133 USD/bbl on the day that the USA announced a ban on all Russian fossil fuel imports. In 2021, Russia produced on average 11.3 million barrel/day, about a tenth of global oil supply and was the largest global exporter of oil. In addition, the capacity to ramp up oil production quickly was and remains limited to a few key suppliers, mainly Saudi Arabia and the UAE that were reluctant to do so. Since June 2022, oil prices have been slowly decreasing due to reduced global demand as very high energy prices are slowly leading into an overall economic slowdown in EU Member States and other OECD countries. Moreover, Chinese oil demand lagged behind expectations because of renewed lockdowns. Production cuts announced by OPEC+, to take effect from November 2022, are likely to put upwards pressure on prices again.

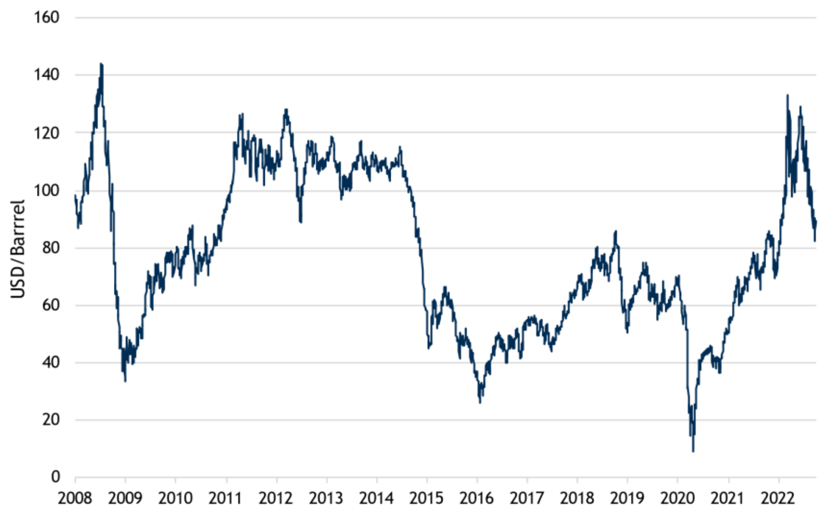


Figure 72: The Brent crude oil price (incl. Fuel Oil Barges/F.o.b.) from 2008 to October 2022, indicated by the Daily Europe Brent Spot Price FOB in $ per barrel (nominal prices).

Source: S&P Platts

4.1.2 Wholesale coal prices

Given the recent absolute increase in coal consumption in the EU, in response to very high gas prices, it is worthwhile to analyse coal prices in the EU. Figure 73 below shows the wholesale prices of coal from Australia and South Africa, which are generally representative for global coal (import) prices. After consistently decreasing coal prices between 2012 and 2021, among others due to decreasing demand, coal prices spiked significantly since the end of 2021 until at least September 2022. This can mainly be explained by very high natural gas prices and subsequently favourable conditions to switch (back) from gas to coal power generation —mainly in the EU and Asia —, though in the EU partially mitigated by simultaneously increasing carbon allowance prices making coal-fired generation less attractive compared with gas.

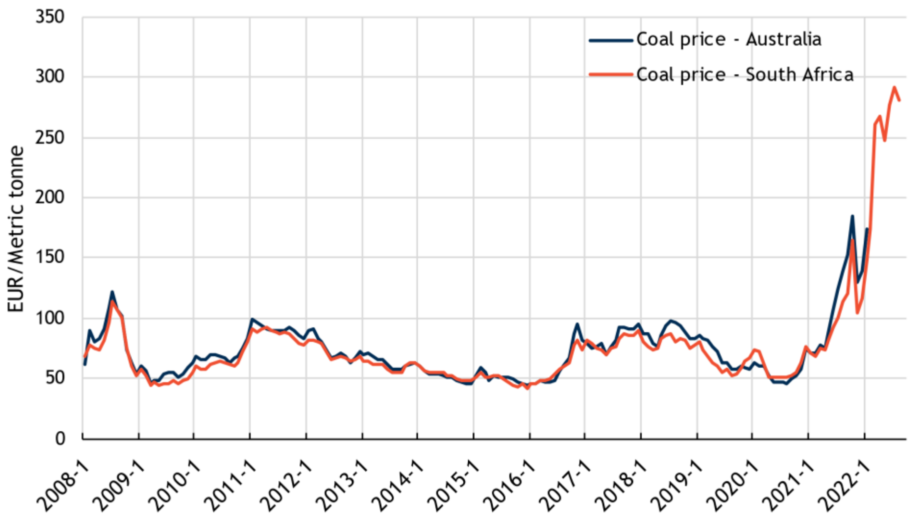


Figure 73: Wholesale coal prices (FOB) from Australia and South Africa from 2008 to 2022 in nominal euros (for South Africa up to September 2022, Australia up to January 2022)

Source: World Bank

Figure 74 takes a further look at the import prices for main coal users in the EU and its main trading partners. Coal prices (including taxes) in the EU27 are higher than in China and the US and comparable with prices in Japan. In recent years, the average EU coal price was between 80-120 EUR/tonne. Coal prices also differ within the EU: prices in Czechia and France are above the European average, while prices in the two largest coal consuming and producing countries – Poland and Germany – are below the average. Coal prices follow similar trends despite some countries having structurally lower or higher price levels, due to differences in tax levels or transport costs. Figure 74 shows that wholesale prices of coal are very similar (at least for coal imported from Australia and South Africa) and thus price differences between coal using countries do not stem from differences in the wholesale prices.

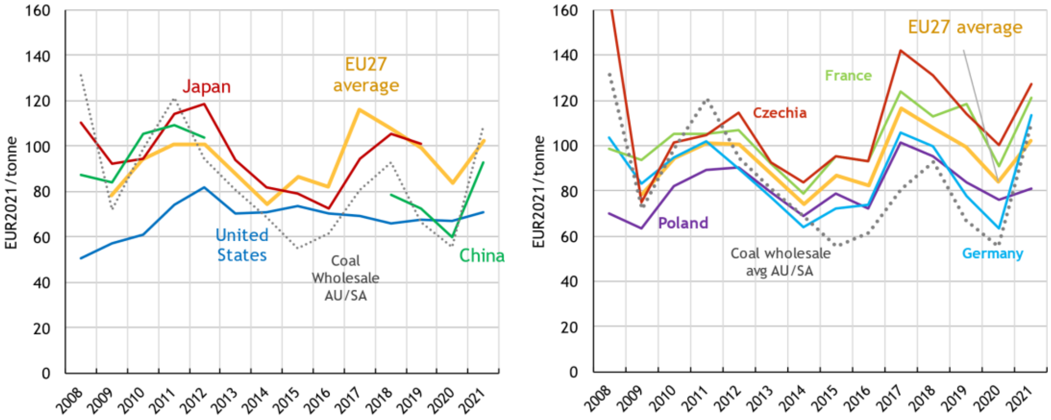


Figure 74: Imported coal prices including taxes in the EU27 and main trading partners from 2008 to 2021 in real EUR2021 prices.

Source: COMEXT, Eurostat, World Bank.

4.2 Wholesale prices of oil-based fuel products

Crude oil is the main feedstock to produce oil products, and oil product prices closely follow the development of the crude oil price. This is visible in the below Figure 75 if we compare the Brent oil price with the representative wholesale prices of the main oil products in Western Europe.

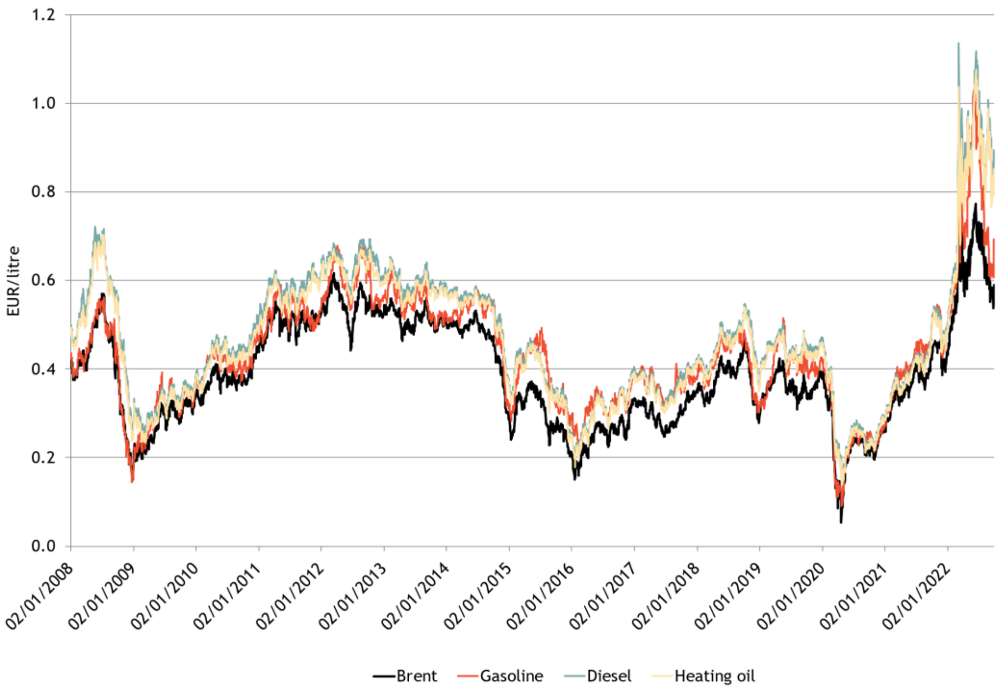


Figure 75: Crude oil (Brent) and European wholesale gasoline, diesel and heating oil prices in nominal EUR/litre from 2008 to September 2022.

Source: S&P Platts, ECB (for exchange rates).
The following oil product prices were used: Gasoline Prem Unleaded 10ppmS FOB AR Barge (gasoline), ULSD 10ppmS FOB ARA Barge (diesel) and Gasoil 0.1%S FOB ARA Barge (heating oil) The following conversion rates were used: crude oil 159 litre/barrel, gasoline 1350 litre/ton, diesel and heating oil 1186 litre/ton.

However, when looking at the crack spreads (i.e. the difference between the wholesale prices of oil products vs. crude oil - Figure 76); these spreads were rather volatile, particularly in 2022. While diesel and heating oil follow similar paths, the spread for gasoline diverged more.

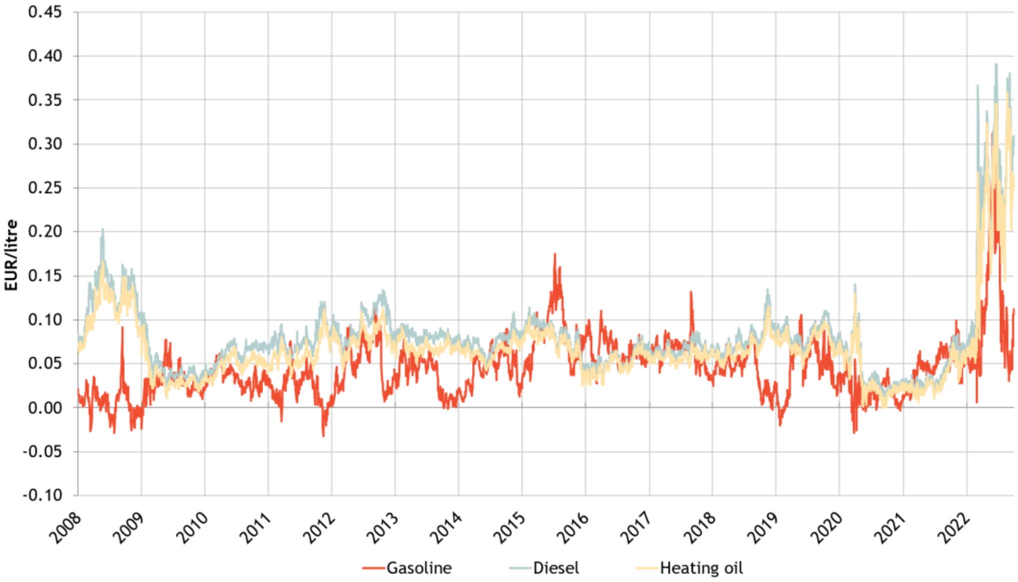


Figure 76: Crack spreads of gasoline, diesel and heating oil from 2008 to September 2022 in nominal EUR/litre.

Source: S&P Platts, ECB (for exchange rates)
Crack spreads are calculated as the difference between the Brent crude oil price and the price of the following products: Gasoline Prem Unleaded 10ppmS FOB AR Barge (gasoline), ULSD 10ppmS FOB ARA Barge (diesel) and Gasoil 0.1%S FOB ARA Barge (heating oil)
The following conversion rates were used: crude oil 159 litre/barrel, gasoline 1350 litre/ton, diesel and heating oil 1186 litre/ton

The supply-demand conditions of the different products are different (both from crude oil and from each other), which affects their crack spreads. For example, the 2008 oil price rise was driven by industrial growth in China, leading to a big increase in the demand of middle distillates (e.g. diesel, heating oil), which was reflected in the high crack spreads of these products. There are also seasonal differences in demand, for example, gasoline demand is higher in the summer and typically resulting in a relatively high crack spread during that period; in times of low demand crack spreads can even turn negative (i.e. gasoline is cheaper than crude oil). In the summer of 2015, gasoline crack spreads reached unusually high levels as low crude oil prices boosted gasoline demand.

Oil product supply can also fluctuate, for example as a result of refinery maintenance or natural disasters affecting refinery operations; this will also affect crack spreads. Examples of these include Hurricane Harvey in the US that triggered the spike of European gasoline crack spreads in late August 2017; low and negative crack spread of gasoline in end of 2018 and in beginning of 2019 reflecting the US leaving the Iranian deal and reduced production in Libya and Venezuela.

In 2020, the pandemic first led to widening crack spreads in spring 2020 as a result of plunging crude oil prices, but afterwards spreads stayed low during the lockdown period as a result of ample refined supply and low demand. After lifting Covid restrictions, economic recovery led to crack spreads increasing during 2021. In 2022, all crack spreads saw a huge increase to historically high levels on the back of increasing crude oil prices and tight supply. In July 2022, crack spreads for gasoline tumbled however, while spreads for diesel and heating oil stayed high.

4.3 Retail prices of oil and fuel products

In addition to electricity and gas, oil products constitute an important part of the energy costs of both households and industry. Oil products have a dominant role in transport, particularly in road freight, maritime and air transport. Around 50% of all crude oil is converted and used in the road transport sector, 9% is used in air transport and 7% in (international) maritime transport[34]. In the case of space heating, the share of oil products is declining but in certain Member States, it still plays an important role. Globally, residential use constitutes 5% of all crude oil use. Lastly, about 25% of crude oil use in OECD countries is used in industry, of which two thirds is non-energetic use in the petrochemical sector.

The retail price of oil products (presented in the following sections) depends on several factors. Variations in the price of crude oil will obviously have an impact on retail prices but crude oil costs often constitute a relatively small part of the final price. Crude oil is traded in US dollars but the finished products are sold in euros or other national currencies: variations in exchange rates will hence influence the cost of the crude oil component.

A significant part of the retail price is taxes: excise duties, other indirect taxes and VAT. Differences in prices between fuels and countries are primarily due to diverging tax rates. These taxes make an important contribution to the tax revenue of Member States (see Chapter 11). In the case of motor fuels (gasoline and diesel), taxes typically make up more than half of the final price.

Excise duties are generally a fixed amount per quantity (usually litre or kg), i.e. not influenced by the price of crude oil. VAT, on the other hand, is set as a percentage of the price (including the excise duty) and, therefore, changes in the crude oil price will have an impact on the absolute value of the VAT component.

VAT rate regulation in the EU

Rates of both the excise duty and VAT vary by product and by member state, resulting in significant price differences across Europe. Nevertheless, Member States do not have complete freedom when setting the tax rates. The Energy Tax Directive (2003/96/EC) sets minimum excise duty rates for gasoline, gasoil, kerosene, LPG and heavy fuel oil. The Directive is currently under revision as part of the European Green Deal process, which could lead to changes in fuel taxation, including minimum tax levels set on the basis of energy content (EUR/GJ) and allowances for the environmental impact of each fuel.

In case of VAT, the VAT Directive (2006/112/EC) requires that the standard VAT rate must be at least 15%; currently the standard VAT rates applied by Member States range from 17% (in Luxembourg) to 27% (in Hungary). In case of oil products, Member States typically apply the standard VAT rate. Under certain conditions, however, Member States can set a lower VAT rate for specific products and services; for example, a few Member States apply a reduced rate for heating oil.

The high share of fixed taxes in the price acts as a buffer: fluctuations in the retail price of oil products (particularly motor fuels) are significantly lower than the fluctuation of the crude oil price. Variations in the exchange rate have a similar effect: the oil price and the value of the US dollar usually move in the opposite direction: a strengthening dollar typically coincides with decreasing oil prices and vice versa.

[34] Source: OECD, 2019

This means that changes in the oil price, whether upwards or downwards, are mitigated by the exchange rate and the volatility of the oil price expressed in euros is smaller than the volatility of the price expressed in dollar.

Finally, although their share in total use is still relatively limited, alternative fuels provide an increasing share of the energy mix in transport and other sectors and their importance is expected to grow in the future. Therefore, in this report price data is also included for LPG, bioethanol and biodiesel.

4.3.1 Methodology

The analysis in this section is based on the data of the weekly Oil Bulletin, published on the website of DG Energy.[35]

The analysis covers the three main petroleum products sold in the retail sector: gasoline (Euro-super 95), diesel (automotive gas oil) and heating oil (heating gas oil). The time horizon is from 2005 to 2022. All Member States are covered but data for Bulgaria and Romania is available from 2008 and for Croatia from 2013 when they joined the EU. In case of heating oil, Slovakia does not report prices since October 2011. Greece does not report prices for the summer period (from May to mid-October) when heating oil is not traded.

Prices reported in currencies other than the euro were converted into euro, using the ECB exchange rate of the day for which the price applies. For each year and each Member State, an average price was calculated as an arithmetic average of the weekly prices and an EU average price was calculated as the weighted average of these with weights in the previous year's consumption.[36]

4.3.2 General findings

Figure 77 shows that the absolute prices of oil products are different but their evolutions closely mirror each other as they all reflect the development of crude oil prices, which in general is the most volatile component of retail prices.

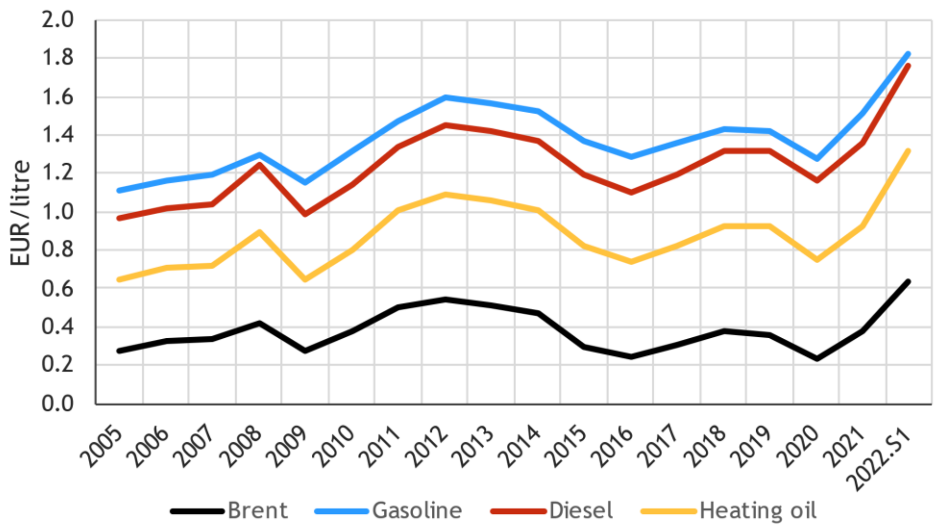


Figure 77: Average retail price of oil products in the EU in nominal EUR/litre.

Source: Oil Bulletin, S&P Platts

[35] https://energy.ec.europa.eu/data-and-analysis/weekly-oil-bulletin_en
[36] For all 2022 tax data, average tax rates in July 2022 are used, instead of an average over the first semester.

The difference in the average absolute price of the three products can be mostly attributed to the diverging tax rates between fuels.

VAT rates in EU Member States

All EU countries but Ireland and Luxembourg have the same VAT tax rates for all the fuels. Ireland and Luxembourg have the same VAT rates for gasoline and diesel, but lower for heating oil. In total, most of the price difference comes from excise taxes; the Energy Tax Directive also sets a higher minimum excise rate for gasoline (0.36 EUR/litre) compared to diesel (0.33 EUR/litre). In line with the minimum rates, most countries have higher excise tax rates for gasoline than for diesel, with heating oil rates being the lowest generally.

Among EU Member States, Belgium is now the only state where the two motor fuels (gasoline and diesel) are taxed at the same excise tax level, with heating oil taxed less. In practically all Member States, the excise duty rate of gasoline is higher than that of diesel, which is higher than that for heating oil[37]. Few Member States (Bulgaria, Czechia, Hungary, Netherlands and Romania) apply practically the same excise duty rates for diesel and heating oil, with excise for gasoline higher[38]. In most Member States, however, heating oil is taxed at a lower level. Czechia is the only country that has subsidies for heating oil.

Several Member States increased the excise duty rate in recent years, resulting in a gradually increasing (weighted) average tax rate. According to the Energy Tax Directive, the minimum excise duty rate for diesel increased from 0.302 EUR/litre to 0.33 EUR/litre on 1 January 2010, which required some Member States to adjust their rates.

Contrary to the general trend, the weighted average excise duty rate for gasoline fluctuated slightly from 2014 to 2016 (Figure 78). While a few Member States indeed reduced the excise duty rate for gasoline in this period, the decrease was driven mainly by exchange rate developments, in particular the depreciation of the pound sterling which made the UK excise duty (unchanged in the local currency) significantly lower when expressed in euros. Austria is the only member state that had other indirect taxes (mostly intended to curb pollution) on fuel throughout the period. Some Member States introduced them since 2010 or in the last eight years (CY, ES, GR, HU, IE, LV, NL, PT, SI, SK), but other Member States did not. Since indirect taxes are small compared to other taxes, we addressed them in our analysis of excise taxes.

[37] I.e. gasoline excise > diesel excise > heating oil excise
[38] I.e. gasoline excise > diesel excise = heating oil excise

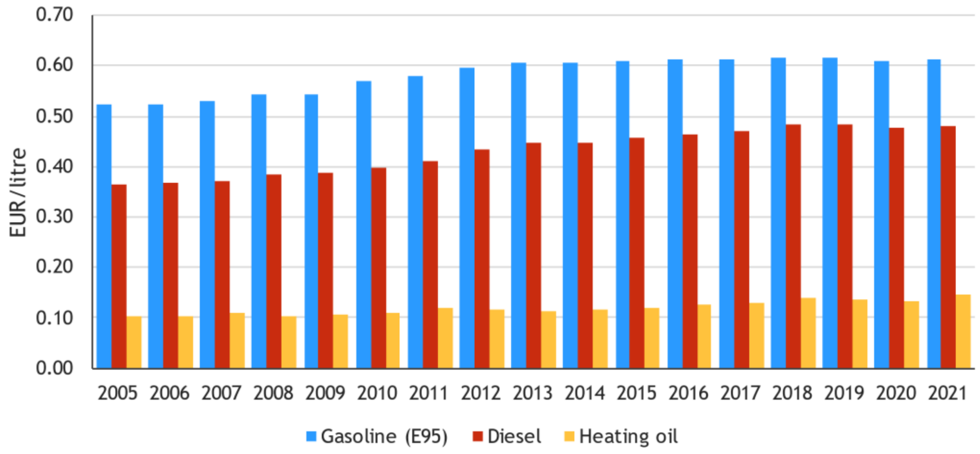


Figure 78: Average excise duty rates for oil products in the EU (nominal EUR/litre)

Source: Oil Bulletin

If the net (excluding excise tax & VAT) prices of the three products are compared, the difference is significantly lower. In fact, during the whole period the net price of diesel is slightly higher than that of gasoline, while if we include taxes diesel prices are lower. Figure 79 also depicts the evolution of the Brent crude oil price (recalculated into EUR/litre), showing that crude oil is the main component of the net price without taxes. Over the period, the crude oil price represented on average 65-70% of the net price of gasoline and diesel.

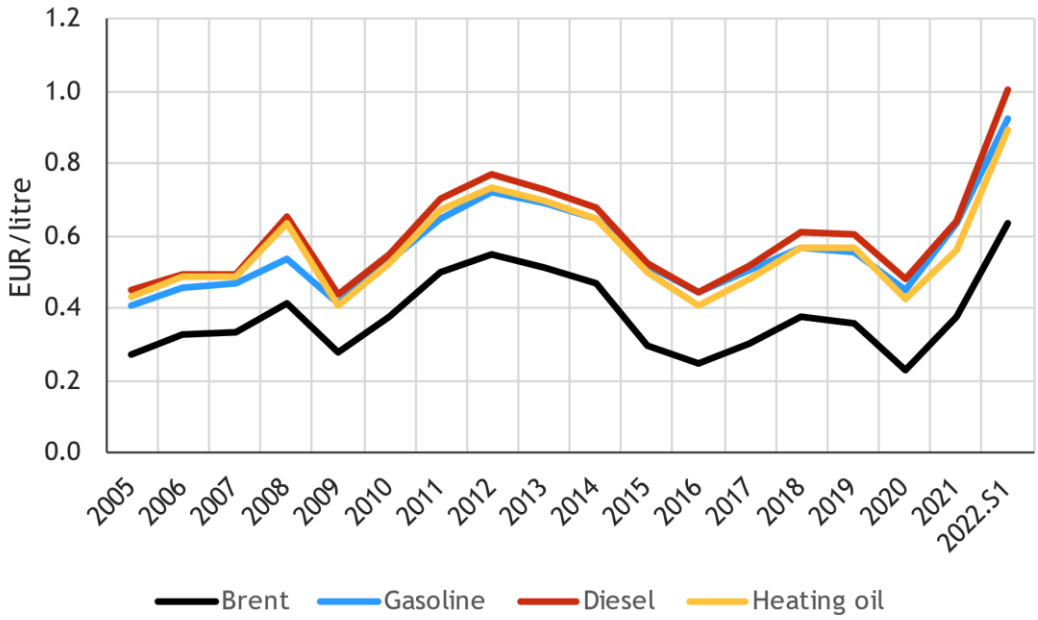


Figure 79: Average annual retail price of oil products in the EU in nominal EUR/litre, *without* taxes (net price).

Source: Oil Bulletin, World Bank

4.3.3 Gasoline / Petrol

As shown in Figure 80, in most Member States, the evolution of gasoline prices clearly follows the trend of crude oil prices; differences in the absolute level are mainly due to diverging tax treatment. Average prices have moved in a relatively wide range, with the difference between the highest and lowest price on average being about 0.55 EUR/litre. The range widened towards 0.83 EUR/litre in the first half of 2022.

The highest prices in 2022 were found in the Netherlands (2.12 EUR/litre), the lowest in Hungary (1.29 EUR/litre[39]). From 2019 to 2022, Germany had the largest increase of 39%, from 1.42 EUR/litre 2019 to 1.97 EUR/litre in the first half of 2022 (all in nominal prices). Austria, Czechia, Estonia, Spain, Finland, Latvia, Lithuania, Luxembourg and Sweden all saw greater than 30% increases in this period. At the other end of the spectrum is Malta, where the price in the first half of 2022 was among the lowest in the EU at 1.34 EUR/litre and was 3% lower than in 2019. This is the result of Malta freezing energy prices since the Covid-19 outbreak and continuing this measure during the recent market price increases.[40]

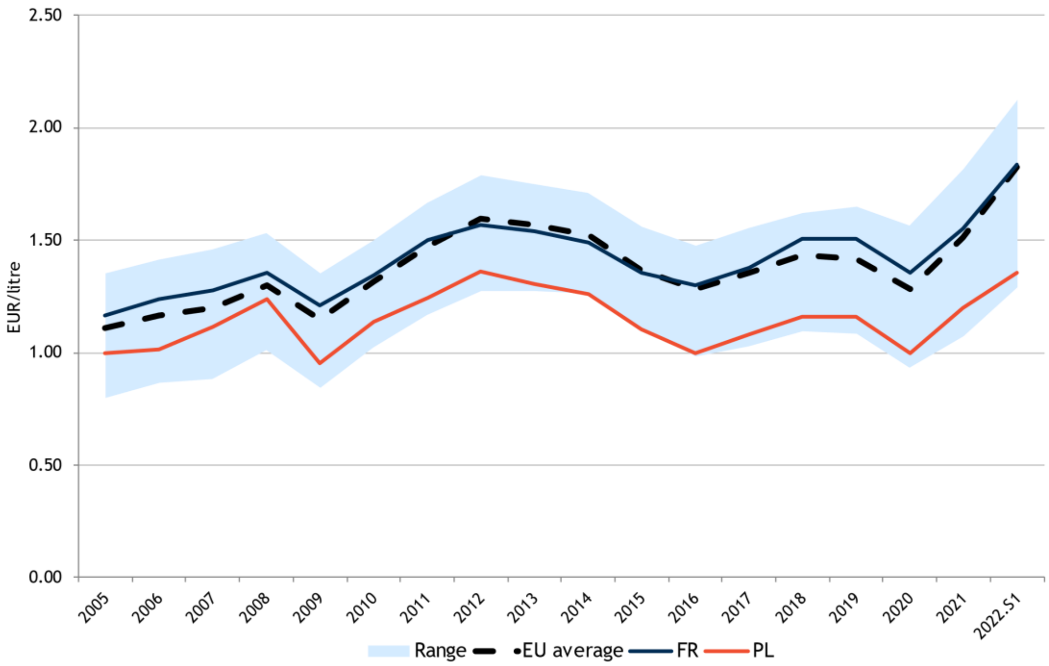


Figure 80: Average retail price of gasoline in the EU27, France and Poland, including taxes and VAT.

Source: Oil Bulletin, DG Energy

Looking at net prices, excluding taxes, the difference between the highest and the lowest price was smaller, typically between 0.10 and 0.20 EUR/litre. However, Covid-19 and the recent energy crisis have made wholesale prices fluctuate more in recent years, the result of which is an increasing difference in the retail price of gasoline between EU countries.

Besides external economic factors, the net price depends on a number of variables, including the source of supply (local refinery or import), transport costs and constraints (e.g., low water levels have restricted inland waterway transport), industry structure and competition. In the first half of 2022, the lowest net price was reported by Malta at EUR 0.59/litre, while the highest was reported by Germany at EUR 1.00/litre. Average net prices follow the representative wholesale price[41].

[39] Hungary introduced regulated retail prices for E95 and diesel in November 2021.
[40] Reuters (2022): https://www.reuters.com/business/energy/malta-maintain-energy-prices-pre-covid-levels-2022-10-24/
41 S&P Platts Gasoline Premium Unleaded 10ppmS FOB AR Barge

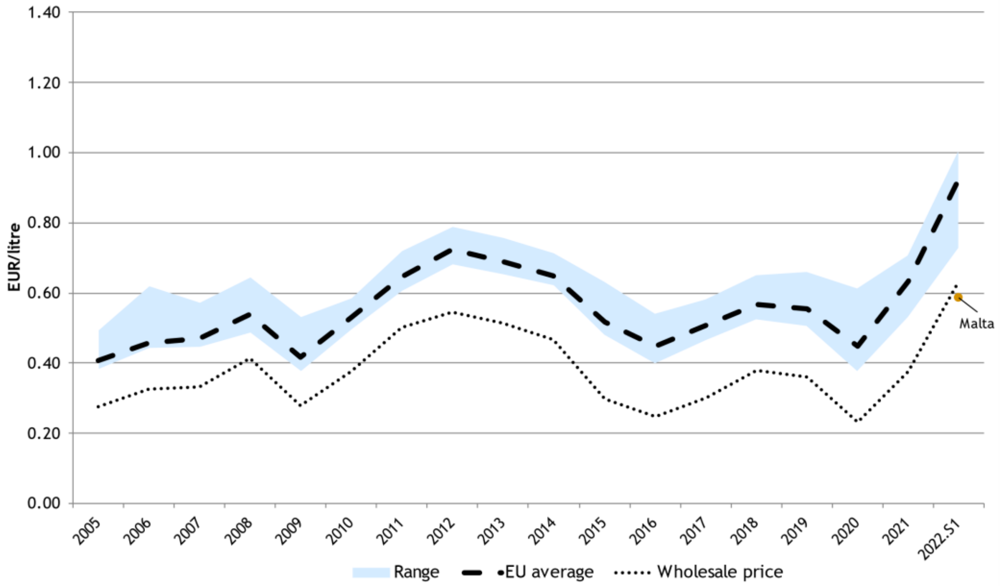


Figure 81: The retail price of gasoline on average in the EU27, in comparison with the wholesale price, in nominal EUR/litre, without taxes.

Source: Oil Bulletin, DG Energy, S&P Platts
The wholesale price is Gasoline Prem Unleaded 10ppmS FOB AR Barge reported by Platt
Note: Range in 2022.S1 excludes Malta, which is a clear outlier in 2022 given its frozen gasoline prices and is therefore displayed separately.

Excise duty is an important component of the retail gasoline price. The average level of excise duties in the EU have remained stable from 2012 (0.60 EUR/litre) to 2021 (0.59 EUR/litre) in nominal terms. In several Member States, excise duty rates increased significantly between 2008 and 2021, with the biggest increases in Greece (98%), Latvia (74%) and Malta (64%), while in some MS smaller increases came from inflation-indexation of the rate (such as the Netherlands). In other large Member States rates decreased in the period 2008-2021, such as Hungary (-18%) and Poland (-22%).

The average duty rate has decreased in 2022 as several countries have implemented (temporarily) lower rates in light of the current energy crisis. These temporary cuts are discussed separately in Chapter 11. In some countries excise duty is indexed for inflation and thus increases every year in nominal terms (such as the Netherlands), while in others the rate is not indexed and thus stays constant in nominal terms (such as Germany), until a rate adjustment is implemented. Although, in Germany, it should be noted that other taxes, e.g. related to CO_2 emissions, are increasing.

In Hungary and Poland, the excise duty rate in euros was lower in 2021 than in 2008, mainly because of exchange rate developments (in national currencies, the excise duty rates increased over this period). For most of the period, Bulgaria generally had the lowest rate, just above the minimum level prescribed by the Energy Tax Directive. France had plans to further increase the excise duty annually via an increasing ‘carbon’ component, but in response to political protests in 2018, further rate increases have been postponed.

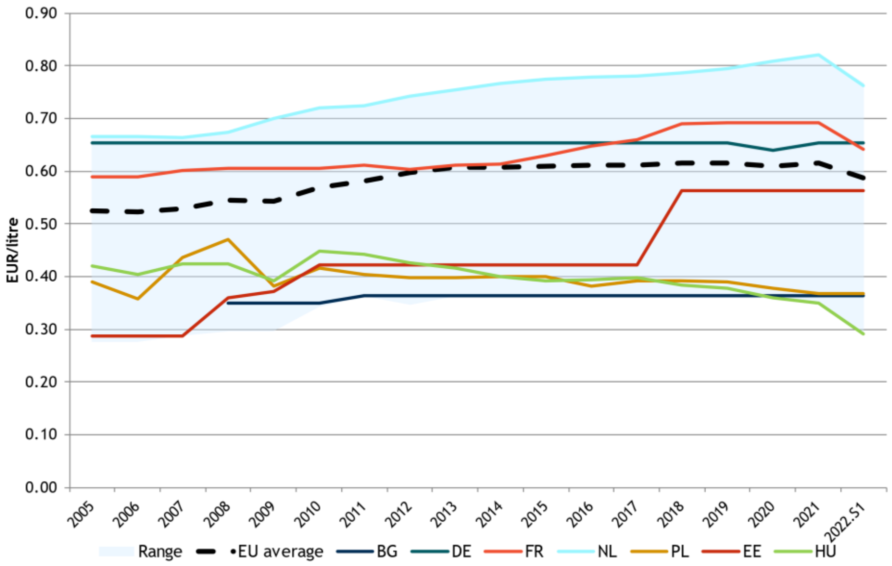


Figure 82: The excise duty rate of gasoline in nominal EUR/litre, including rate changes up to July 2022.

Source: Oil Bulletin, DG Energy.

In a shift towards more consumption-based taxation in the EU, the average VAT rate steadily increased, from 19.3% in 2005 to 21.5% in 2014. However, since 2014, the VAT rate in the majority of Member States has not changed anymore and the average VAT rate in the EU has stayed at 21.5%.

Although the VAT rate is fixed, the effective VAT tax level fluctuates based on the total change in the price excluding VAT. As a result, the VAT tax per litre was 0.24 EUR/litre in 2019 and decreased to 0.22 EUR/litre in 2020 when oil product prices went down. After oil product prices increased again, in the first half of 2022 the average level reached 0.32 EUR/litre.

The total average EU tax component in 2021 was 58%, which reflect peaks in the net fuel price. In comparison, when oil prices were down in 2020 after the first Covid-19 lockdown measures, the tax component was at 65% – Figure 83 shows the changes in the composition of gasoline prices.

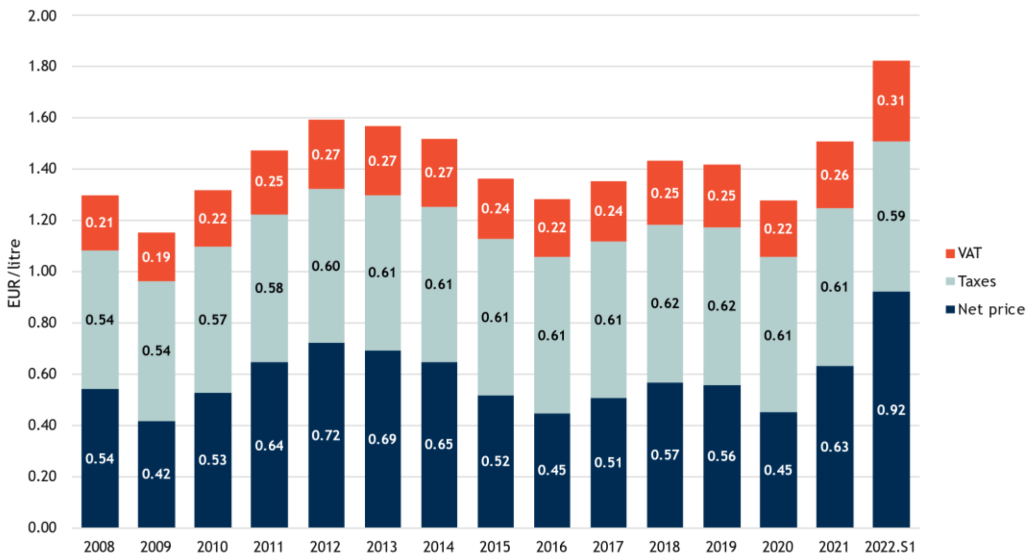


Figure 83: Average retail price of gasoline in the EU in nominal EUR/litre by price component, includes most temporary tax reductions up to July 2022.

Source: Oil Bulletin, DG Energy

The next graph shows the composition of the average gasoline price by Member State in the first half of 2022. As one can see in Figure 84, net prices are very similar (except in Malta due to policy intervention) and price differences mostly are the result from different tax levels (mainly excise taxes). Hungary was the country with the lowest retail price at 1.29 EUR/litre, whilst the Netherlands saw the highest at 2.12 EUR/litre.

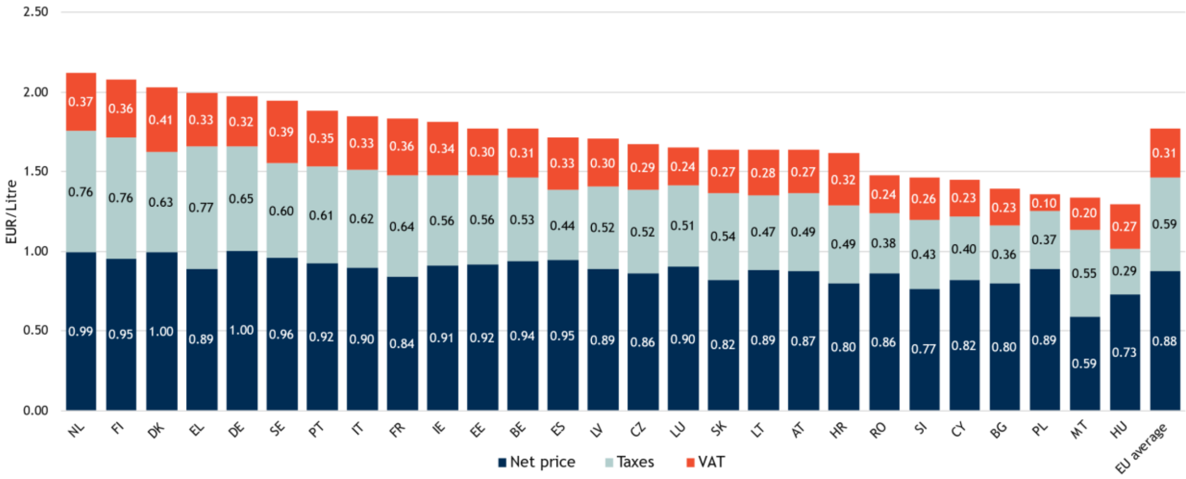


Figure 84: Average retail price of gasoline in the first semester of 2022 by Member State and price component.

Source: Oil Bulletin, DG Energy

4.3.4 Diesel

Similar to gasoline, the evolution of diesel prices followed the trend of the crude oil price and with considerable differences in the absolute level, mainly explained by the diverging excise duty and VAT rates in Member States. In comparison to gasoline prices, average retail prices for diesel diverged more between Member States. The price range grew from 0.26 EUR/litre in 2009 to 0.44 EUR/litre in 2013. Between 2013 and 2021, the difference in diesel prices continued to stay in the same range.

If the two most expensive countries (Italy, Sweden) were disregarded, the range would be considerably narrower. On the lower end of prices in 2021 were Bulgaria (1.06 EUR/litre), Lithuania (1.18 EUR/litre) and Poland (1.18 EUR/litre).

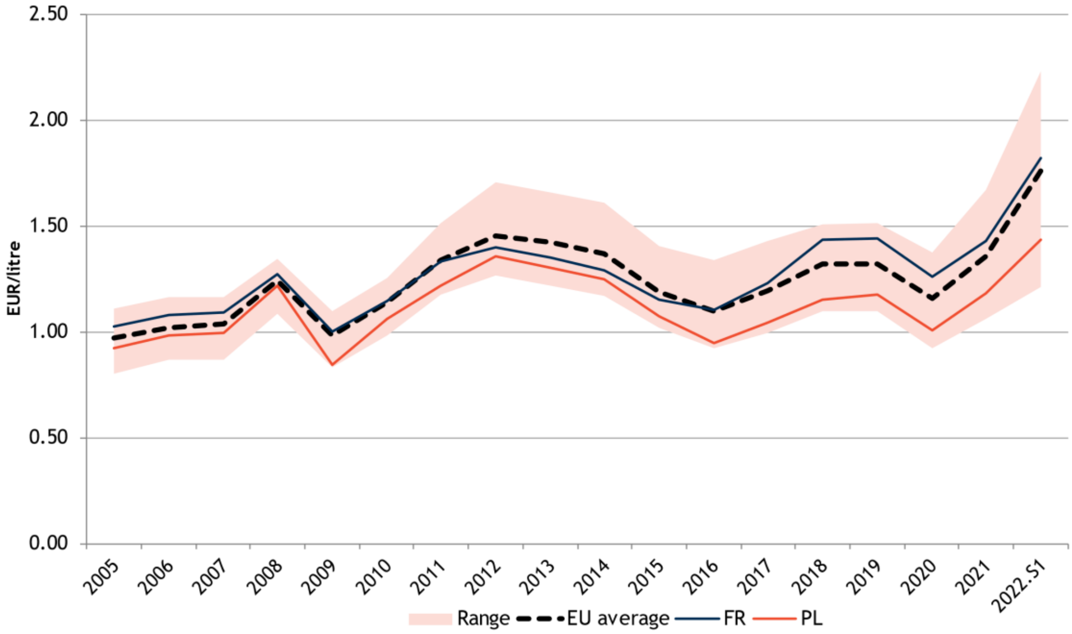


Figure 85: Average retail price of diesel in the EU, including taxes and VAT.

Source: Oil Bulletin, DG Energy

For diesel net prices (without taxes), the differences between EU countries are much smaller than when taxes are included (see Figure 86). This shows that diverging diesel retail prices in Europe are mostly the result of diverging tax rates. Malta— similar as with gasoline prices— is a clear outlier. In the first semester of 2022 net prices on average increased from 0.64 EUR/litre in 2021 to 1.00 EUR/litre, mainly reflecting crude oil price increases. Highest net prices in the first semester of 2022 were in Sweden (1.35 EUR/litre) and Finland (1.15 EUR/litre), lowest were in Hungary (0.81 EUR/litre) and Slovenia (0.83 EUR/litre).

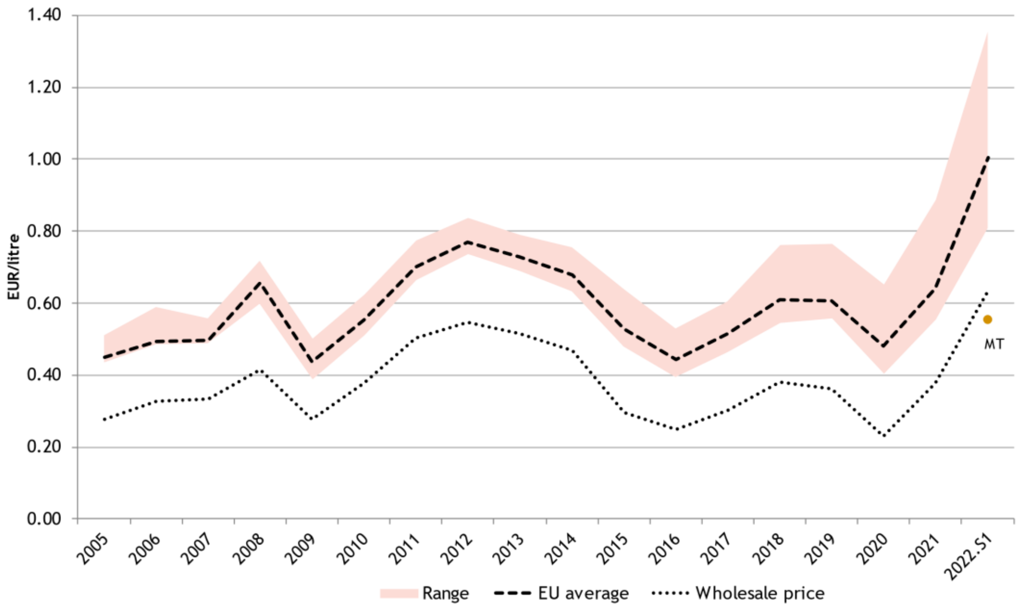


Figure 86: Average nominal retail price of diesel in the EU, *without* taxes

Source: Oil Bulletin, DG Energy, S&P Platts. The wholesale price is Gasoline Prem Unleaded 10ppmS FOB AR Barge reported by S&P Platts
Note: Range in 2022.S1 excludes Malta, which is a clear outlier in 2022 given its frozen gasoline prices is therefore displayed separately.

The nominal excise duty rate of diesel has, on average, stayed close to 0.45 EUR/litre between 2013 and 2022 (Figure 87), which in real terms means that excise duties are gradually reducing. The average shifted upwards from 2010-2013 when Italy increased their excise duty rate by +0.20 EUR/litre (40% increase), reaching a level of 0.62 EUR/litre in 2013 and staying constant afterwards. Excise duties in France also substantially increased between 2014 and 2018 as a result of a new 'carbon' price component. At the lower end of the spectrum, Bulgaria imposes the minimum rate prescribed by the Energy Tax Directive.

Most recently excise duty levels were falling, especially in the first half of 2022, when the average EU rate reduced by 6%. This is mainly the result from (temporary) reductions to compensate for increasing energy prices. For example, in Hungary the average duty rate decreased from 0.33 EUR/litre to 0.26 EUR/litre — the lowest level in the EU (Hungary does have the highest VAT rate in the EU of 27%).

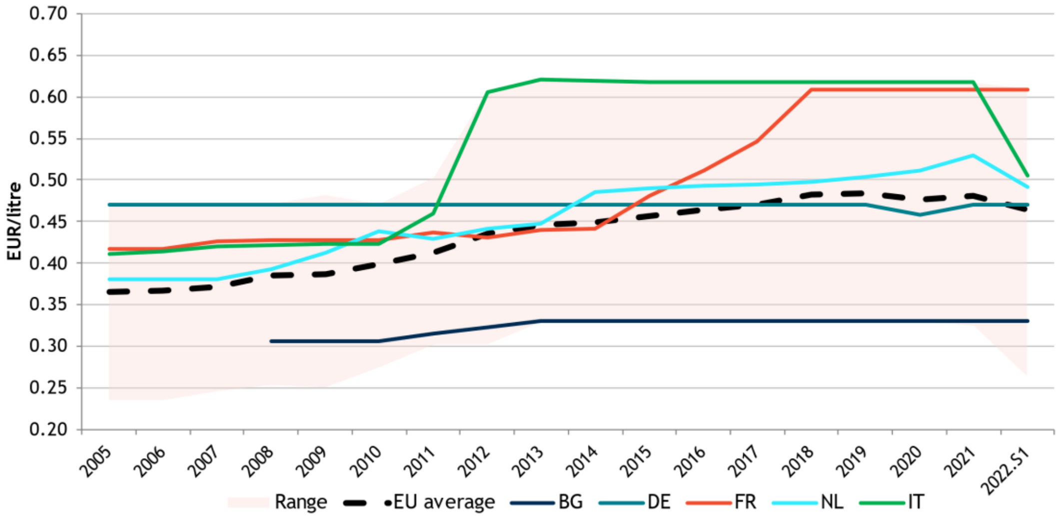


Figure 87: The average EU27 excise duty rate of diesel in nominal EUR/litre, as well as in selected EU countries.

Source: Oil Bulletin, DG Energy

The average (unweighted EU27) VAT rate of diesel also gradually increased from 19.8% to 21.5% by 2016. From 2016 to 2021, VAT rates in all countries were unchanged. In 2021 and the first half of 2022 VAT rates were (temporarily) reduced in Poland (from 23% to 8%), Greece (24% to 20%) and Finland (24% to 21%). Still, the VAT component per litre increased in the first half of 2022 to the highest level since 2012 at 0.29 EUR/litre.

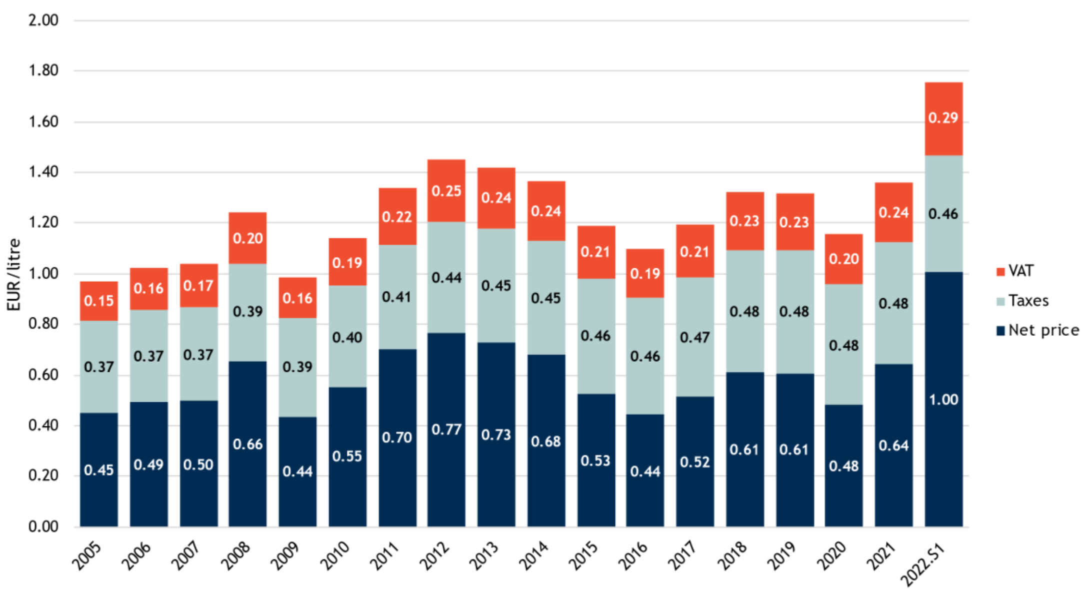


Figure 88: Average annual retail price of diesel in the EU by price component

Source: Oil Bulletin, DG Energy

The next graph (Figure 89) shows the composition of the average diesel price by Member State in the first semester of 2022. Sweden had the highest retail price at 2.23 EUR/litre, Malta the lowest at 1.21 EUR/litre. The high net price component leads to price convergence between EU countries due to a lower absolute influence of taxes and VAT on the retail price. 20 member states have a diesel price between 1.50 EUR/litre and 2.00 EUR/litre, with an average EU price of 1.76 EUR/litre.

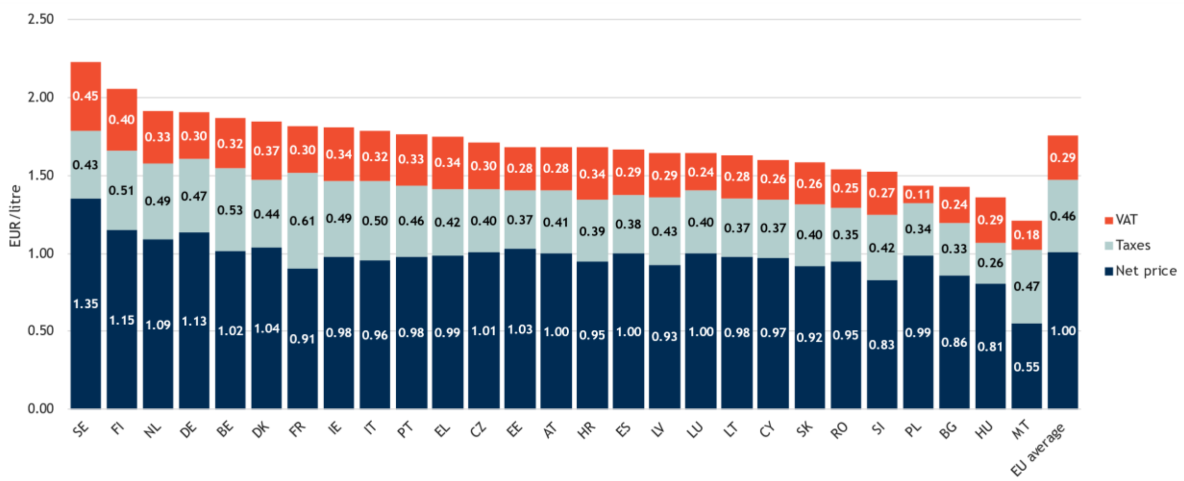


Figure 89: Average retail price of diesel in first semester of 2022 in nominal EUR/litre by Member State and price component.

Source: Oil Bulletin, DG Energy

4.3.5 Gasoline vs diesel

As illustrated in the former sections, gasoline has been typically taxed at a higher rate than diesel. These motor fuels have competed for market shares in the European transport sector, where a lower tax rate on diesel is viewed as one of the key factors in the "dieselization" of Europe by keeping diesel retail prices lower than gasoline, even though the wholesale price of diesel is generally higher. Diesel has a higher air pollutants emission factor per litre consumed than gasoline. On the other hand, diesel engines have higher fuel efficiency and therefore lower CO_2 emissions per km.

The price advantage of diesel, coupled with the improving fuel economy of diesel engines, made diesel cars increasingly popular in the passenger car and light duty vehicle segments in the EU, reaching shares of up to 70-80% in new cars sales in some Member States. In contrast, in other regions of the world, gasoline engines continue to have a dominant role in the passenger car fleet. The “dieselisation” significantly contributed to a gasoline/diesel imbalance: European refineries produce too much gasoline, which has to be exported while diesel output is insufficient to meet demand as Europe has to rely on imports.

The 2015 diesel emission scandal raised renewed questions on the tax advantage of diesel. After unsuccessful attempts to revise the Energy Taxation Directive (ETD) in 2011, the current proposed revision of the ETD of July 2021[42] among others attempts to increase the minimum tax rates of (fossil) fuels and change the tax base from volume to energy content. Given diesel’s higher energy content per litre, this could lead to higher diesel taxes compared to gasoline.

In the longer term, it is expected that electric vehicles will play an increasingly larger role in transport. This change is already apparent in new vehicle registrations. By 2021, fossil shares had decreased to 40% for petrol, 20% for diesel and the remaining 40% being battery electric vehicles (9%), plug-in hybrid electric vehicles (9%), hybrid electric vehicles (20%) and alternative fuel vehicles (3%)[43].

Differences between gasoline and diesel

Since 2005, the average retail price of gasoline has been consistently above the price of diesel, with a 0.14 EUR/litre difference on average in the EU, widening when prices drop and converging when prices increase (Figure 90).

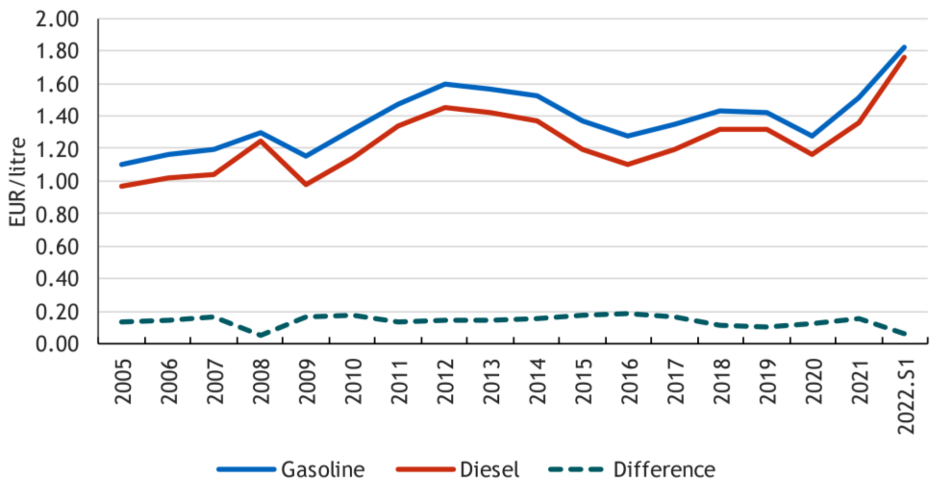


Figure 90: Average retail price of gasoline and diesel in the EU, with taxes (in nominal EUR).
Source: Oil Bulletin, DG Energy

Comparing the prices without taxes (Figure 91), we can see that diesel wholesale prices are higher than gasoline prices over the full period. From 2005 to the first half of 2022, the net price of diesel was on average 0.04 EUR/litre higher than the net price of gasoline.

[42] European Commission (2021). Revision of Energy Taxation Directive.
[43] ACEA (2022). Fuel types of new passenger cars in the EU

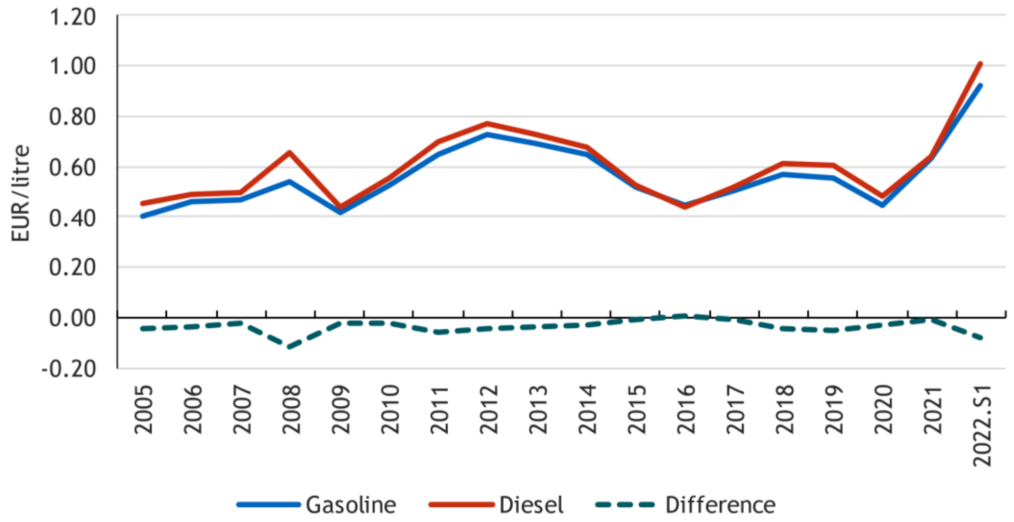


Figure 91: Average retail price of gasoline and diesel in the EU, without taxes (EUR per litre)

Source: Oil Bulletin, DG Energy

The average excise duty rate for gasoline remained around 0.60 EUR/litre since 2012, roughly 0.15 EUR/litre more than diesel (Figure 92), and thereby compensating for the higher net price of diesel. Since 2019, the difference has grown slightly as the result of lower excise duty rates in several Member States.

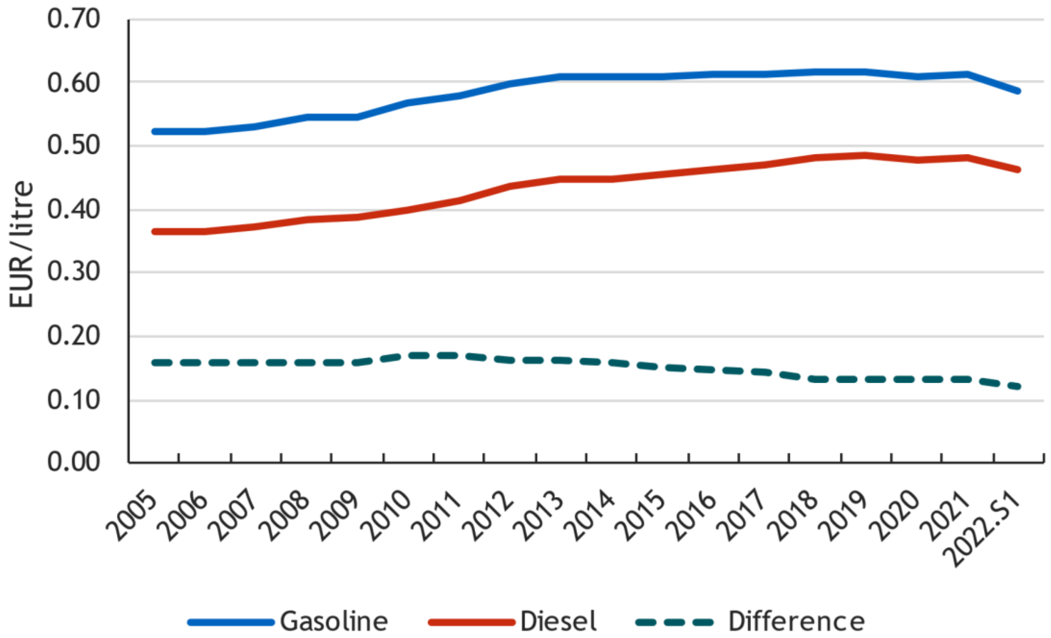


Figure 92: Average excise duty rates for gasoline and diesel in the EU (EUR/litre)

Source: Oil Bulletin, DG Energy

The relative difference between gasoline and diesel excise duty rate was constant from 2005 until 2010, but rates started converging after 2010. As a result, the relative difference reduced from 30% until 2010 to ~22% in 2022.

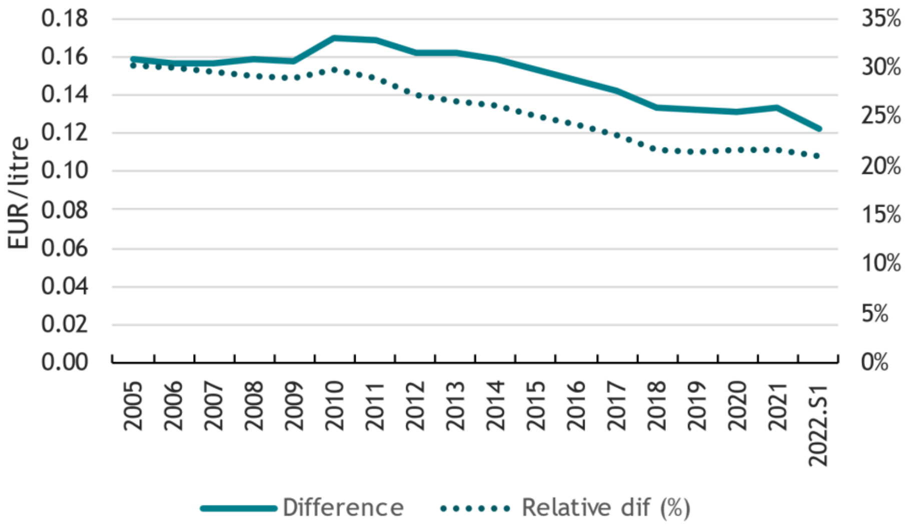


Figure 93: The absolute difference (in EUR/litre) and relative difference (in %) between the average excise duty rate on gasoline and diesel.

Source: Oil Bulletin, DG Energy; (absolute difference = gasoline - diesel)

Figure 94 highlights excise duty changes per Member State. Some movements are highlighted in the figure, particularly the reduction in excise duties for both fuels in Poland and Hungary compared to 2005, and in Germany the significant reduction in excise tax on diesel in the same period. Italy, France and the Netherlands are amongst those that show the highest increase in petrol excise duties in this period.

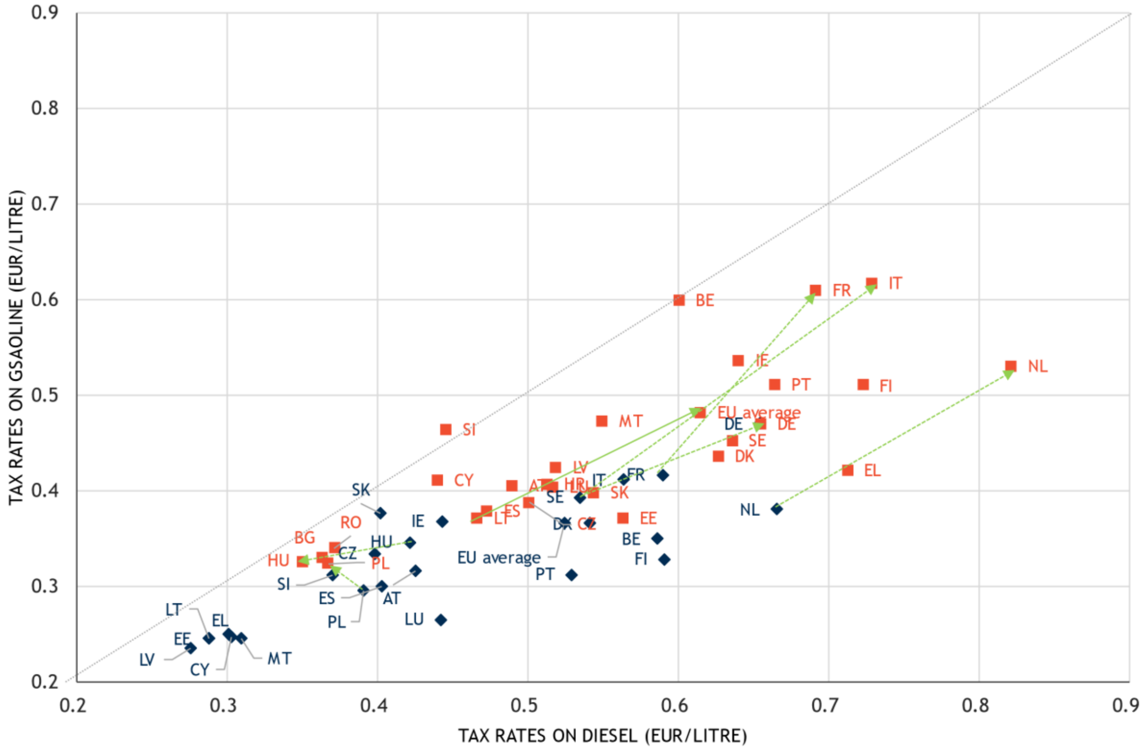


Figure 94: Nominal excise duty rates in individual Member States in 2005 (blue) and 2021 (red).

Source: Oil Bulletin, DG Energy

At EU level (Figure 95), the difference between the average gasoline and diesel excise duty rates decreased from 0.16 EUR/litre in 2005 to 0.13 EUR/litre in 2021. The figure shows that while on average the difference only reduced slightly, there are differences between Member States. For example, in Greece the gasoline excise duty rate more than doubled (+137%) in this period while that of diesel grew by 'only' 68%.

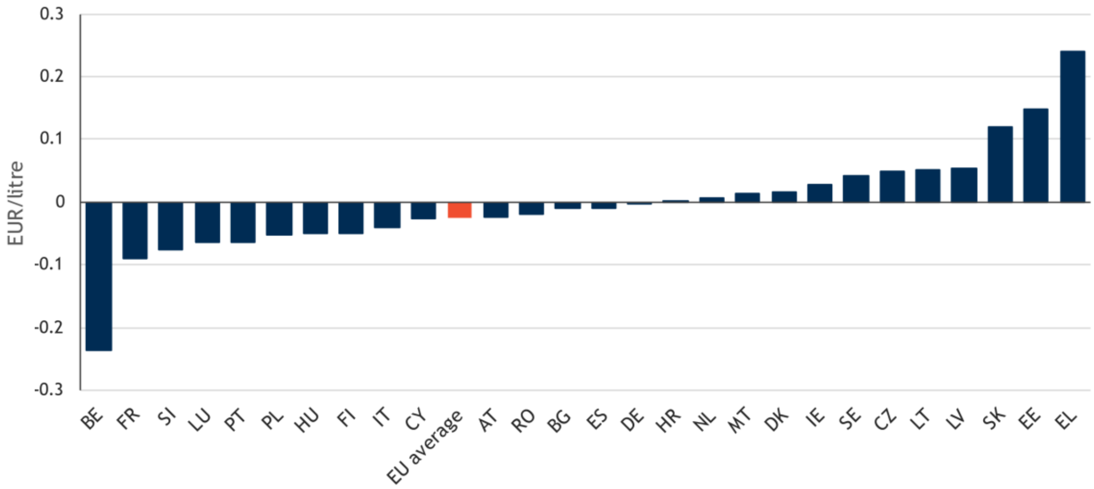


Figure 95: The change of the difference between the gasoline and diesel excise duty rates between 2005 and 2021.

Source: Oil Bulletin, DG Energy
Note: For Bulgaria & Romania the figure shows the change between 2008 and 2021, for Croatia between 2013 and 2021. Example for the graph: In Belgium between 2005-2021 the difference between the gasoline and diesel excise rate reduced with -0.23 EUR from a 0.23/litre difference (gasoline higher) to a 0.00 EUR/litre difference.

Belgium currently is the only MS with unified tax rates for petrol and diesel, although differentials between the two fuels are also very low in Slovenia (only MS with higher diesel than gasoline tax), Cyprus, Hungary, Bulgaria, Romania and Poland. Excise duties for both fuels in the latter four are amongst the lowest of all MS.

4.3.6 Heating Oil

Heating oil delivered 15% of the total household heating demand in 2019.[44] While the use of heating oil in most Member States is decreasing and relatively small, there are a couple of Member States in which the use of heating oil forms one of the primary heating sources for households (see Figure 96). The largest consumers of heating oil are Germany (37% of total EU27 consumption in 2020), Spain (13%), France (13%), Belgium (8%) and Italy (8%).

[44] Odysee-Mure (2020). Heating energy consumption per energy source.

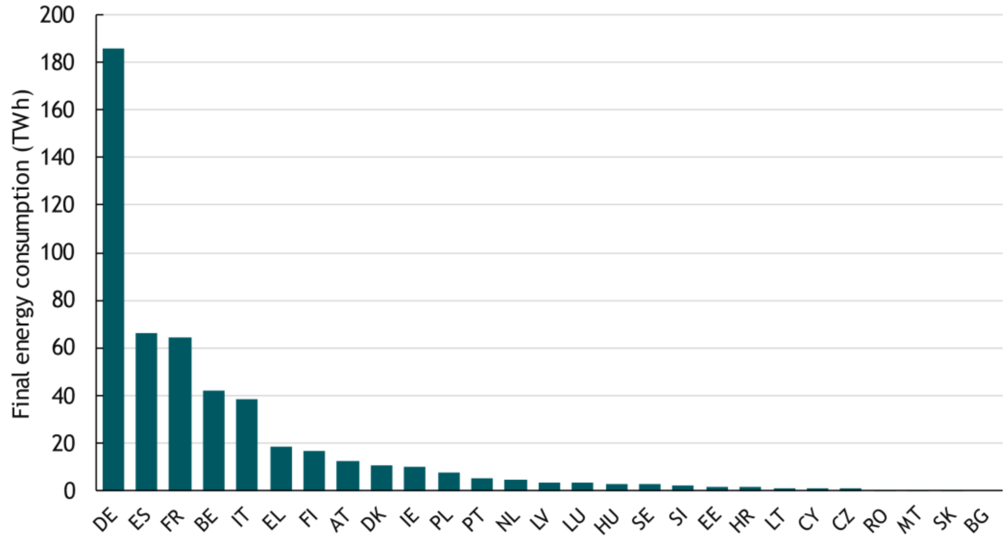


Figure 96: Annual heating oil consumption in 2020 in EU Member States, converted to TWh.

Source: Eurostat

In the first half of 2022, retail heating oil prices have seen a substantial increase throughout the EU: a 50% increase from 0.86 EUR/litre average to 1.32/litre. Price differences between MS remain large due to different excise duty rates. The highest retail price is in Denmark (1.90 EUR/litre) and lowest in Malta (1.00 EUR/litre, due to the earlier mentioned price regulation).

Most of the countries with high heating oil prices have a rather low level of heating oil consumption. Germany however is by far the biggest consumer of heating oil in the EU and its price has been consistently below the EU average (Figure 97). Due to most large consumers having low relative heating oil prices, the consumption-weighted average price in the EU is close to the lowest MS price level.

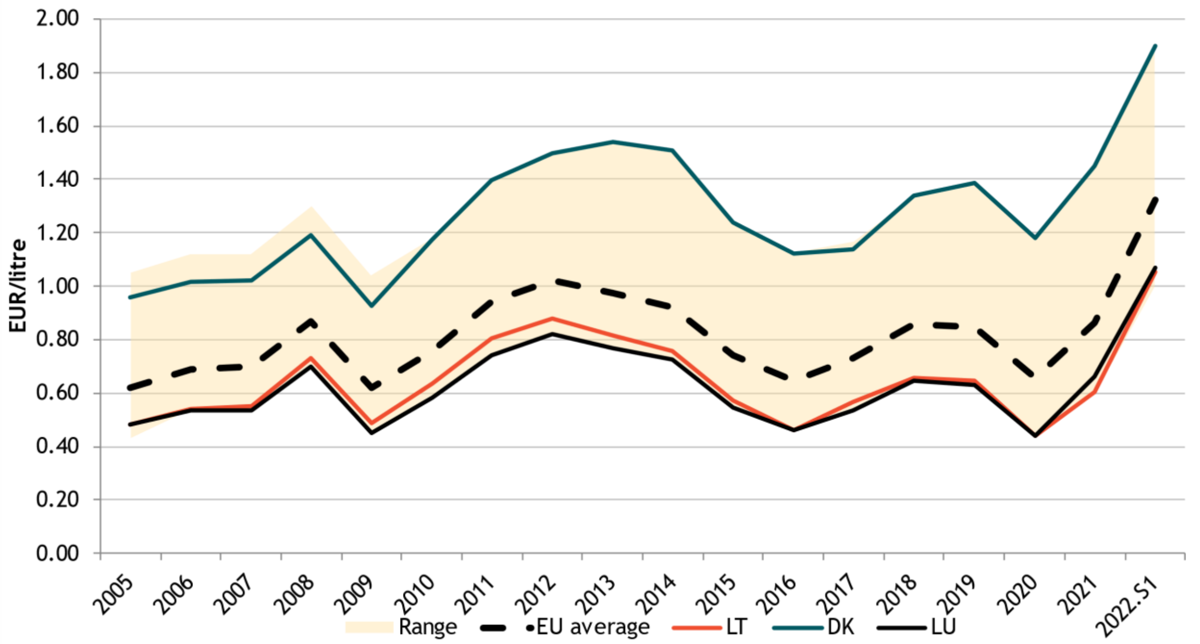


Figure 97: The average retail price of heating oil in the EU, including Lithuania, Denmark and Luxemburg.

Source: Oil Bulletin, DG Energy

The price differences for net prices (without taxes) are smaller but substantial: the range gradually increased from 0.15EUR/litre in 2005 to around 0.30 EUR/litre in 2022. This difference is moderately higher than for other motor fuels. Comparing the EU average net price with a representative wholesale price (Figure 98) shows that retail prices of heating oil have also closely followed the wholesale price.

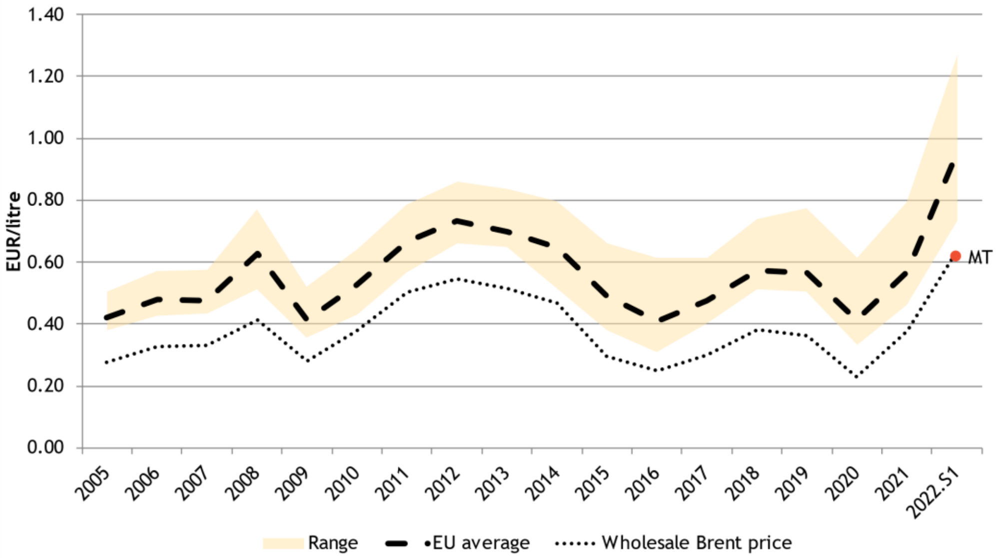


Figure 98: The retail net price of heating oil in the EU, without taxes, compared with the wholesale price of Brent crude oil.

Source: Oil Bulletin, DG Energy, S&P Platts
Note: Again, because of price regulations Malta's price is very low and not included in the range.
The wholesale price is Gasoline Prem Unleaded 10ppmS FOB AR Barge reported by S&P Platts. *The heating oil price in the Netherlands is not included, due to low prices while only having minimal heating oil usage.*

The average excise duty rate of heating oil (Figure 99) has gradually increased in nominal terms since 2005 from 0.10 EUR/litre to 0.15 EUR/litre in 2022. Although most Member States apply a higher rate, the main consuming Member States of heating oil, such as Germany and Spain, have excise duties of respectively 0.06 EUR/litre and 0.09 EUR/litre. In Germany, this is partially compensated by an additional CO_2 tax (trading system) increasing the overall tax level on heating oil.

The Netherlands raised their excise duty rates by a significant amount during the period 2005-2022, and are together with Sweden, Denmark, Portugal and Italy, the countries with highest excise tax rates in the EU as of 2022. The excise rate for heating oil in the Netherlands is equal to the diesel excise tax rate (0.53 EUR/litre in 2021). After a gradual raise of the carbon tax component from 2014-2018 in France, France's rate is now slightly above the EU average. Luxembourg, previously the country with the lowest excise duty rate, raised its rate from 0.01 to 0.06 EUR/litre in 2021, due to a new carbon tax component. The excise rates of Belgium and Lithuania are on the minimum level set by the Energy Tax Directive (0.021 EUR/litre).

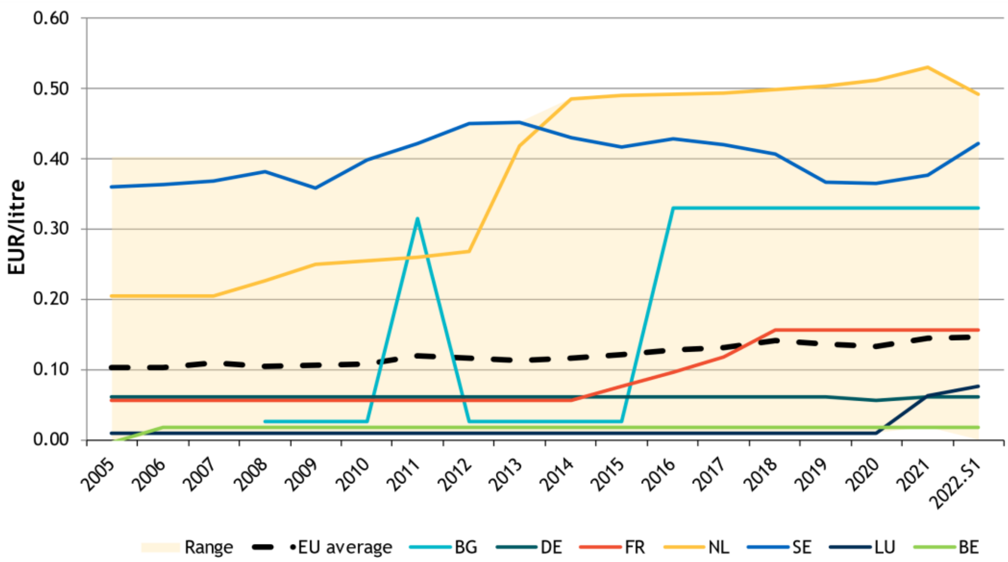


Figure 99: The nominal excise duty rate of heating oil in the EU27 (consumption-weighted average), as well as Bulgaria, Germany, France, Netherlands, Sweden and Luxemburg.

Source: Oil Bulletin, DG Energy

The average VAT rate of heating oil also increased between 2005 and 2021 (Figure 100) from 19% to 21%. Portugal is the sole Member State in 2022 to reduce (temporarily) its VAT rate (from 23% to 13%) in order to mitigate rising energy costs for households.

The average retail price of heating oil follows the same pattern as seen previously for gasoline and diesel, trending upwards and downwards with changes in the wholesale crude oil price. The tax component (tax + VAT) was 37% in 2020 and reduced to 28% in the first half of 2022, its share declining when retail prices increase and increasing when retail prices decrease. In 2022, the average price was 1.32 EUR/litre, consisting of 0.95 EUR/litre net price (72%), 0.15 EUR/litre taxes (11%) and 0.23 EUR/litre VAT (17%).

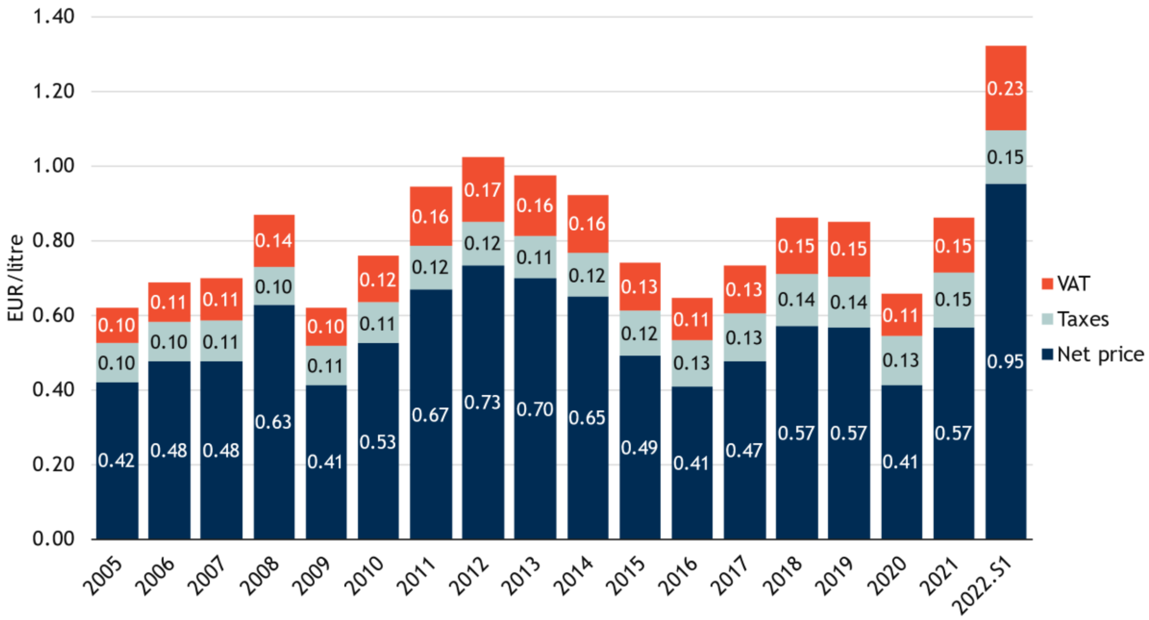


Figure 100: Average retail price of heating oil in the EU (consumption-weighted average) by price component

Source: Oil Bulletin, DG Energy

The next graph (Figure 101) shows the composition of the average heating oil price by Member State in 2022. It shows that Denmark has the highest retail price, followed by the Netherlands and Italy. Belgium, Luxemburg, Croatia, Lithuania and Malta all have comparably low prices between 1.00-1.10 EUR/litre.

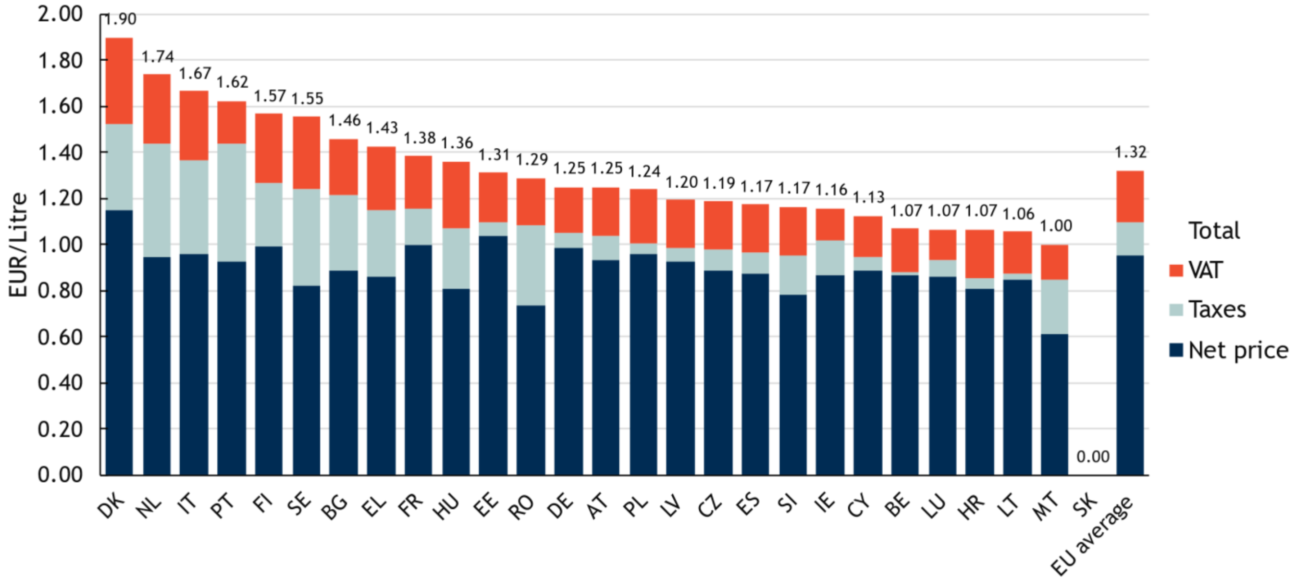


Figure 101: Average retail price of heating oil in the first semester of 2022 by Member State and price component.

Source: Oil Bulletin, DG Energy

4.3.7 International comparison of oil product prices[45]

Gasoline / petrol

Retail prices in all G20 countries, except the UK, are lower than the EU average (Figure 102 and Figure 103). Prices in the US have remained at around half the EU level, despite increasing oil price trend since the start of 2021. Tax is the main differentiator in prices between the EU and other regions. For example, where EU taxes have been on average about 0.85-0.95 EUR/litre since 2008, in the US, taxes (federal + state average) have been around 0.10-0.15 EUR/litre since 2015, and federal taxes have not changed in 30 years.[46]

Of the other G20 countries, retail prices including taxes in Turkey and South Korea used to be higher than the EU average but recently fell below the EU average.[47] Retail prices excluding taxes are higher in several G20 countries, although these prices may not exclude all relevant taxes.

In sum, differences in tax treatment are instrumental in explaining the price differences across G20 countries. As EU taxes on fuels are among the highest globally, it results in a high retail price compared to other G20 countries. Prices have increased significantly since 2020 following the increasing price of

[45] This section is based on price data collected by Enerdata and covers G20 economies.
[46] EIA (2022). Fuel tax overview.
[47] In Turkey lower retail prices are driven by a combination of regulated prices in Turkish Lira in combination with a high inflation rate resulting in devaluation of the exchange rate of the Lira with the Dollar/Euro.

crude oil. Exchange rate effects have a strong influence on retail prices; most oil trade is still conducted in US dollars.

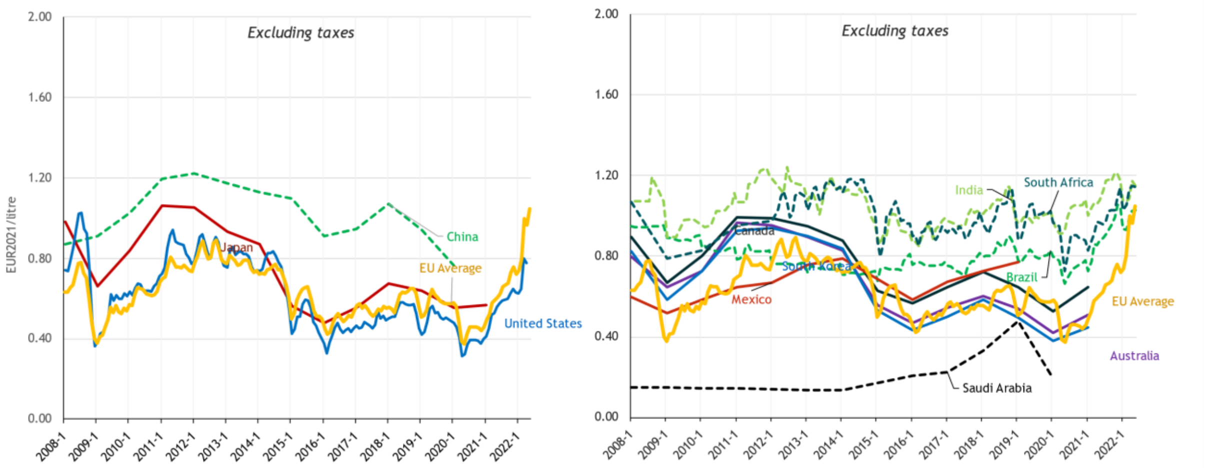


Figure 102: International comparison of retail gasoline prices in EUR2021/litre (real prices), excluding taxes. For some countries, included data is up to May 2022.

Source: Oil Bulletin, DG Energy; IEA; US DoE; Enerdata (METI, ANP, SAPIA)
Note: prices are expressed in real (2021) euros; dotted line highlights that it is unclear if the excluding tax price actually excludes all relevant taxes.

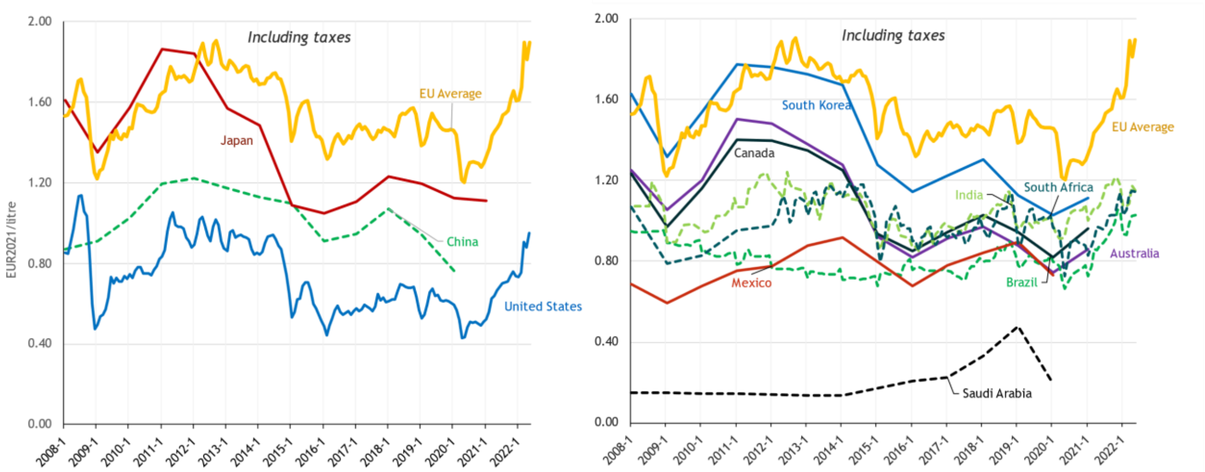


Figure 103: International comparison of retail gasoline prices in EUR2021/litre (real prices), including taxes. For some countries, included data is up to May 2022.

Source: Oil Bulletin, DG Energy; IEA; US DoE; Enerdata (METI, ANP, SAPIA, PPAC)
Note: prices are expressed in real (2021) euros; dotted line highlights that it is unclear if the excluding taxes price actually excludes relevant taxes

Diesel

The international price picture of diesel is similar to gasoline (Figure 104 and Figure 105). The EU average price is the highest among the G20 countries, which is explained by a high tax component - about 50% of the final price. Similar to gasoline, the US retail price for diesel has been roughly half of the EU average price throughout the period, due to much lower taxes in the US around 0.11 EUR- 0.16 EUR/litre. Diesel retail prices excluding taxes are very similar for the EU and US, whilst many other G20 countries have had higher net prices than the EU. Since 2021, prices in the EU and in several other G20 countries (e.g. South Africa, India, and Brazil) have increased significantly following the increasing price of crude oil.

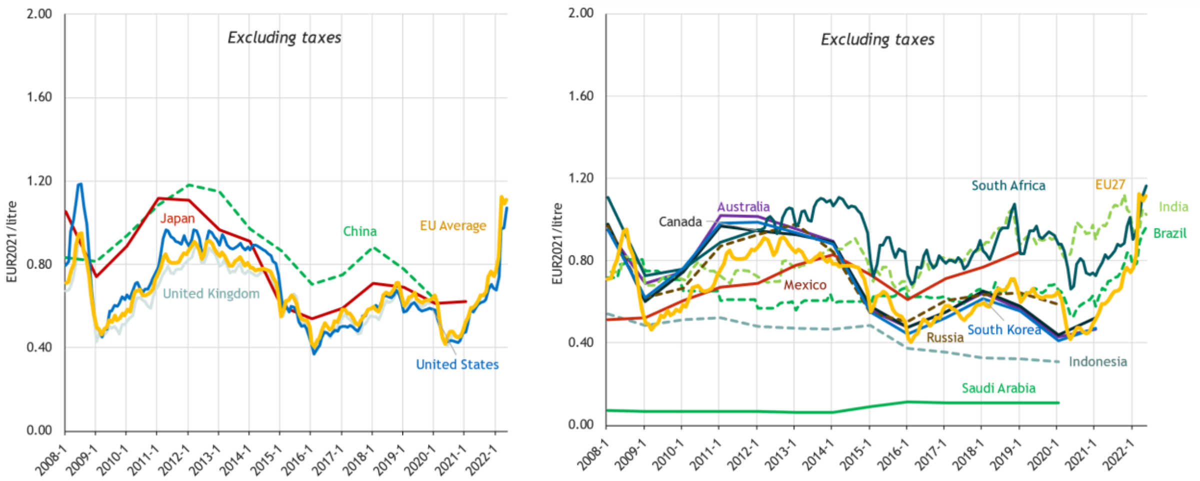


Figure 104: International comparison of retail diesel prices excluding taxes in real EUR2021/litre prices, up to May 2022 for selected countries.

Source: Oil Bulletin, DG Energy; IEA; IEA; US DoE; Enerdata (METI, ANP, SAPIA, PPAC)
Note: prices are expressed in real (2021) euros; dotted line highlights that it is unclear if the excluding taxes price actually excludes relevant taxes

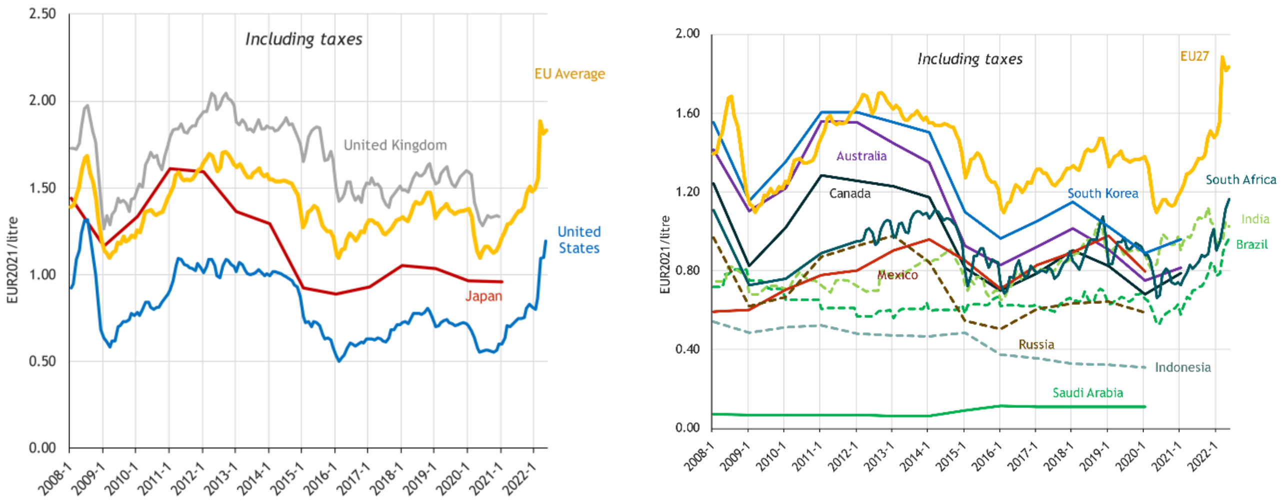


Figure 105: International comparison of retail diesel prices including taxes in real EUR2021/litre prices, up to May 2022 for selected countries.

Source: Oil Bulletin, DG Energy; IEA; EIA; IEA; US DoE; Enerdata (METI, ANP, SAPIA, PPAC)
Note: prices are expressed in real (2021) euros; dotted line highlights that it is unclear if the excluding taxes price actually excludes relevant taxes

Heating oil

EU average prices for heating oil are more similar to other G20 countries, due to the lower average tax rate (Figure 106). Heating oil prices have significantly increased since 2021, which can be seen in the figure for the EU; heating oil data after 2020 is not available for other countries, but a similar (net price) trend is expected in other countries in the period 2021-2022.

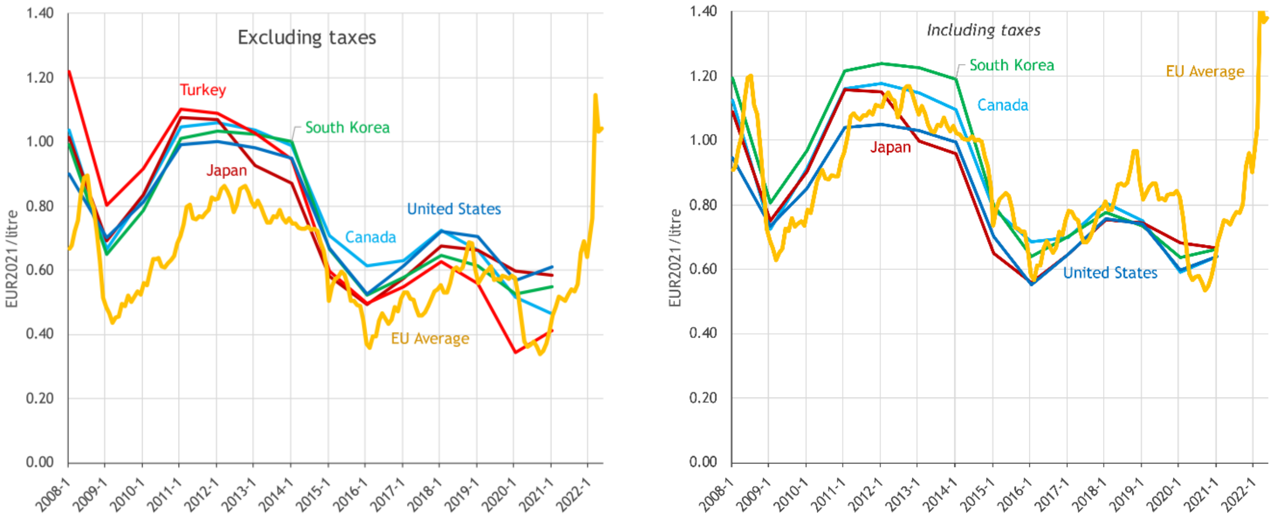


Figure 106: International comparison of heating oil prices in real EUR2021/litre, both including (right) and excluding (left) taxes.

Source: Oil Bulletin, IEA

Heavy fuel oil

Heavy fuel oil (with high sulphur content) is mainly used in marine vessels, due to its lower cost as a residual oil. However, heavy fuel oil also has higher pollutant emissions than less polluting fuels such as diesel and gasoline. Global heavy fuel oil prices have been comparable in the EU, Canada and the US since 2008. Prices in South Korea and Japan are higher, while prices in Mexico on average were lower. Retail prices (including taxes) for heavy fuel oil are significantly lower (about half) of heating oil prices and even a smaller share when compared with diesel and gasoline. This is the result of lower wholesale prices (without tax) due to the low quality of heavy fuel oil and minimum tax levels applied to heavy fuel oil in most countries.

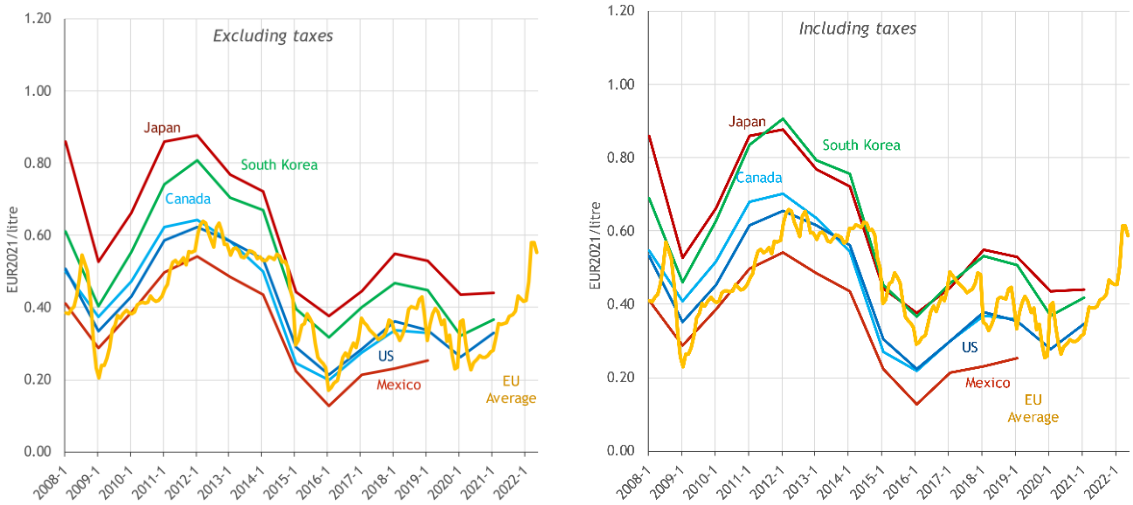


Figure 107: International comparison of heavy fuel oil prices in real EUR2021/litre, both excluding (left) and including (right) taxes.

Source: Oil Bulletin, IEA

4.4 Alternative fuels

In this and the next section, we are analysing the consumption and prices of the following alternative fuels[48]: liquefied petroleum gases (LPG), biogasoline (pure or blended), biodiesel (pure or blended), other liquid biofuels and biogases.

4.4.1 Consumption

The use of alternative fuels has been promoted in order to substitute fossil oil-based fuels and their volume has more than tripled since 2005. However, they still represent only a small fraction the used energy in transport and together represented only 3.6% of final energy consumption in the EU in 2020 (Figure 108).

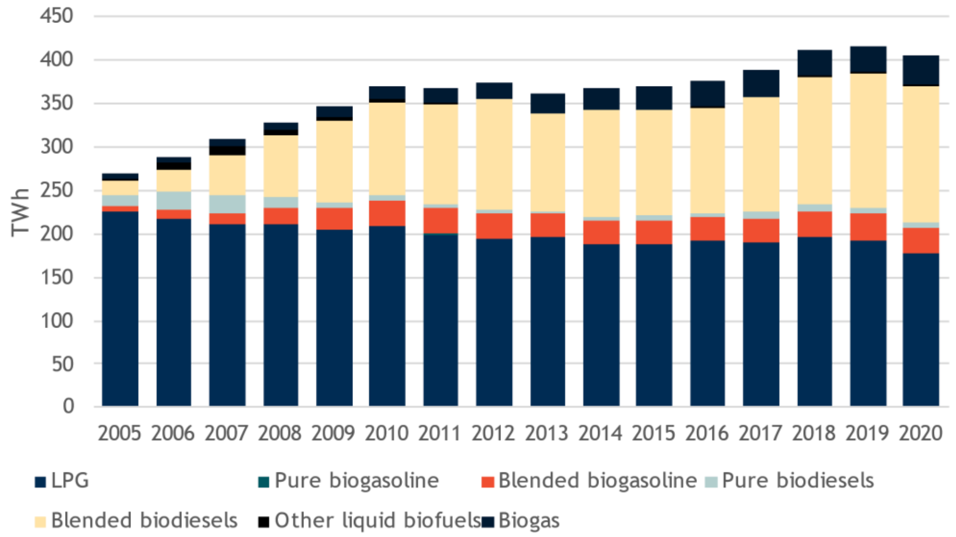


Figure 108: final energy consumption in all sectors combined for selected alternative fuels

Source: Eurostat, all figures in GWh.
Note: The consumption values of blended fuels refers only to the energy content of the biofuel. For example: in case 100 TWh of blended biodiesel with 5% pure biodiesel is used, blended biodiesel consumption is 5 TWh.

About 61% of alternative fuels is consumed for transport (Figure 109). Blended fuels (biogasoline and biodiesels) account for the majority of alternative fuel consumption (73% of total consumption in transport).

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48 The proposed Regulation on the deployment of alternative Fuels Infrastructure defines alternative fuels as "fuels or power sources which serve, at least partly, as a substitute for fossil oil sources in the energy supply to transport and which have the potential to contribute to its decarbonisation and enhance the environmental performance of the transport sector, including a) **alternative fuels for zero-emission vehicles** (electricity, hydrogen, etc.), b**) renewable fuels** (bio and synthetic) and c) **alternative fossil fuels** for a transition phase (CNG, LNG, LPG)".

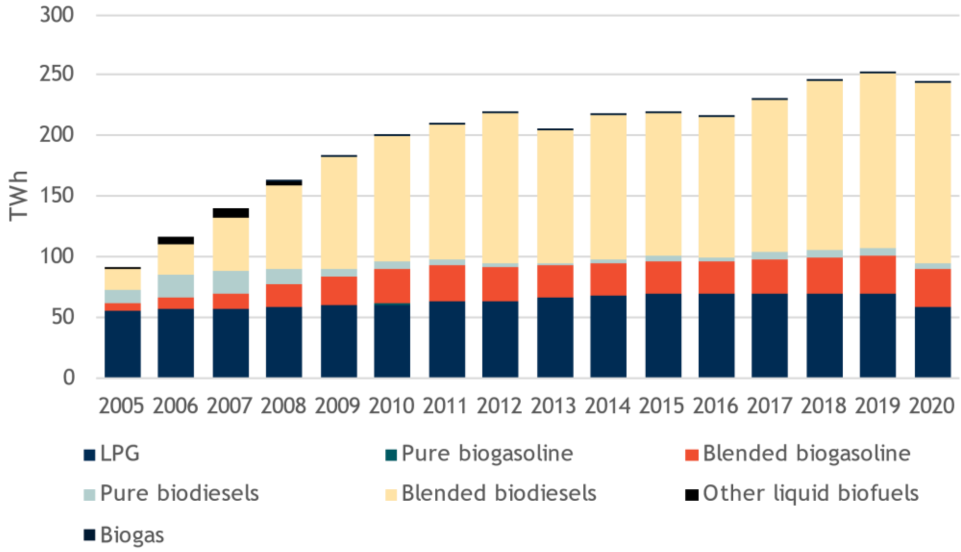


Figure 109: Transport Final Energy Consumption of selected alternative fuels

Source: Eurostat, all figures in TWh.

Household consumption is 29% of the total. LPG is the main alternative fuel used by households (Figure 110), mostly used for heating and cooking as substitute for natural gas in homes not connected to the gas grid. In addition, biogas use was 20 TWh in 2020.

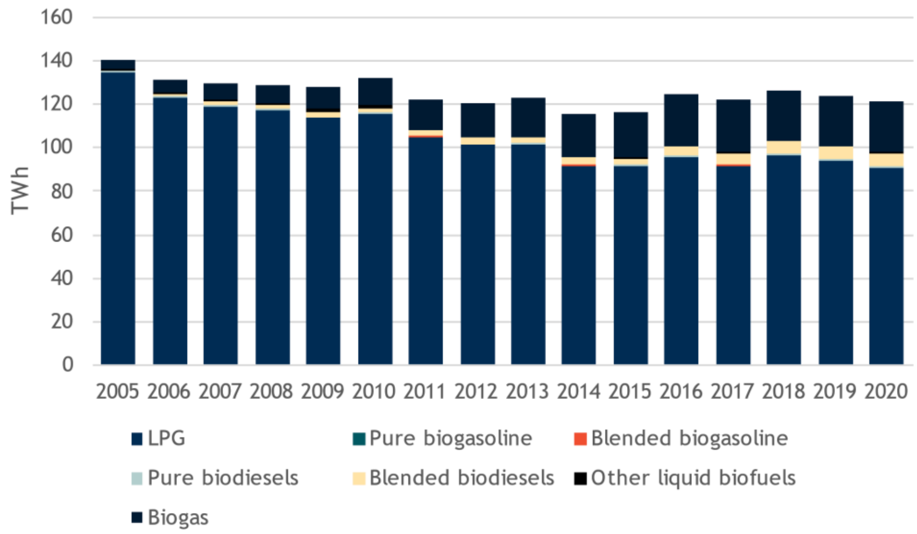


Figure 110: Household (and other sectors) Final Energy Consumption of selected alternative fuels

Source: Eurostat, all figures in GWh.

Industrial use of alternative fuels account to 9% of the total. In industry LPG is the most widely used alternative fuel with small shares of biogas and blended biodiesels (Figure 111).

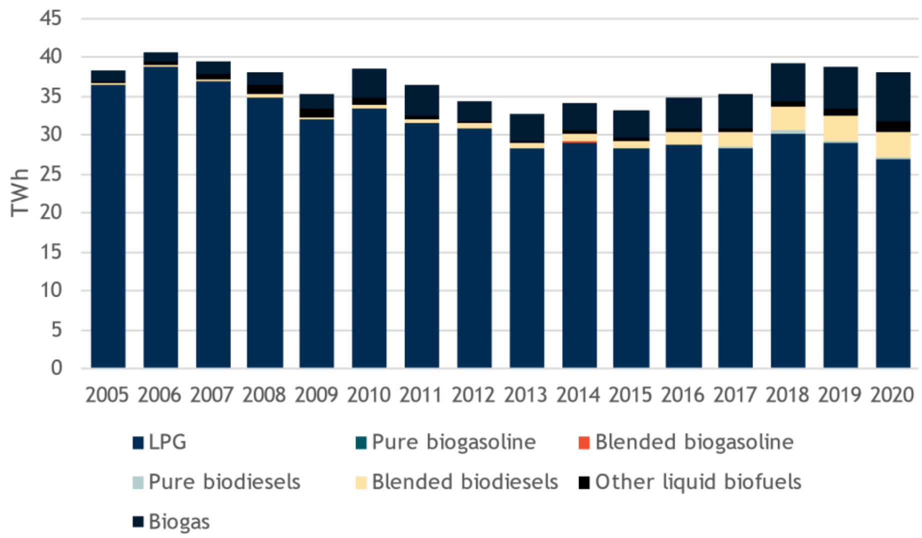
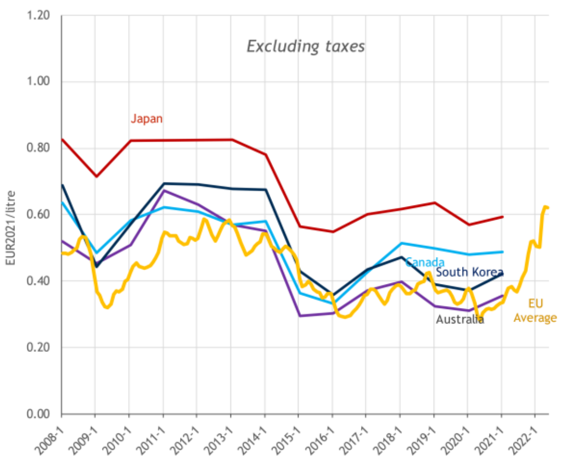


Figure 111: Industrial final energy consumption of selected alternative fuels.

Source: Eurostat, all figures in TWh.

4.4.2 LPG

In the case of Liquefied Petroleum Gas or LPG used for transport (Figure 112), EU average retail prices including taxes fluctuated within a relatively small range between 2008 and 2020. Since 2021, the EU average price has increased sharply, and a similar trend is expected in other countries, although this data is not available yet in the figure below. Price trends follow crude oil prices, the feedstock for most LPG production.



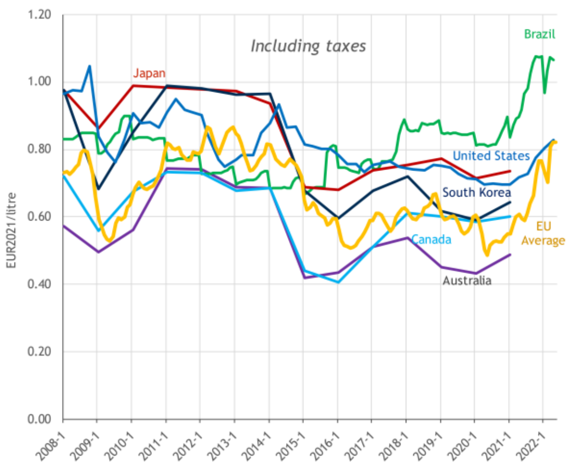


Figure 112: International comparison of retail prices of LPG in real EUR2021/litre, both excluding taxes (left) and including taxes (right)

Source: EU Oil Bulletin, IEA; US DoE; Enerdata (METI)

4.4.3 Biofuels

Bioethanol prices (Figure 113) in the two main global producers — the US and Brazil — are relatively similar and have been around 400 EUR2021/Mt between 2015 and 2020. Since 2021, bioethanol prices in Brazil started increasing to 600 EUR2021/Mt on the back of higher global fuel prices. Although data is

lacking, a similar recent trend can be seen in the US (US ethanol Chicago pipeline price).[49]
Prices in the EU (T2 Rotterdam Barge) are in general 50-150% higher, due to higher local production costs.[50] Bioethanol E85 prices — a blend of 85% bioethanol with 15% gasoline — are primarily driven by gasoline prices and are therefore closely related to gasoline price movements.

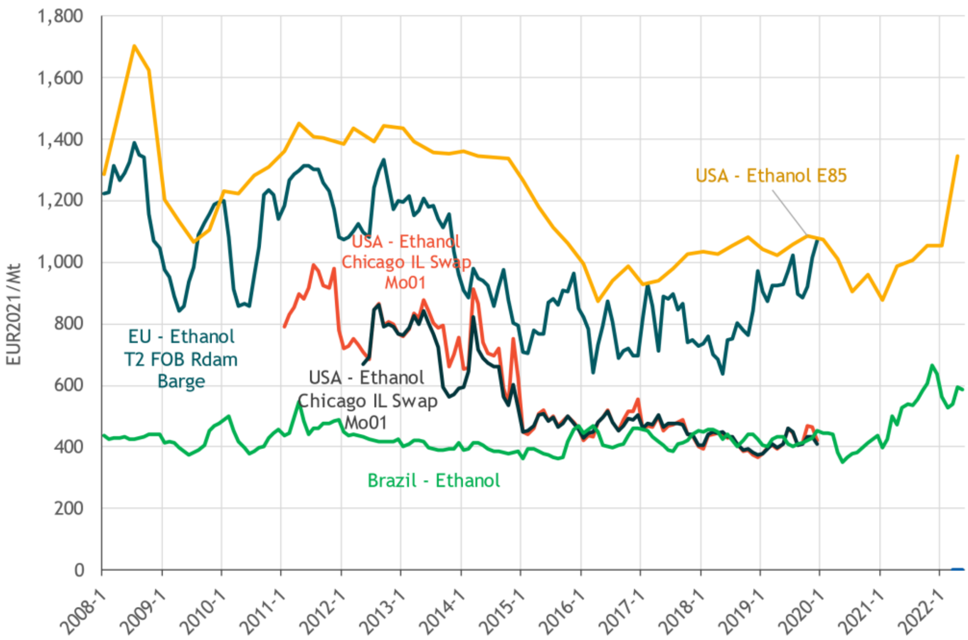


Figure 113: International comparison of bioethanol prices and Bioethanol E85 (bioethanol mixed with gasoline) in real EUR2021/litre.

Source: S&P Platts, US AFDC, Enerdata (ANP)

For biodiesel, wholesale prices (excl. taxes) in the EU are similar to the US, due to biodiesel prices being very much correlated with diesel and thus crude oil prices, as engines running on biodiesel can switch to diesel in case of high prices. Prices in Asia (Biodiesel FOB SE Asia) are in general 100-200 EUR2021/Mt lower than in the US and EU. Most recent price data from the US (Biodiesel B99, Figure 114) shows that, similar to bioethanol, prices have increased through 2021 and 2022, from around 8,008 EUR2021/Mt in 2021 to around 12,002 EUR2021/Mt in 2022. While detailed data is not included, other regions have seen similar price increase trends.

[49] A (small) part of the price movement is explained by a decline in the EUR:USD exchange rate, increasing the EUR value of US prices.
[50] Mizik et al (2020). The Major Driving Forces of the EU and US Bioethanol Markets with Special Attention Paid to the COVID-19 Pandemic

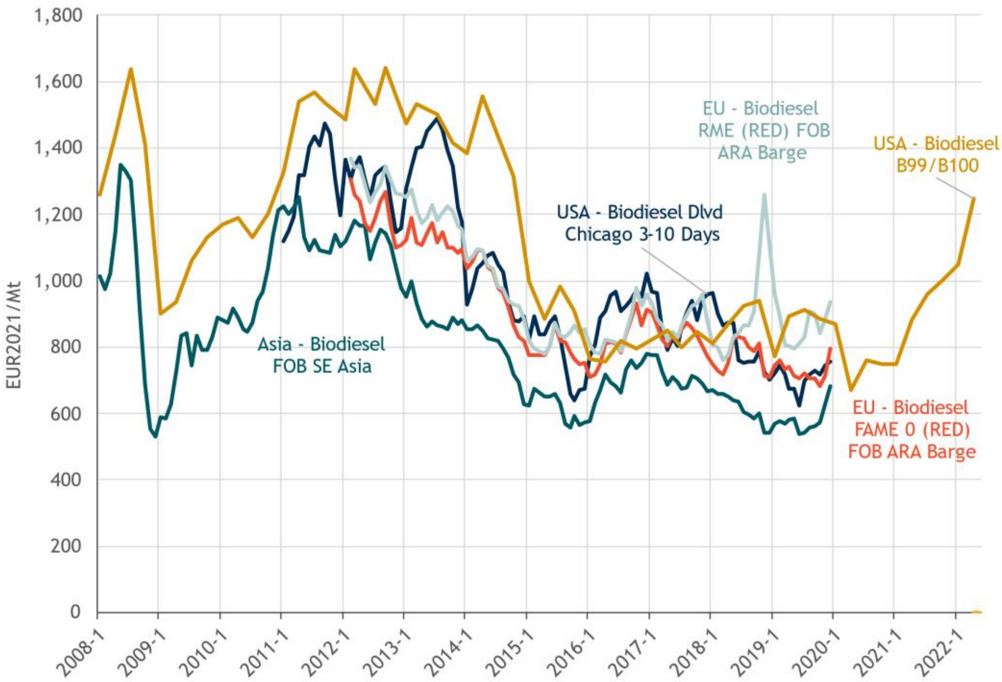


Figure 114: International comparison of wholesale prices of biodiesel

Source: S&P Platts

4.4.4 Electric mobility

Home charging for households

Households either have the choice to subscribe to a home EV charging service (for which they will be provided a dedicated tariff for charging EVs) or to charge their vehicle using a "normal" electricity tariff (the tariff charged for all household activities). According to our survey, all countries investigated (EU27 and non-EU27 countries), have off-peak tariffs (see Table 2).

Table 2: Survey on off-peak tariffs (2022)

	Country	Off peak tariff
EU27	France	YES
	Austria	YES
	Belgium	YES
	Germany	YES
	Spain	YES
	Sweden	YES*
	Denmark	YES
	Finland	YES
	Norway	YES
Non-EU	UK	YES
	China	YES
	Japan	YES
	South Korea	YES**
	Canada (Ontario)	YES
	USA	YES
	Australia	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).
**South Korea: Incremental prices, with seasonal prices. This is not really off-peak prices with differentiated prices during a day.
Source: Author

Figure 115 depicts average off-peak and on-peak tariffs dedicated to EV charging at home. Values are given for EU countries (blue shade) and non-EU countries (dark shade). Orange diamonds mark the household average electricity price (a tariff used for all household activities not only EV charging).

Average off-peak and on-peak tariffs dedicated to at home EV charging varies substantially throughout the world. The countries with the lowest off-peak tariffs are South Korea, Canada (Ontario) and Australia (New South Wales). Spain has the lowest off-peak tariffs in the EU. In almost every country, dedicated EV charging services seem attractive: off-peak and on-peak tariffs are lower than the average household average electricity price.

In addition, in some countries (e.g. Canada, the USA and Norway), subscribing to a preferential EV charging system "sanctions" households if they charge during on-peak period: in peak-hours they will pay more than if they were using a "normal" electricity tariff. Therefore, the cost savings of using such charging systems as a household depends not only on its consumption pattern for EV charging but also for other electricity use.

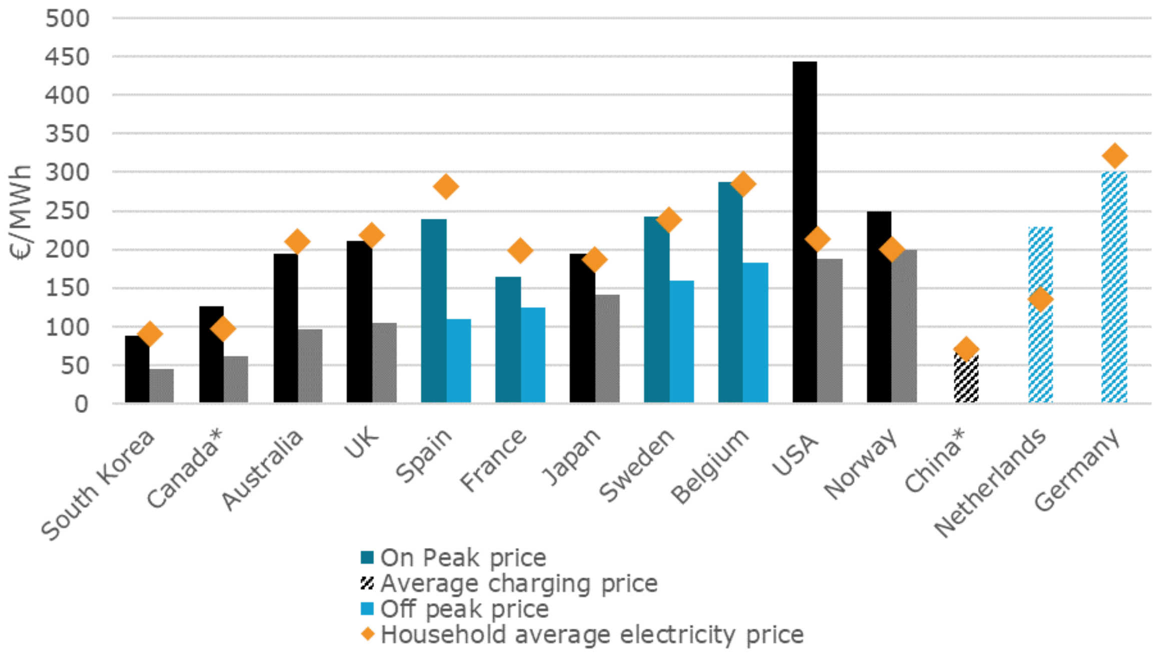


Figure 115: EV charging price at home in 2021 for both on peak and off peak charging, as well as the household average electricity price.

Source: Authors calculation based on Eurostat (2022) data and national sources
*Note on prices: China: average 2020 EV charging price at home; *Canada: Ontario Price; *USA: California Price; *Australia: New South Wales price*

Public charging stations

Two types of public charging stations exist: 'normal' Alternative Current (AC) and fast' Direct Current (DC) charging stations.

'Normal' AC charging is preferred for long-period parking (>20mins) and is most common currently on the market due to their low costs (including production, installation, and functioning costs). These AC charging stations allow EV recharging within a few hours; it can provide up to 22 kW of charging power.

DC (fast) charging stations normally provide around 50 kW or more (and can reach an output of 250 kW) and are typically used for time periods of up to 30 minutes.

Figure 116 shows the minimum-maximum prices found at different AC public charging stations in various countries. The orange diamond represents the average AC station price. The dark dotted line illustrates the average EU household electricity price; this element illustrates the tariff difference between AC public charging and home charging.

Slovakia, Portugal, Hungary and Czechia have the lowest public AC charging prices. The differential between minimum and maximum prices can be quite significant (e.g. in the Netherlands, France, Austria and Belgium). In Slovakia and Portugal, the average AC public charging price is cheaper than the EU27 average household electricity price. Other countries such as Czechia, Spain and Belgium also have several AC public chargers with lower prices than the EU average household electricity price.

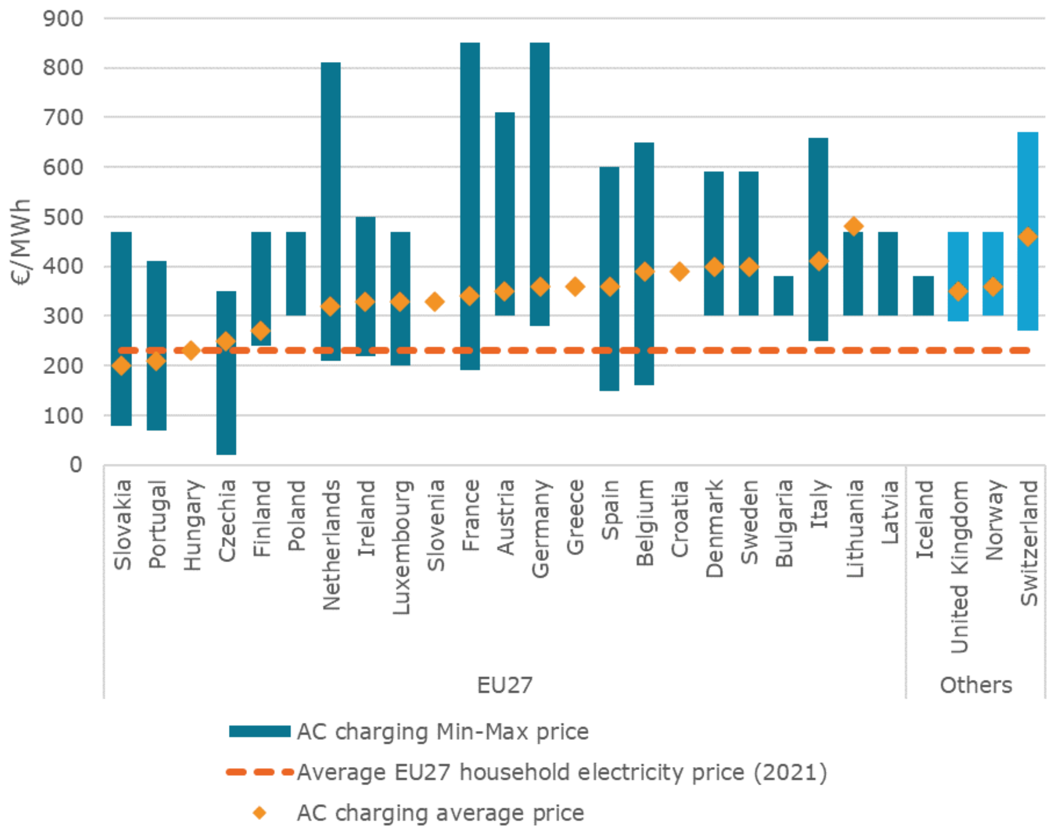


Figure 116: AC public charging price (EUR/MWh, 2022)

*Excluding Romania and Estonia
Source: Authors calculation from European Alternative Fuels Observatory; Eurostat; National sources

Figure 117 shows the minimum-maximum prices found at different DC public charging stations in various countries. The orange diamond represents the average DC station price. The dark orange dotted line illustrates the average EU27 household electricity price.

In general, DC charging prices are around 40% higher than those for AC charging. Portugal, Finland, Czechia, and Hungary have the lowest DC charging tariffs. The differential between minimum and maximum prices can be quite significant (e.g. in France, Germany, the Netherlands or Belgium). Portugal on average has lower DC charging prices than the EU27 household electricity price, while Czechia and Luxembourg also report minimum prices below this level.

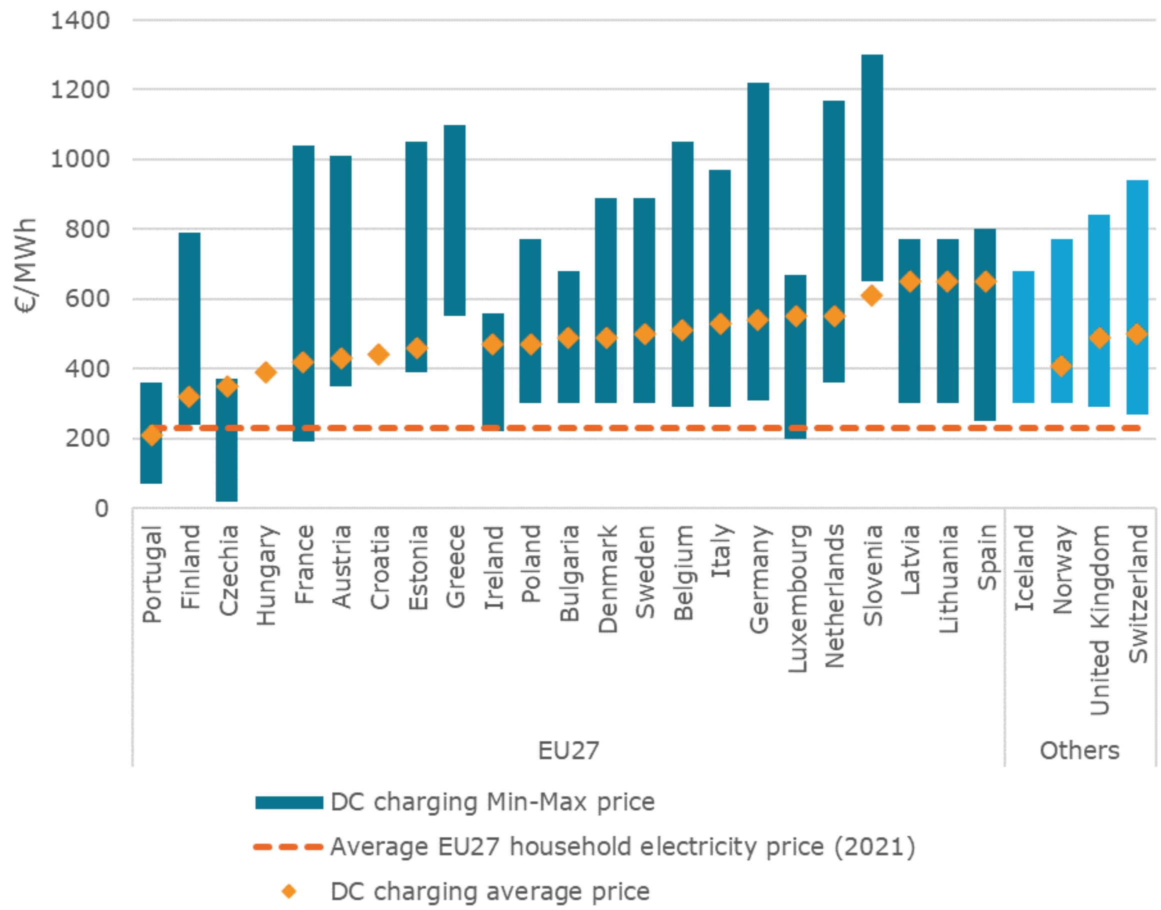


Figure 117: DC public charging price (EUR2021/MWh

Source: Authors calculation from European Alternative Fuels Observatory; Eurostat; National sources
*Excluding Romania

4.4.5 Electricity Storage

The cost of electricity storage is a complex indicator depending on multiple factors. When comparing the storage cost at country level in Europe, there is currently *no structured harmonized data*. When comparing storage technological choices, many studies and articles focus on the investment cost only. As this does not cover all cost components, it is often misinterpreted. For instance, a cheaper battery pack (in EUR/kWh) does not always lead to lower storage costs. The considered application and the type of service determine the eventual storage cost.

Whilst imperfect, the 'Levelised Cost of Storage' (LCOS)[51] indicator offers a more complete overview of the cost of storage by including the type of application and several economic factors (such as the cost of capital). Depending on the storage functionality needed for the project, the LCOS can be estimated in EUR/MW or EUR/MWh.

[51] The LCOS quantifies the discounted cost per unit of discharged electricity for a specific storage technology and application.

The cost of storage is less dependent on the country of installation[53], but more on the type of application it is installed for. The main factors influencing the cost of storage are:

- the technology (within which the important factors are CAPEX, OPEX, lifetime, self-discharge…),
- the frequency of use (number of cycles per year),
- the total capacity installed (in MW),
- the typical discharge duration (and thus the energy storage capacity in MWh).

In addition, not all technologies are suitable for all applications. For instance, the slow response time of Pumped Hydro Energy Storage (PHES) makes this technology unsuitable for primary response applications.

Different studies have estimated the LCOS. The most complete, a 2019 analysis by Schmidt et al. (Figure 118) compared the cheapest energy source for various technologies using both the LCOS in power terms (i.e. annualized capacity cost) and in energy terms.

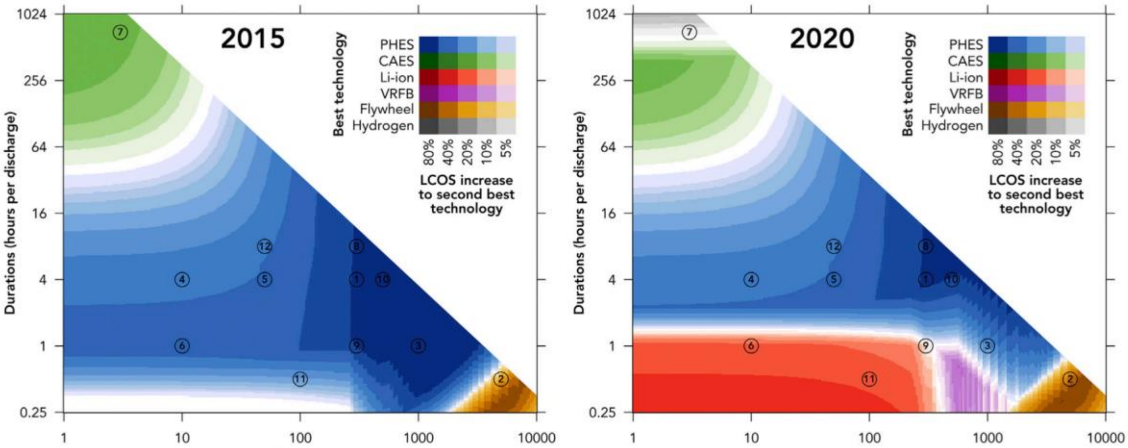


Figure 118: Technology with the lowest LCOS in energy terms (US$/kWh) for various use cases[52]

N.B: Circled numbers represent the requirements of 12 key applications[53]. Colours represent technologies. Shading indicates how much higher the LCOS of the second most cost-efficient technology is; meaning lighter areas are contested between at least two technologies, while darker areas indicate a strong cost advantage of the prevalent technology. White spaces mean LCOS of at least two technologies differ by less than 5%. The LCOS is estimated for an electricity price of 50 US$2018/MWh, a simulation made for a 500 US$/MWh price in 2030 gives a slightly higher advantage to Li-ion.

Back in 2015, pumped hydro (PHES) was still the cheapest storage technology for most applications (except seasonal storage, which is dominated by compressed air). Since then, Li-ion has gained strong traction and has become the preferred choice for three applications (Black Start, Power Quality and power reliability) and it is expected to become the lowest-cost technology for 9 out of 12 applications by 2030. Batteries can support different applications (e.g., primary and tertiary responses) thus giving them an advantage over flywheels. Batteries have also **no geographic limitation and can be installed almost anywhere**. This is a strong advantage versus hydro and compressed air, which have a limited development potential in Europe due to a lack of relevant locations.

[52] Schmidt et al. Projecting the Future Levelized Cost of Electricity Storage Technologies
53 1 - Energy Arbitrage ; 2 - Primary Response ; 3 - Secondary Response; 4 - Tertiary Response; 5 - Peaker Replacement; 6 - Black Start; 7 - Seasonal Storage; 8 - T&D Investment Deferral; 9 - Congestion Management; 10 - Bill Management; 11 - Power Quality; 12 - Power Reliability

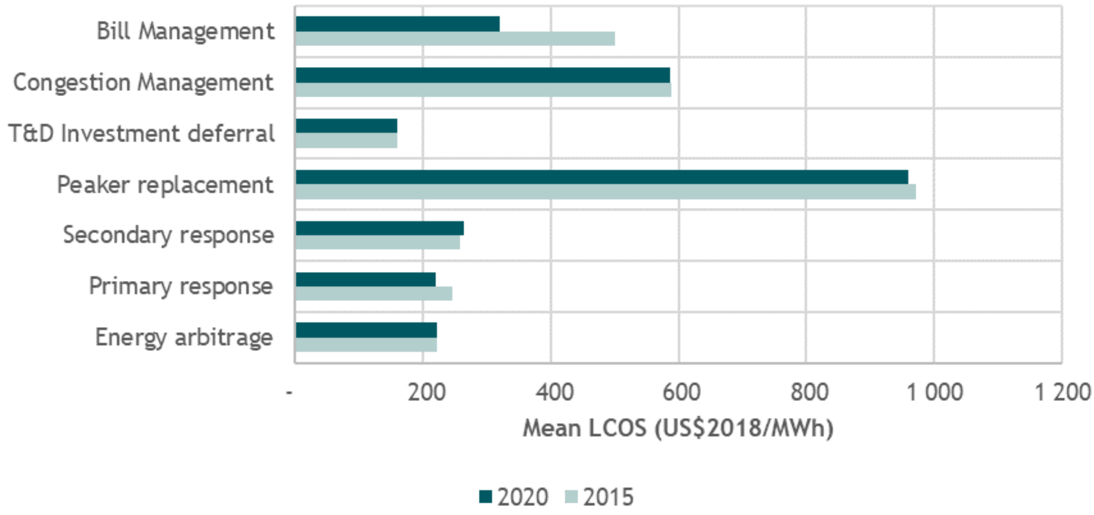


Figure 119: Mean LCOS of the most efficient technology for different applications ($US2018/MWh)

N.B: We did not include Tertiary response, Black start, Seasonal storage, Power Quality and Power Reliability that have LCOS over 1000 US$2018/MWh

Focus on Li-ion batteries

The majority of li-ion battery applications are in electric vehicles (75% in 2022[56]) in the short to medium term. However, in the smaller market of stationary storage, Li-ion is becoming a reference technology for two types of applications:

- **Front of meter large-scale stationary storage**. In particular for primary and secondary reserve applications (depending on countries' legislations).
- **Behind the meter residential storage.** In particular in Germany (70% of newly installed storage capacity in 2020[54]) and to a lesser extent in Italy. While Germany benefits from historical market penetration (thanks to past subsidies), a high rate of residential PV and a high electricity price, the Italian market is mainly driven by national subsidies.

For primary reserve applications, the initial capital cost of the Li-ion battery represents 65 to 70% of the project's total levelised costs.

[54] SolarPower Europe (2021). European Market Outlook for residential battery storage 2021-2025.

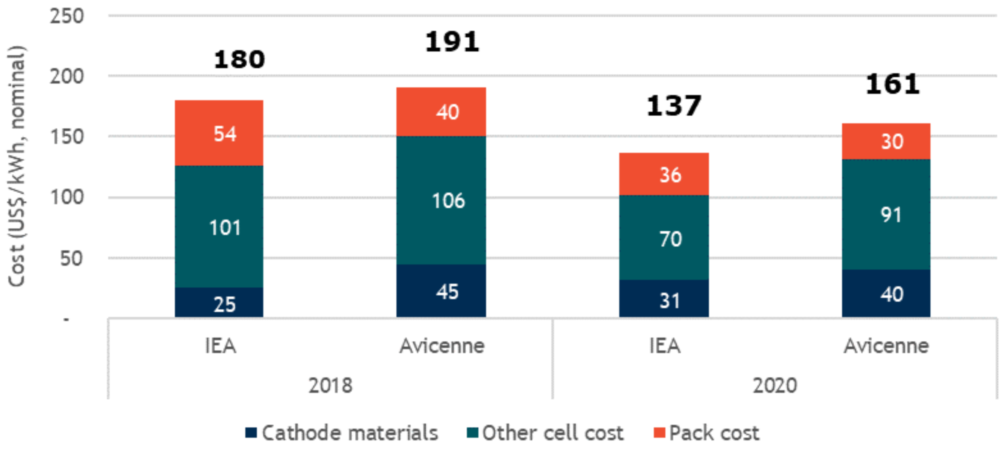


Figure 120: Average pack price of lithium-ion batteries

Source: IEA, 2018[55]; AVICENNE, 2019[56]

According to IEA, the cost of Li-ion battery packs decreased sevenfold between 2011 and 2021[55]. This is mostly due to the scale effects for production costs (per cell), energy and overhead costs. This is true both at the pack and cell level.

Cathode material costs have been relatively stable in absolute terms. They represented around 23% of the battery pack costs in 2020[55,57]. Battery pack prices are now strongly dependent on mineral prices (e.g., Manganese, Cobalt and Nickel for NMC and Iron and Phosphate for LFP, and Aluminium for NCA). Since 2021, these prices have increased considerably, driven by high demand and only slowly increasing supply. The cost of materials for an LFP cathode have risen by 343% between June 2021 and May 2022 (Figure 121).

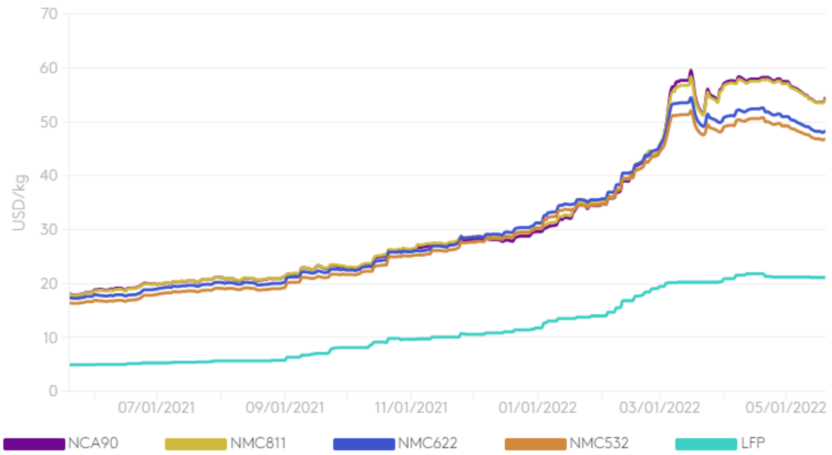


Figure 121: Estimated cathode active material cost (materials only), US$/kg (Fastmarket, 2022[57])

In conclusion, stationary storage capacities are expected to keep on growing, mostly driven by the integration of intermittent (renewable) energy into the grid. While pumped hydro historically had the largest capacity, Li-ion batteries are expected to provide the majority of the future stationary (short-term) storage market. Their prices have shown a strong decrease and are expected to keep decreasing in

[55] IEA (2022). Average pack price of lithium-ion batteries and share of cathode material cost, 2011-2021
[56] Avicenne (2019). The Rechargeable Battery Market and Main Trends 2018 - 2030
[57] Fastmarkets (2022). European Battery Raw Materials Conference 2022 – ten things we learned

the coming years, mainly due to the development of large-scale factories for the EV market. However, the recent price spikes in raw materials and the transport congestion are risks to this trajectory. Despite a potential (but uncertain) decrease in the mid-term (with the rise of raw materials' production), those prices are expected to stay high (e.g., at least in the next three years for Lithium[58]).

4.4.6 Hydrogen

Given its characteristics, storage for longer time periods using batteries is currently not efficient techno-economically. For longer-term storage, such as seasonal storage, hydrogen could provide a more cost-effective solution.

Hydrogen cost by electrolysis - grid-connected

The cost of hydrogen produced by electrolysers connected to the grid differs a lot across EU Member States. As shown in Figure 122, the main input to the final price is the wholesale price of electricity, while taxes, grid fees, CAPEX and maintenance also contribute to the final cost of hydrogen. To overcome the lack of price data for hydrogen, we use the concept of levelised cost of hydrogen (LCOH) to estimate the cost of production[59]. The lowest LCOH across the EU is recorded in Sweden at 2.0 EUR/kg, while the highest price is in Cyprus at 7.7 EUR/kg for 2022.[60]

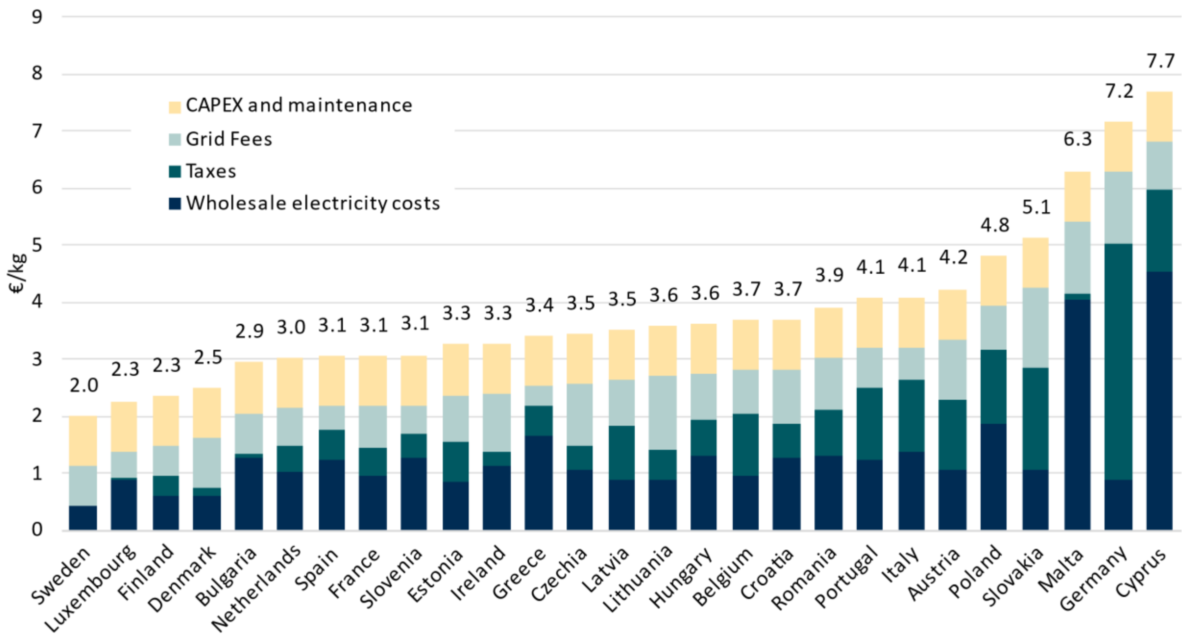


Figure 122: LCOH Grid-Connected Electrolysis with Cost Breakdown

Source: FCHO

Hydrogen cost by electrolysis - connected to renewables

The LCOH in 2022 produced by electrolysers directly connected to solar and wind plants can be seen in the below graphs (Figure 123 and Figure 124). For solar, the lowest LCOH is in Portugal at 3.8 EUR/kg and the highest in Finland 11.7 EUR/kg, since the LCOE of solar PV is substantially lower in warmer climates.

58 AVINCEE ENERGY 2022, Bloomberg, Macquarie, August 2022

59 The annual average capacity factor used is 45%, using average wholesale electricity prices. In practice, this simplifies the balance between paying back the high CAPEX investment through high operational hours while using as low as possible electricity prices.

60 FCHO (2022). Levelised Cost of Hydrogen

Regarding onshore wind, the lowest LCOH is recorded in Ireland at 2.8 EUR/kg and the highest in Cyprus at 7.5 EUR/kg. Lowest LCOH for offshore wind electrolysis is recorded in Ireland at 4.45 EUR/kg, while the highest LCOH is recorded in Cyprus at 10.4 EUR/kg. LCOH reductions are anticipated over time both based on a decreasing CAPEX and on further decreases of renewables LCOE.

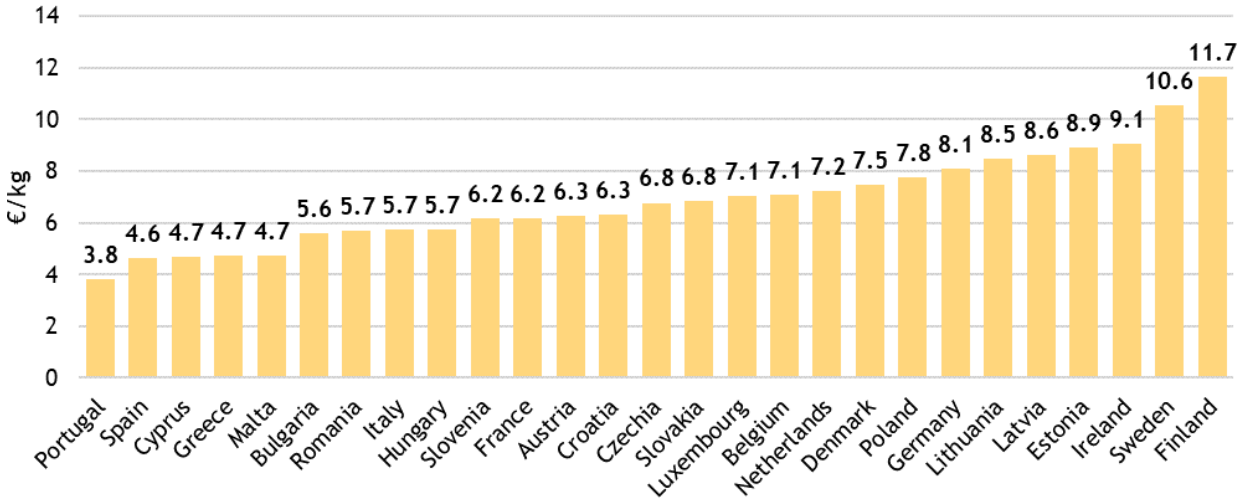


Figure 123: LCOH - Electrolysers Directly Connected to Solar

Source: FCHO

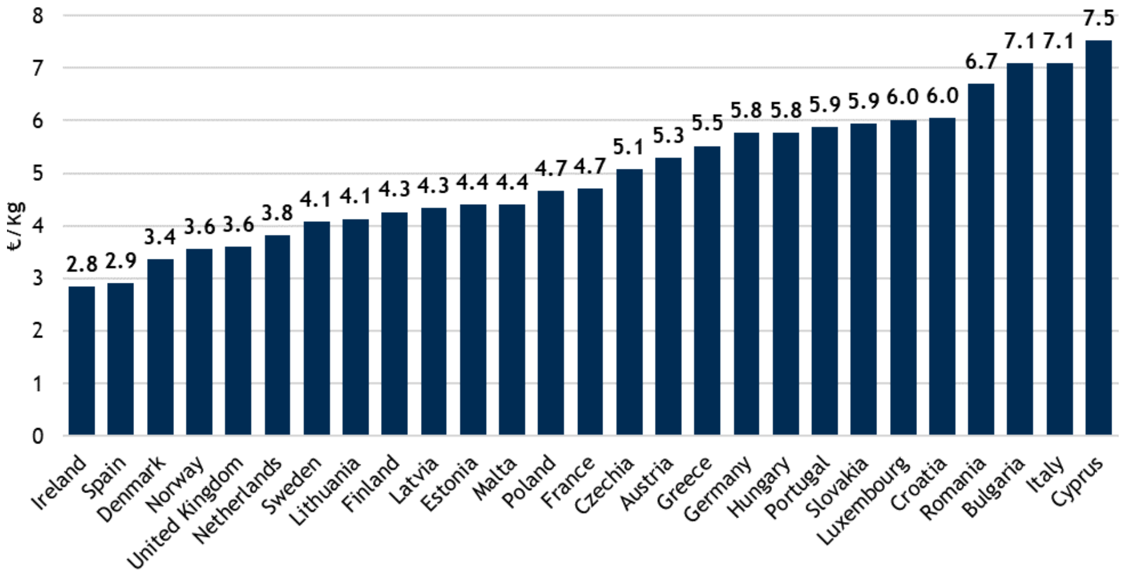


Figure 124: LCOH - Electrolysers Directly Connected to Wind on-shore

Source: FCHO

Hydrogen prices for mobility - refuelling sales prices

Hydrogen prices at Refuelling Stations (HRS) across Europe are not publicly available. However, some operators publish prices that currently range from 9.99 EUR/kg in Belgium to as high as 24.95 EUR/kg in the Netherlands. In Germany, H_2 refuelling sales prices are almost unified across the country, linked to H2 Mobility's HRS network[61]. According to this operator, the unit price for hydrogen has remained stable around 9.5 EUR/kg for the past ten years before increasing to 12.85 EUR/kg in June 2022[62], representing

[61] https://h2-mobility.de/

[62] https://energynews.biz/hydrogen-price-goes-up-to-e12-85-kg/

the first significant price increase in ten years. In France, the price has fluctuated around 10-12 EUR/kg in 2020[63] and 2021[64].

It is likely that hydrogen prices remain high for the next years due to the high electricity and natural gas prices since 2021. While hydrogen in the future should be mainly produced using renewable electricity in order to contribute to a decarbonized energy system, most current hydrogen sites use grid electricity.

Grey hydrogen by SMR Production Cost and Price

Conventional hydrogen production using fossil fuels currently accounts for more than 95% of the hydrogen produced in the EU, mainly through steam reforming of natural gas (SMR) technology. According to Hydrogen Europe, the hydrogen production cost in 2020 through SMR stood at 1.41 EUR/kg. The sales price (Figure 125) is highly dependent on the traded volume where prices range from 1.31 EUR/kg for volumes over 5,000 tons to 9.5 EUR/kg for volumes between 1-10 tons.

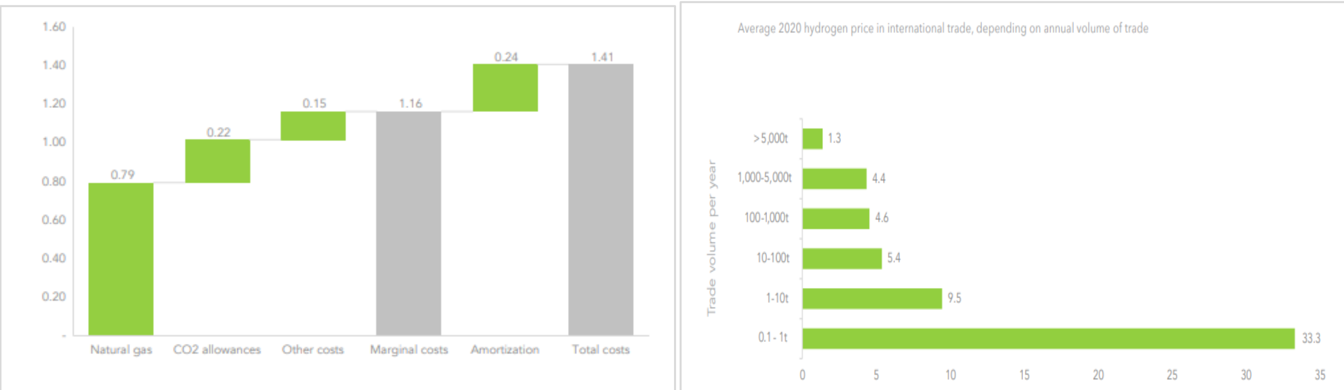


Figure 125: Average hydrogen production Cost through SMR and sales price in the EU in 2020 in EUR/kg

Source: Hydrogen Europe

In 2021, the situation has dramatically changed, with prices inflated due to the substantial natural gas price increases. As shown in Figure 126, prices of hydrogen through SMR increased from less than 2 EUR/kg in January to around 7 EUR/kg in December 2021 based on the month-forward market price.

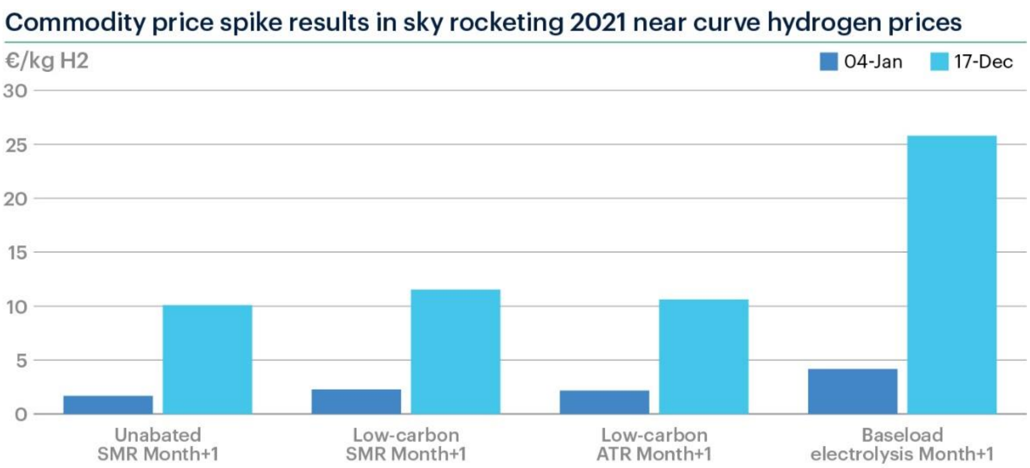


Figure 126: Hydrogen market prices using SMR, ATR and baseload electrolysis in January and December 2021.

Source: ICIS

[63] https://twitter.com/infinergia/status/1218618688460509184
[64] https://www.largus.fr/actualite-automobile/hydrogene-le-plein-au-prix-du-gazole-en-2030-10527405.html

5 Household energy expenditure

Energy is a basic need for all households. As either their consumption or retail prices increase, households have to spend more of their income on energy needs. Examining household energy expenditure is important for understanding the financial pressures households face to meet their basic energy needs (including heating and transport) and give an indication of households' ability to cover their energy needs. In the first part of this chapter, the importance of energy products and transport fuels in household expenditures is examined across the EU Member States. This covers energy expenditures related to heating and transport[65], analyses differences across income groups, and examines changes in energy expenditures over time.

Taking a closer look at energy expenditures for households has become increasingly important in the last two years. Rising energy prices, particularly during 2022, resulted in a growing number of households facing higher than usual energy expenditures and struggling to cover their energy needs. In 2021, this had already prompted the European Commission to publish a toolbox of measures[66] ranging from emergency income support to households and state aid for companies to targeted tax reductions to tackle surging energy prices, as well as strengthening the Just Transition fund to ensure that Member States and vulnerable households were better supported.

More recently, further energy price increases in 2022 disproportionally affect the most vulnerable households, SMEs, and energy—intensive economic sectors (more on that in Chapter 6). The EU has since responded with the REPowerEU Plan, which aims to support the transition to clean and affordable energy production and reduce the energy burden. Additionally, in the "Save Gas for a Safe Winter" plan the EU Commission proposed gas demand reduction plans for the EU, while an inframarginal price cap and a 'solidarity contribution' from oil and gas firms is intended to finance the support measures for European households and industry.

The second part of this chapter therefore focuses on the effects that increased energy prices have on household expenditures, including a price elasticity analysis to examine how households across income groups will be affected by shifts in energy prices.

Main findings:

In 2020, the poorest households[67] in the EU spent on average EUR 953 on energy products (electricity, gas, liquid and solid fuels, and heating), around 7.8% of their total expenditure[68]. Absolute expenditures and shares of total expenditures, however, vary greatly between Member States. For example, **absolute energy expenditures** for low-income households in 2020 varied between EUR 676 in Hungary and over EUR 1500 in Luxemburg, for example. Similarly, **the share of expenditure** spent on energy (excluding transport fuels) in 2020 ranged between 3% in Luxemburg and 17% in Czechia. Often, high absolute expenditures do not correspond to high shares of energy expenditures relative to total expenditures.

[65] Expenditures are differentiated by energy and transport. For energy expenditures these relate to electricity, gas, liquid fuels, solid fuels, and heat energy. For transport expenditures these relate to petrol, diesel, and other fuels.

[66] Tackling rising energy prices: A toolbox for action and support. October 2022

[67] In this report, the poorest households are defined as those in the first income decile or where no decile data is available as those in the first income quintile.

[68] This average is based on expenditure data from those Member States that reported for 2020 and where the number of surveyed households were reported. This includes Austria, Belgium, Bulgaria, Czechia, Hungary, Italy, and Luxemburg. The average was weighted according to the number of households.

Middle-income households tend to have higher absolute energy expenditures, but the percentage share is lower in their household budgets. On average, in 2020, middle-income households spent only 6.4% of their total expenditures on energy. Expenditure shares among income groups also varies geographically. While spending is higher in Central and Eastern Europe (at around 10-22%), it is significantly lower in North and Western Europe (between 3-8%).

Expenditures on transport fuels represent on average in 2020 around EUR 352 for low-income households, equivalent to around 2.6% of total expenditures. By comparison, middle-income households spend EUR 887 or 3.8% of their total expenditures. This can be linked to higher levels of motorized private transport in higher income groups.

Between 2010 and 2020, the share of energy expenditure decreased slightly for all income groups, as seen in Table 3. Particularly for low-income households, there was a decrease in the share of energy expenditures from almost 10% to just under 8%. For other income groups this decrease was marginal. The share of expenditures spent on transport fuels remained nearly unchanged for all income groups.

Table 3: Overview of changes of share of expenditure on energy and transport across Member States (2010-2020)

	2010	2020	2010-2020
Share of expenditure on energy			
Low-income households	9.9%	7.8%	-2.1%
Low middle-income households	7.6%	7.2%	-0.4%
Middle-income households	6.9%	6.4%	-0.5%
Share of expenditure on transport energy			
Low-income households	2.2%	2.6%	0.3%
Low middle-income households	3.6%	3.9%	0.3%
Middle-income households	4.1%	3.8%	-0.3%

Source: DG ENER ad hoc data collection on household consumption expenditures[69]

5.1 Data on household expenditures

The following chapter focuses on absolute energy expenditures comparing households across Member States, as well as putting expenditures in relation to total expenditures on products and services. This gives a good indication of the burden households face to cover their energy costs. Additionally, the differences across Member States of households with different incomes are examined to analyse how this cost burden is experienced across income groups. Energy expenditure of the residential sector usually covers heating, lighting, cooking needs, cooling, and the operation of electrical appliances. Additionally, changes of energy and transport expenditures over a ten-year period (2010-2020) are analysed.

This chapter draws primarily on data provided by national statistical authorities on expenditures and further ad hoc data collection on household consumption expenditures by the Directorate General for Energy. Members of the Household Budget Survey Working Group (EU Member States) were contacted requesting data collection on energy expenditure. This additional data allows for more disaggregated

[69] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

information of energy expenditures across income groups and for improved evidence-based policy making by the Commission regarding affordability of energy services.

In order to show differences across income groups, this chapter includes data on consumption expenditures of three household groups: low-income, low-middle income, and middle income. In the 2020 edition of the Energy prices and costs report, these three income groups were defined using income deciles. With the exception of three Member States (Germany, Poland, and Denmark), all of the data provided are reported in income deciles (one tenth of the population, arranged into income strata). Households in the first income decile are defined as low-income; low-middle income households are in the third income decile; and the fifth income decile is used as a representation of middle-income households. For those Member States where only quintile data is available the first, second, and third income quintiles are used respectively[70].

It should be noted that the data collected is not harmonized across Member States and data is not reported consistently for the year 2020. For the following figures, the most recent available data for each Member State is used.[71] All data in this report is based on the data delivered by the Member States.

5.2 Share of energy fuels and use in households

To understand how consumption and expenditures on energy products evolve and are related to national contexts, it is important to examine how energy consumption in the residential sector differs between EU Member States, both in terms of types of fuels and their end-use. EUROSTAT publishes annual data on final energy consumption of households in the residential sector. Figure 127 shows the distribution of energy products of households in 2020. Across the EU27, the majority of energy consumption is covered by electricity (25%) and natural gas (32%). Renewables and wastes account for another 19%, followed by petroleum products (12%), derived heat[72] (8%), and solid fuels (3%).

Around half of the EU Member States draw predominantly on electricity to meet their household needs, while the other half rely predominantly on gas. In seven Member States households use electricity as their main source of energy. Especially in Sweden (51%), Bulgaria (41%), Spain (42%), and Cyprus (42%) electricity plays a significant role in the residential sector. Natural gas plays an equally important role across the EU: Italy (52%), Luxemburg (52%), Hungary (64%), and the Netherlands (68%) are among those that rely predominantly on natural gas to meet their energy needs in the residential sector.

It should also be noted that six Member States draw primarily from renewables and waste, notably Croatia (46%), Latvia (40%) and Slovenia (41%) are able to cover their household energy needs in this way. While many Member States are heavily reliant on one type of fuel source, most notably natural gas, in other Member States the share of fuels used to cover household energy consumption is more evenly distributed. This can be observed across the EU in Belgium, Germany, and France, for example, as well as in Czechia, Lithuania, Romania, Estonia, but also in Denmark, Finland, Greece, and Portugal.

[70] This is the case for Germany, Denmark, and Poland.
[71] Most recent data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.
[72] Derived heat is heat delivered to households in the form of heat, e.g. through district heating systems. This heat may be produced from different sources such as natural gas, heating oil, coal, cogeneration using such fuels, geothermal, etc.

Two Member States stand out, because of their unusual energy mix: Poland relies predominantly on solid fuels (alongside derived heat and natural gas) and Ireland relies heavily on oil and petroleum products (43%).

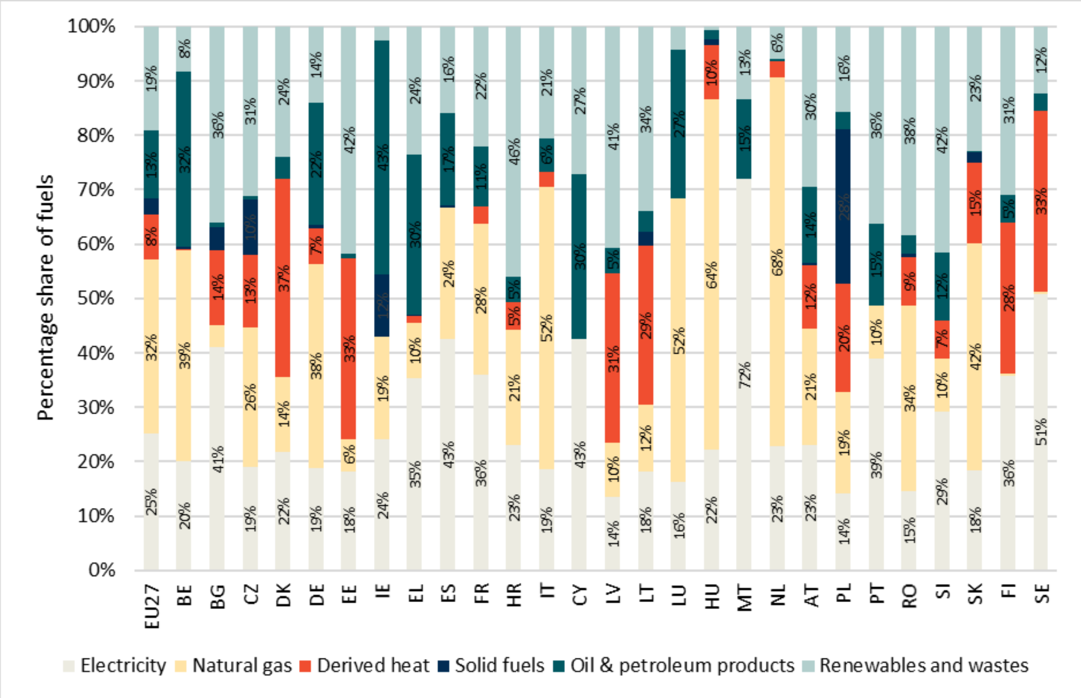


Figure 127: Share of fuels in final energy consumption in the residential sector of Member States in the EU27 (2020)

Source: Eurostat (nrg_bal_c)

Additionally, the distribution of end-uses across EU Member States in the residential sector is also relevant for understanding consumption expenditures. In Figure 128, the share of final energy consumption in the residential sector by type of end-use in 2020 can be seen for all Member States. Across the EU, households require most of the energy for space heating (63%). Both water heating and energy required for lighting and appliances make up around 15-15% of household energy use. Cooking requires around 6% of total end use, while space cooling and other end-uses cover around 1.5%.

Lighting and (active) space cooling in the EU are covered entirely by electricity. Around half of the energy used for cooking is also covered by electricity. Natural gas use is predominantly related to space and water heating, where renewables only cover around one quarter of energy needs for space heating. Derived heat only plays a significant role in relation to water and space heating, whereas oil products cover in equal portions energy used for space heating, cooking, and water heating.[73] This however varies across Member States. The highest proportions of energy used for space heating among residential energy use can be seen in Luxemburg (81%), Belgium (73%), Slovakia (73%), Estonia (72%), and Austria (70%).

In warmer climates, space heating is far less relevant, which can be observed in Spain, Portugal, Cyprus and Malta in particular. In Malta and Cyprus, this also coincides with much higher energy use for space cooling with 12% and 10% respectively. In several Member States, energy use for lighting and appliances lies significantly above the EU-27 average. In Bulgaria, France, Portugal, and Sweden this lies at around

[73] Based on data from: Eurostat (2022)

20%, while in Spain and Malta this is particularly high at 32% and 29%, respectively. Finally, it should also be noted that for households in Portugal, a significant share of their energy use (31%) is related to cooking.

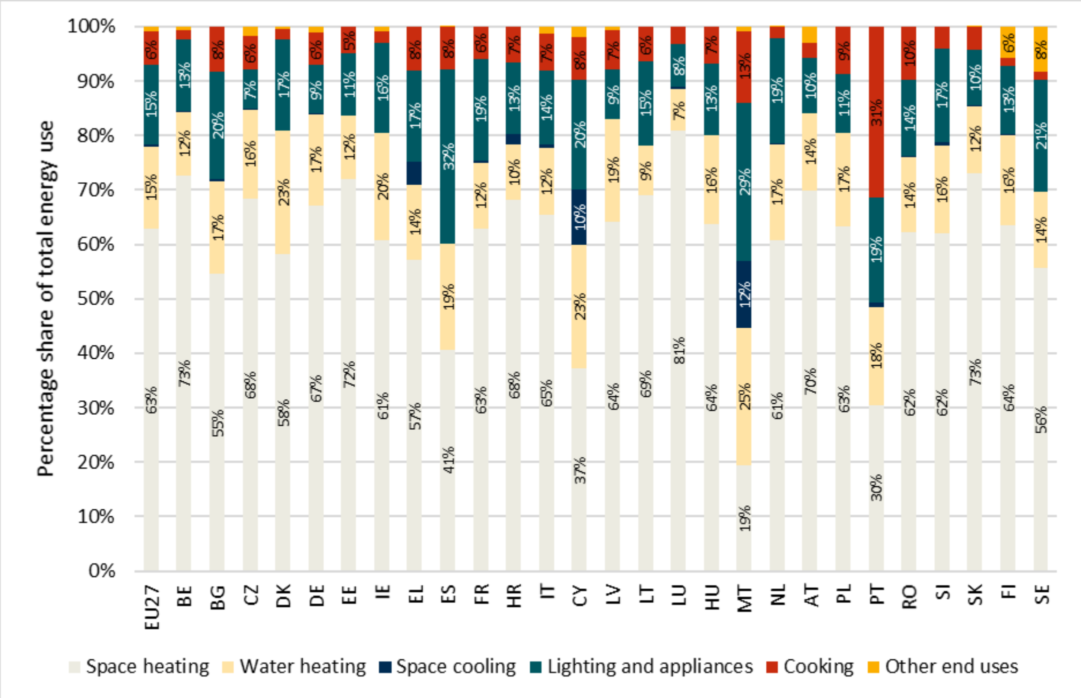


Figure 128 Share of end-use energy consumption in the residential sector of Member States in the EU27 (2020)

Source: Eurostat (nrg_bal_c)

5.3 Energy product expenditure in household budgets

Energy expenditures are only one part of total household expenditures. To assess the role that energy expenditures play, that share of energy-related expenditures is examined in relation to other consumption expenses. Next to energy, expenses covering basic needs such as food, housing and transport are of particular importance for households. Figure 129 shows the breakdown of annual consumption expenditures of average households across the EU.

In almost all Member States expenditures on the above listed basic needs range between 40-60%. Expenditures for energy range from 5-10% of total expenditures. Particularly high spending on energy can be observed in Central and Eastern Europe (i.e., Bulgaria, Hungary, Lithuania, Poland, Romania, and Slovakia). Households in Slovakia and Bulgaria have the highest expenditures on energy at 12% of their total consumption expenditures. By comparison, households in Luxemburg have the lowest energy expenditures in relation to total expenditure at only 2.5%. The average household in the EU in 2020 spent around 6% of their total expenditures on energy products.[74]

Where relative energy expenditures are generally higher in Member States with lower GDP, housing related expenditures were higher (and energy expenditures lower) in Member States with a higher GDP per capita. This was for example the case in Germany where housing expenditures were 28% of total expenditure, as well as Spain (26%), Finland (28%), Ireland (30%), and Luxemburg (32%). A notable

[74] This average is based on expenditure data from those Member States that reported for 2020 and where the number of surveyed households were reported. This includes Austria, Belgium, Bulgaria, Czechia, Hungary, Italy, and Luxemburg. The average was weighted according to the number of households.

exception in this trend is Cyprus, where housing expenditures were also high (22%) and energy expenditures relatively low (below 4%). Expenditures for both energy and housing were particularly low in Malta representing less than 10% of total expenditure in total. This may be due to high levels of homeownership, governmental housing support for low-income households, and low overall energy prices.

Expenditures for food and non-alcoholic beverages took up a significant portion of total spending for households across the EU. The shares were higher in Member States with lower purchasing power per capita, such as Bulgaria (33%), Lithuania (31%), and Romania (32%). Transport related expenditures, including for mobility services and fuels, make up a significant portion of expenditures for households. These are also related to GDP and purchasing power per capita. In France and Slovenia, 18% and 21%, respectively, of total expenditures relate to transport. The majority of these are related to mobility services, rather than fuels for personal transport. This may be related to extensive public transport networks being used widely. Additionally, in Slovenia, high expenditure on fuels for personal transport may relate to the high percentage of the rural population that could be more reliant on private automobile transport and high associated costs. By comparison, only around 7% and 8% are spent by households in Romania and Bulgaria, respectively. In Romania, this could be related to low diesel and petrol prices in EU comparison, as well less dense public transport networks.

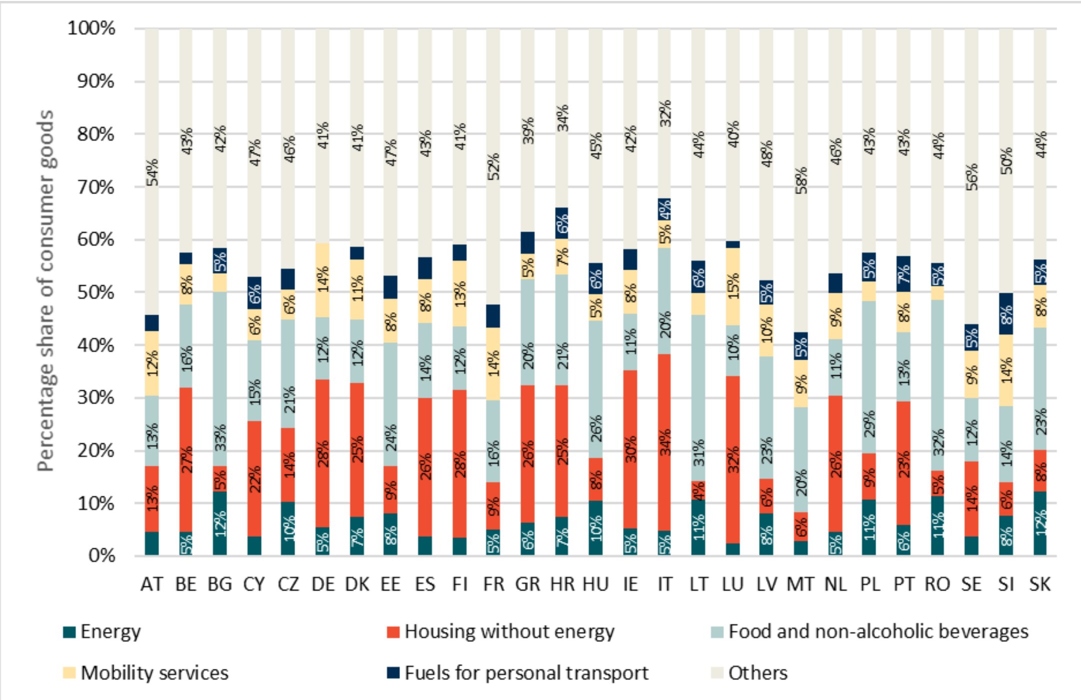


Figure 129: Shares of consumer goods in household expenditure of Member States in the EU27[75]

Source: DG ENER ad hoc data collection on household consumption expenditures

While household energy expenditures make up only a small portion of total expenditures on average, this varies between income groups. This can be seen in Figure 130: the share of energy expenditure of total expenditures is shown for the three income groups defined above: low income, low-middle income, and middle income.

[75] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available. Germany did not report any data on fuels for personal transport, meaning this data is not fully comparable.

Overall, relative energy consumption expenditures are higher for low-income households than for the middle-income group. With the exception of Lithuania, Poland and Bulgaria, the higher the average expenditures, the bigger the differences between the income groups. In some countries, the share of energy expenditures is higher for low-middle or middle-income households. This is may be the case as some low-income households will self-regulate their energy use and lower their energy consumption (and associated expenditures) to cover other basic needs. On the other end of the spectrum, in Member States such as Luxemburg, Sweden and Finland, where average energy expenditures are below 5%, the differences between the income groups are very small.

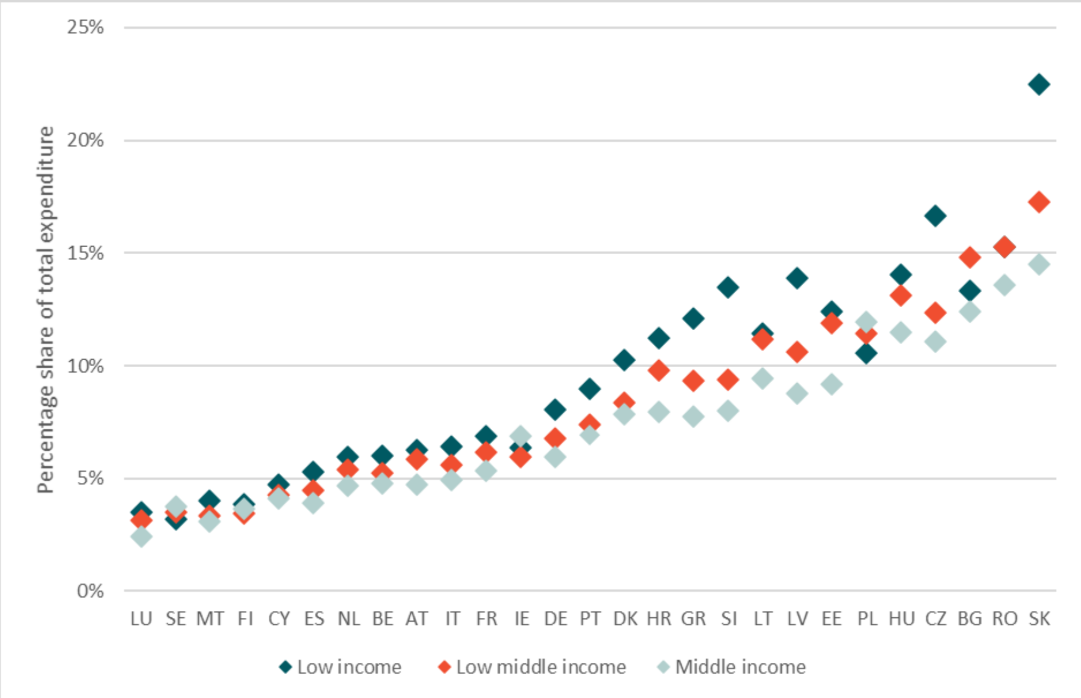


Figure 130: Energy share in total consumption expenditure by income group of Member States in the EU27[76]

Source: DG ENER ad hoc data collection on household consumption expenditures

5.4 Energy expenditure (excluding transport) in households with low income

This section focuses in particular on households with low income. On average, low-income households spent EUR953 on energy in 2020, which represents 8% of their total consumption expenditures.[77] This, however, varies greatly between Member States, both in terms of absolute expenditures and share of total expenditures (Figure 131).

Absolute expenditures in Latvia and Romania are particularly low (below EUR500), while the majority of low-income households spend between EUR500-EUR1000 annually on energy. This may be related to very low energy prices. Highest absolute expenditures can be seen in Luxemburg and most notably in Denmark,

[76] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

[77] This average is based on expenditure data from those Member States that reported for 2020 and where the number of surveyed households were reported. This includes Austria, Belgium, Bulgaria, Czechia, Hungary, Italy, and Luxemburg. The average was weighted according to the number of households. The number of households taken into account for the calculation of this average is representative of around 23.5% of all households in the EU in 2020.

where households with the lowest incomes spend over EUR 2500 on energy. Extremely high energy prices, that are due to high taxes on electricity for example, are key drivers of high expenditures. However, revenues of energy taxes are channelled back into the social welfare system that in turn supports low-income households extensively. There is, generally speaking, a regional divide in the EU, where in countries with higher GDP absolute expenditures on energy are higher, also for low-income groups.

Generally, even when absolute expenditures are relatively low, the share of total expenditures on energy is relatively high at around 15%. Inversely, the higher absolute expenditures tend to correspond to a lower share of energy expenditures (below 10% of total expenditures), most likely related to higher average household incomes, meaning that even high energy expenditures do not necessarily result in high energy cost burdens. Notable outliers are Cyprus, Sweden, and Finland where low absolute expenditures also correspond to a low share of energy expenditures. This may be related to low energy prices and/or subsidies and social tariffs for low-income households. Relatively high absolute expenditures (above EUR1000) in Slovakia, Czechia, and Slovenia on the other hand also require a large part of expenditures to be used for energy. This, too, can be related to average household incomes, which are lower in these countries and result in high cost burdens, even for lower absolute expenditures. In some instances, energy-related expenditure might also be recorded as part of housing expenditures, especially for households in the rental sector.[78]

This large range in energy expenditures is partially related to the differences in average household income, but differences in household energy prices also play a role. Additionally, differences in the energy efficiency of the building stock play a key role in heating related expenditures. In Slovakia and Czechia, for example, poor energy efficiency standards in the building sector, particularly for low-income groups, coupled with low incomes and high energy prices lead to a high cost burden (22% and 17%, respectively) for low-income households. Extensive social welfare systems in Denmark, Germany, and Luxemburg may also contribute to lowering overall cost burdens of energy expenditures.

[78] Since the data collected through the HBS Ad-hoc working group is not fully harmonized across EU Member States difference such as this may occur.

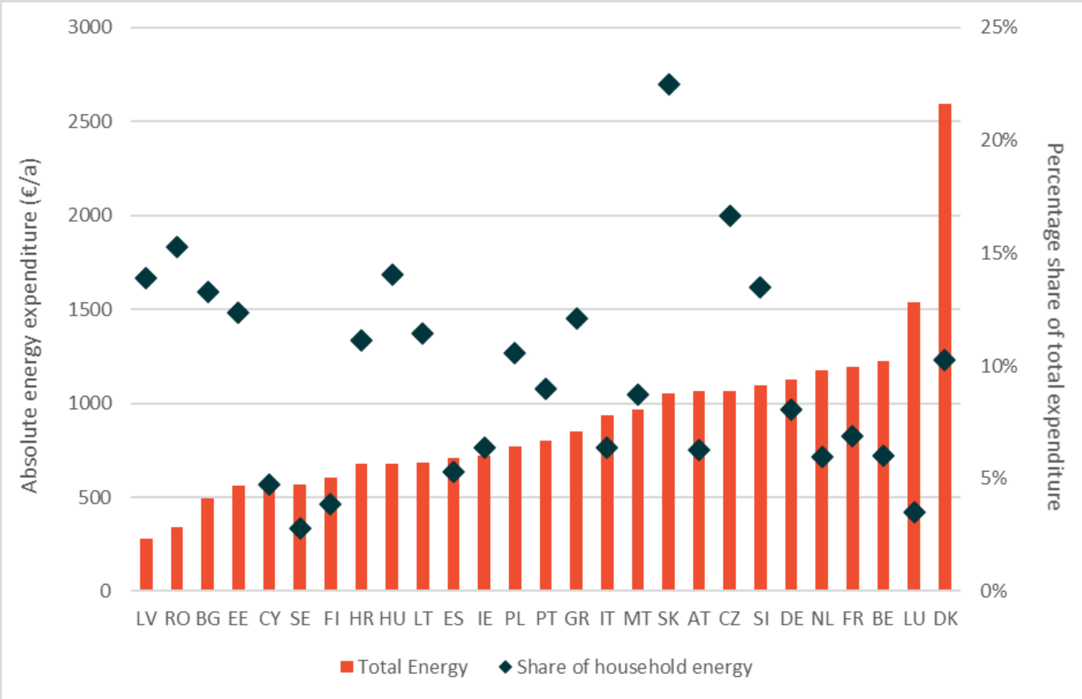


Figure 131: Absolute energy expenditures and share of energy expenditures for low-income households for Member States in the EU27[79]

Source: DG ENER ad hoc data collection on household consumption expenditures

The share of household energy products in the total consumption expenditure of low-income households also varies across Member States (Figure 132). For the majority of these households, energy expenditures are related to electricity and gas. Expenditures on electricity are highest in Sweden (96%), while in the Netherlands, for example, over 70% of energy expenditures are related to gas. High shares of electricity expenditures in Cyprus, Sweden, and Finland may also be linked to the low energy cost burdens in these countries. In Hungary, solid fuels play a significant role (31%) for low-income households because they rely more on wood and coal for heating needs, whereas in Denmark the majority of energy-related household expenditures is related to heat energy (61%), which corresponds to an extensive district-heating network. Higher shares of district heating expenditures can also be observed in Lithuania, Estonia, and Latvia. Liquid fuels, predominantly in the form of heating oil, still play an important role in the household energy mix in Luxemburg, Ireland, and Greece. In Greece, for example, the use of natural gas is limited by the lack of an extensive natural gas distribution grid (partly also due to the large number of islands) and instead diesel oil is used more commonly.

[79] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

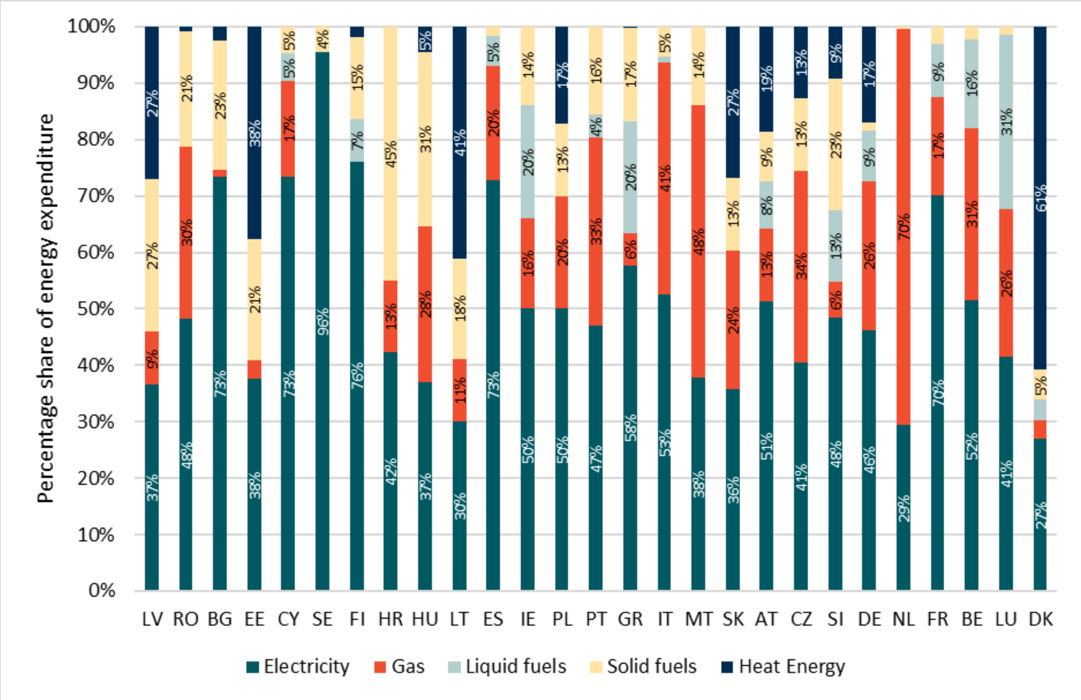


Figure 132: Share of energy products in energy expenditures for low-income households of Member States in the EU27[80]

Source: DG ENER ad hoc data collection on household consumption expenditures

5.5 Energy expenditure (excluding transport) in households with middle-income

Figure 133 and Figure 134 show the relationship between absolute expenditures and the share of energy expenditures in relation to total consumption expenditures, as well as the distribution energy products in expenditures across Member States for both middle-income groups.

Absolute expenditures are higher for households with higher income. Absolute expenditures increase proportional to income, although the higher the income, the less pronounced the increase. This can be observed both in the low-middle and middle-income group, where, in 2020, absolute expenditures averaged at EUR 1199 and EUR 1310 per household, respectively, in comparison to the EUR 593 spent annually by the average low-income household in the EU. Across the income groups, the share of energy expenditures in 2020 is slightly lower for low-middle and middle-income households. In comparison to low-income households, which spend around 8% of total expenditures of energy, low-middle income households spend around 7% and middle-income households around 6% on average of their total expenditures on energy. While regional differences in the share of energy expenditures can be seen across all income groups, these remain pronounced even for middle-income households. In Northern and Western Europe, the share usually ranges between 3-9%, while Central and Eastern European Member States see household energy expenditures around 11-15%. Across income groups, that for those households who have lower absolute expenditures, these correspond to higher relative expenditures and vice versa.

[80] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

In Figure 133 and Figure 134, Member States were ranked according to their absolute energy expenditures. Most countries remain in a similar position relative to other Member States across the income groups. There are, however, notable exceptions. This can be seen in Ireland for example, where absolute energy expenditures for low-middle income households are relatively low by EU comparison, whereas for low-income groups these were towards the middle. Similarly, in Lithuania, the absolute expenditures rise across the income groups, but the absolute expenditures in relation to those in other Member States are much lower for middle-income households. Inversely, where absolute expenditures for low-income households in Sweden were relatively low in comparison to other Member States, the expenditures for middle-income households are relatively high. This may be linked to the strong social welfare system that provides support to low-income households also in relation to housing and energy costs.

Significantly higher energy expenditure in low-middle and middle groups can be observed in several Member States. In Malta, for example, households in the first income decile spend only under EUR 1000 annually on energy, while in the third decile these absolute expenditures increase significantly to around EUR 2800. The share of energy expenditures in relation to total expenditures is also much higher for low-middle income households in Malta (16%) than low-income households or even middle-income households (both at 9%).[81] For all other Member States there is generally a slight decrease in the share of energy expenditures of total consumption expenditures as income increases.

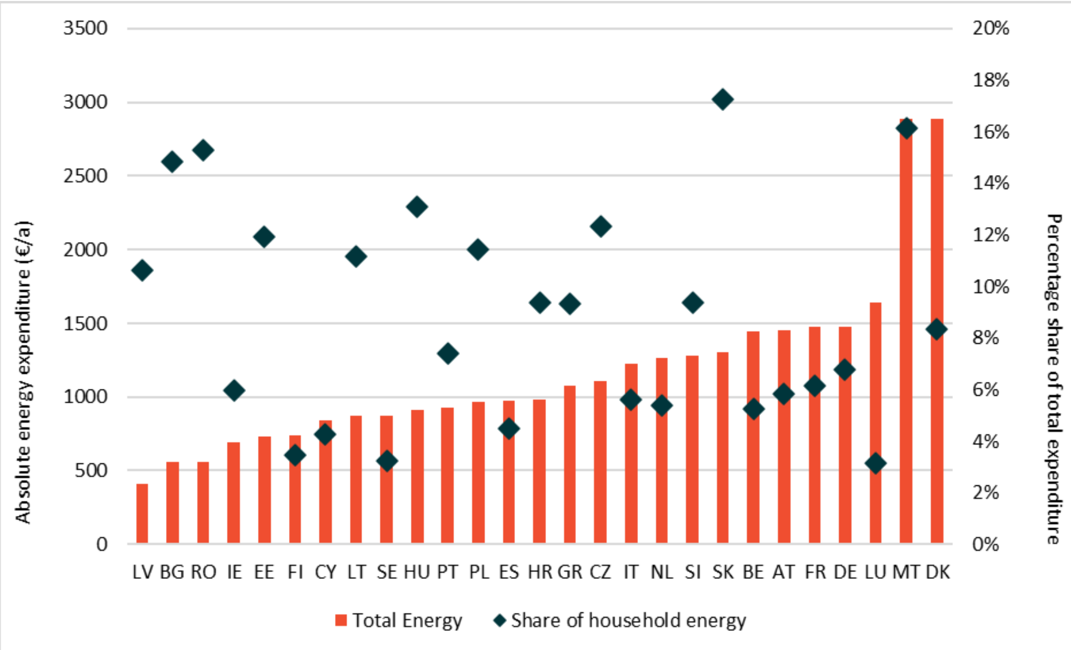


Figure 133: Absolute energy expenditures and share of energy expenditures for low-middle income households for Member States in the EU27[82]

Source: DG ENER ad hoc data collection on household consumption expenditures

[81] For Malta no data was delivered on expenditures for liquid fuels in the 1st and 2nd income quintile. Consequentially, expenditures will be lower for these income deciles and the low-income group as defined in this report and is not comparable to expenditure data for low-middle and middle-income group.

[82] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

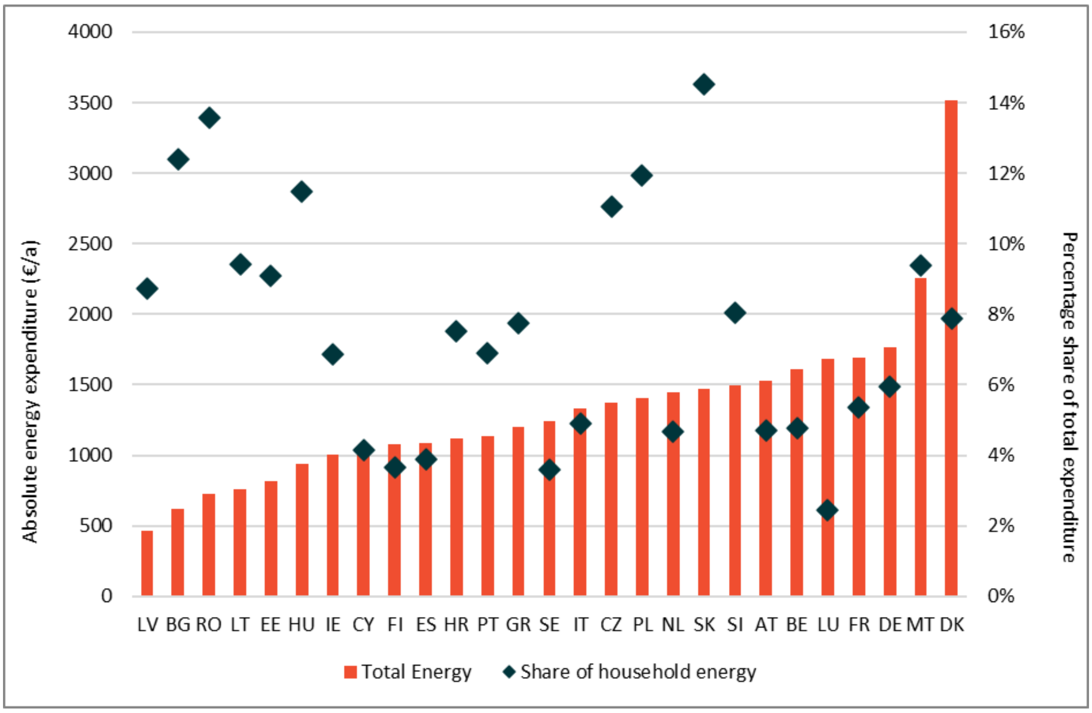


Figure 134: Absolute energy expenditures and share of energy expenditures for middle-income households for Member States in the EU27[83]

Source: DG ENER ad hoc data collection on household consumption expenditures

The share of expenditure on household energy products does not vary greatly in most Member States, although some shifts in energy product shares can be observed (see Figure 135 and Figure 136). In Estonia, Romania, and Malta the share of electricity spending is around 10% lower for middle-income households than for low-income households. This may be related to the housing stock, where newer and more expensive housing will rely less on electricity for heating. In several Member States, the share of solid fuels was also significantly lower for middle-income households. In Lithuania and Hungary, the share was around 10% lower and in Croatia, it decreased from 45% to 27%. This, again, is linked to the housing stock, where low-income households are more likely to be reliant on solid fuels for heating needs and more expensive or modern housing will rely more on gas and other fuels for heating. The share of heat energy was around 10 percentage points higher for low-income households in Denmark and Latvia; for Lithuania even around 20% higher. In Bulgaria and Sweden, the share of heat energy for middle-income households was higher at 8-12% in comparison to 0-2%.

[83] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

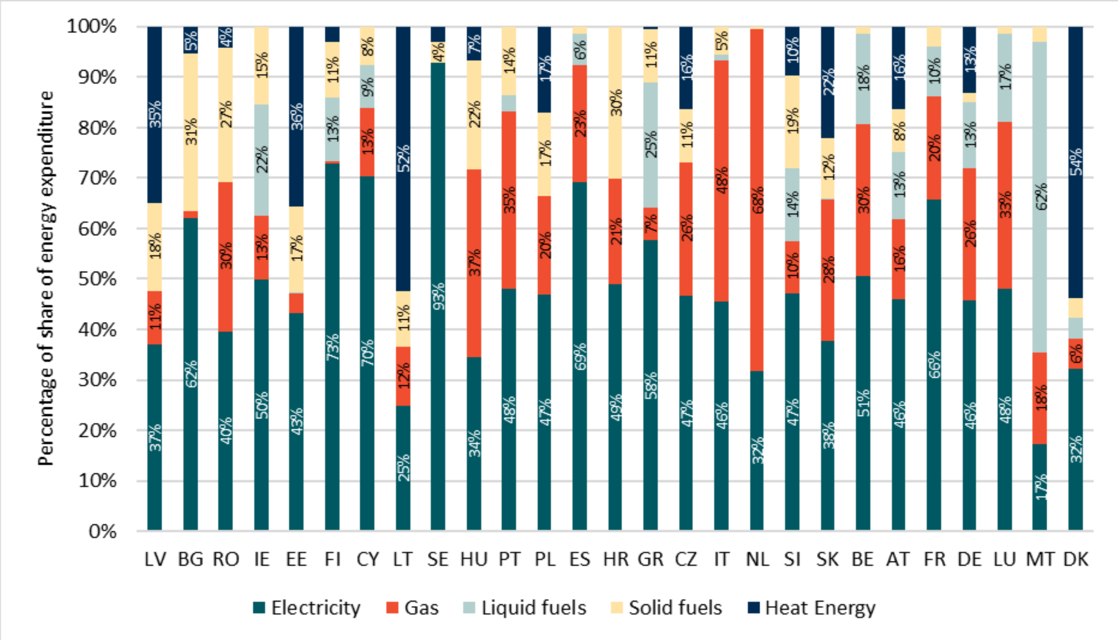


Figure 135: Share of energy products in energy expenditures for low-middle income households of Member States in the EU27[84]

Source: DG ENER ad hoc data collection on household consumption expenditures

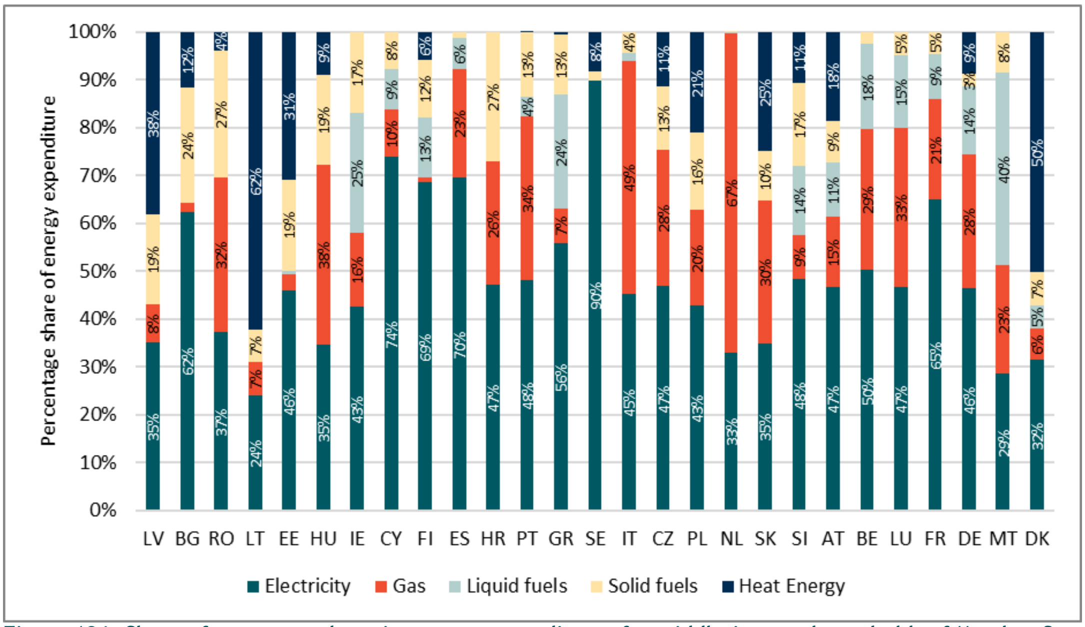


Figure 136: Share of energy products in energy expenditures for middle-income households of Member States in the EU27[85]

Source: DG ENER ad hoc data collection on household consumption expenditures

[84] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

[85] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

5.6 Share of energy in the household expenditure by income and Member States

This section focuses on a regional comparison of Member States, clustered according to their geographical location and comparability of expenditures. This analysis also compares the share of energy expenditures relative to the final expenditure across the three income groups (low, low-middle, and middle income).[86]

Of the seven countries in North Western Europe (see Figure 137), German households spend the highest portion of their total expenditures on energy, while this share is significantly lower for households in Luxemburg. In Germany, these high expenditures can be related to higher spending on gas for heating but may also be related to higher costs of energy. Overall, these shares are below the EU average. It is notable that in Ireland the share of energy-related expenditures is highest for middle-income households. This may be due to higher consumption levels that do not necessarily match the higher incomes or the lack of government subsidies that benefit low-income households benefit[87].

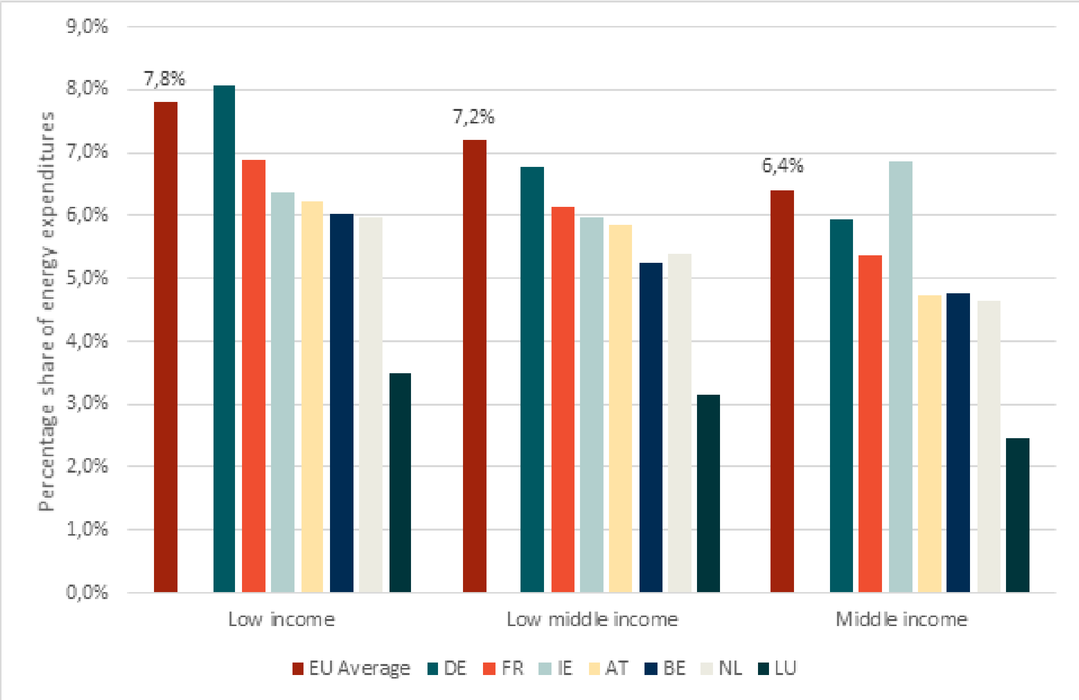


Figure 137: Share of energy expenditure in total expenditure by income groups for Germany, France, Ireland, Austria, Belgium, the Netherlands, and Luxemburg[88]

Source: DG ENER ad hoc data collection on household consumption expenditures

With the exception of Greece, the share of energy expenditures in South European and Mediterranean island countries (see Figure 138) is also below the EU average. This may be due to lower heating needs and lower overall electricity prices. In the lowest income group households spent between 9% and 4% on energy related expenditures. This share decreases for all Member States shown over the income groups. The higher share in Greece is particularly noticeable for the two lower income groups. Especially for the

[86] Due to the significant differences in years of reported data these regional analyses often cover a large time span. Additionally, the quintile data for Germany, Poland, and Denmark should be considered in the comparison between Member States.
[87] For example, low income households in Ireland are often eligible for electricity and gas lump-sum support payments.
[88] Year of data is as follows: Ireland (2015), the Netherlands (2015), France (2017), Germany (2018). For all others 2020 data was available.

low-income households this 12% share is above the EU average. This may be related to the high wholesale electricity prices in Greece.[89]

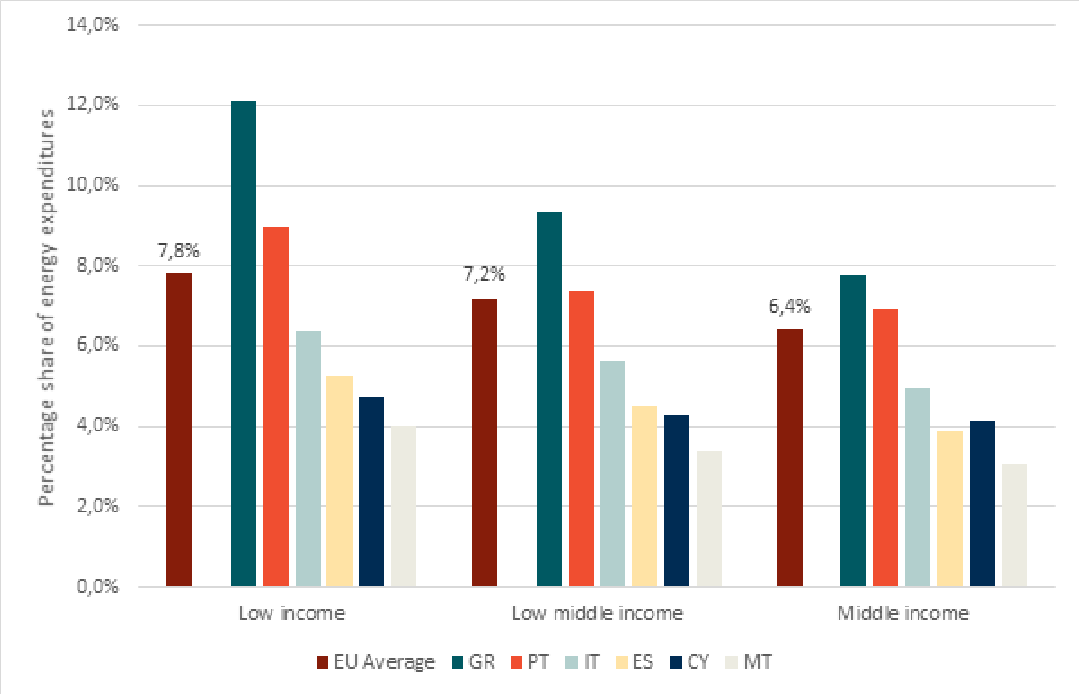


Figure 138: Share of energy expenditure in total expenditure by income groups for Greece, Portugal, Italy, Spain, Cyprus, and Malta[90]

Source: DG ENER ad hoc data collection on household consumption expenditures

In Central and Eastern European countries (see Figure 139), the share of energy in total household expenditure is considerably higher than the EU average. This may be linked to lower energy efficiency in the building stock and thus increased spending on heating, for example, as well as lower total expenditures due to lower income meaning that necessary expenditures such as those related to energy will take on a larger portion of total expenditures. This ranges from 10-22%, with the highest shares for low-income households in Slovakia. It should also be noted that the share of energy expenditures increases slightly across the income groups in Poland. This may be related to higher consumption in higher income deciles as lower income deciles have very low absolute expenditures as per the energy poverty indicators of the EU Energy Poverty Advisory Hub[91].

[89] This may be linked to the lack of competitiveness of domestic lignite-fired power plants. High operational costs and the increase of emission allowances in the EU ETS play a significant role here.
[90] Year of data is as follows: Portugal (2010), Malta (2015), Cyprus (2016), Spain (2017). For all others 2020 data was available.
[91] For more information see: https://energy-poverty.ec.europa.eu/observing-energy-poverty/national-indicators_en.

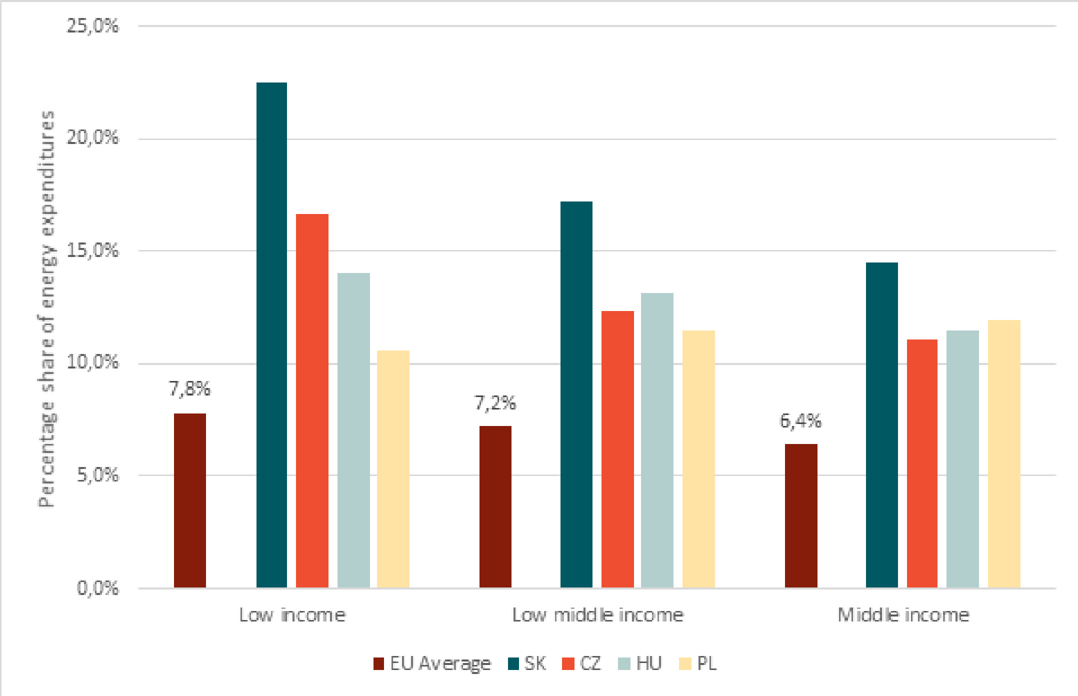


Figure 139: Share of energy expenditure in total expenditure by income groups for Slovakia, Czechia, Hungary, and Poland[92]

Source: DG ENER ad hoc data collection on household consumption expenditures

One of the lowest shares of energy expenditures in total consumption expenditure can be found in Sweden and Finland (see Figure 140). Both in Sweden and Finland, rental payments often include energy costs and it may therefore be difficult to capture energy costs accurately. The share of energy expenditures also does not vary greatly between income groups in these two countries. The higher energy expenditures in Denmark in comparison to the other Nordic countries can be explained by relatively high energy prices.

By comparison, the share of energy expenditures in the Baltic countries is much higher (between 10-14%) and above the EU average (Figure 141). Again, this may be linked to low energy efficiency in the residential building sector, particularly for low-income groups. Particularly in Lithuania where energy efficiency standards are relatively high, however, lower income and lower overall expenditures may be the main driver of the high share of energy expenditures. Although the retail electricity and gas prices are significantly lower in these countries this data reflects the different purchasing powers of households in these Member States.

[92] Year of data is as follows: Slovakia (2019). For all others 2020 data was available.

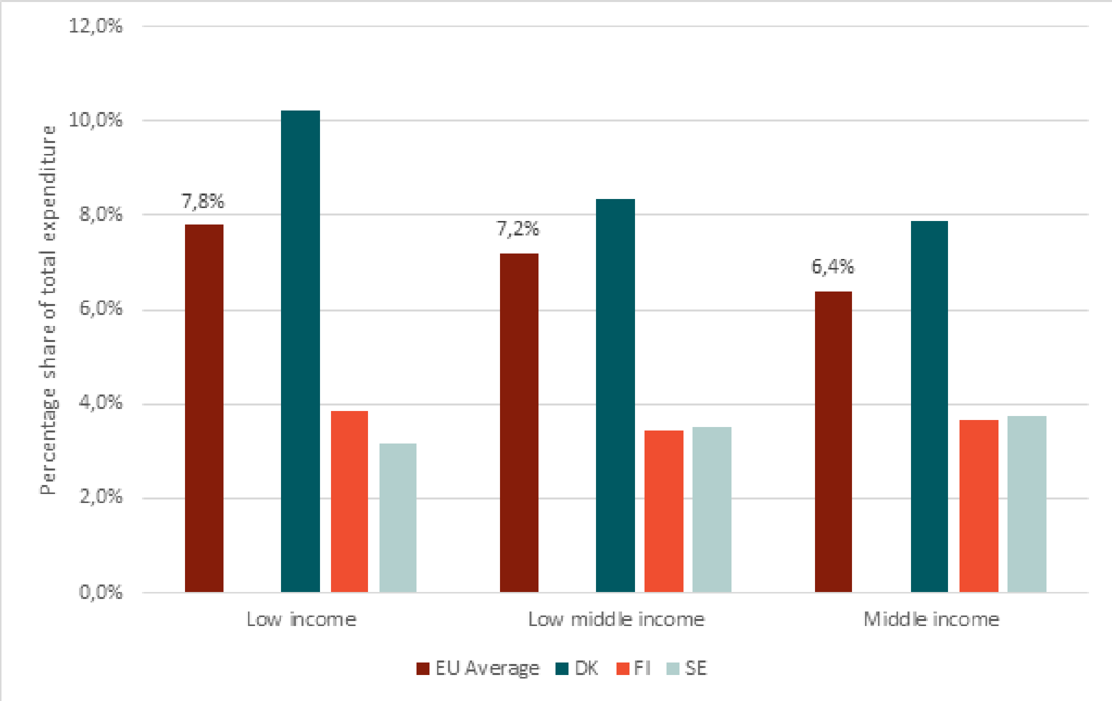


Figure 140: Share of energy expenditure in total expenditure by income groups for Denmark, Finland, and Sweden[93]

Source: DG ENER ad hoc data collection on household consumption expenditures

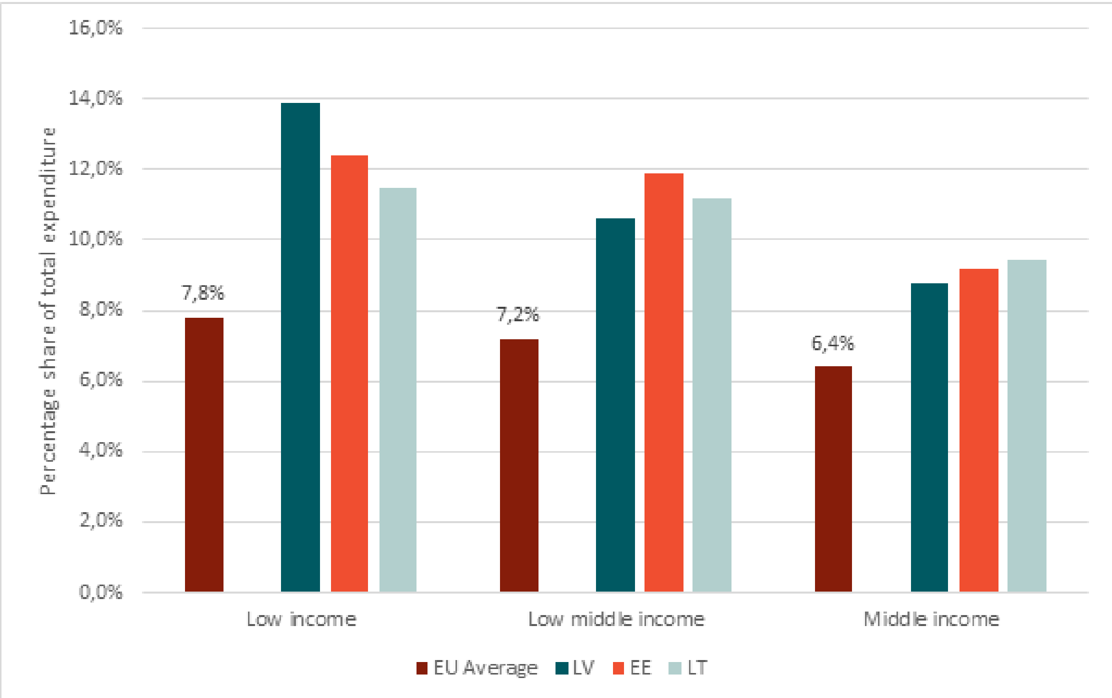


Figure 141: Share of energy expenditure in total expenditure by income groups for Latvia, Estonia, and Lithuania[94]

Source: DG ENER ad hoc data collection on household consumption expenditures

A similar trend can be observed in South East Europe in Figure 142. The share of energy expenditures is relatively high in Romania, Slovenia, Bulgaria, and Croatia and higher than the EU average. Low levels of

[93] Year of data is as follows: Sweden (2012), Finland (2016), and Denmark (2018).
[94] Year of data is as follows: Estonia (2016), Lithuania (2016), Latvia (2019).

energy efficiency as well as lower income levels, again, play a significant role in these Member States and contribute to higher costs for households. It should be noted that in Bulgaria the share of energy expenditures does not decrease across the income groups as with the other Member States and the cost burden of energy remains high even for middle-income households. This could be related to high levels of energy poverty in Bulgaria across income groups in comparison to the other countries shown here, particularly with regard to the self-assessed indicator that asks households whether they are able to keep their home adequately warm.[95]

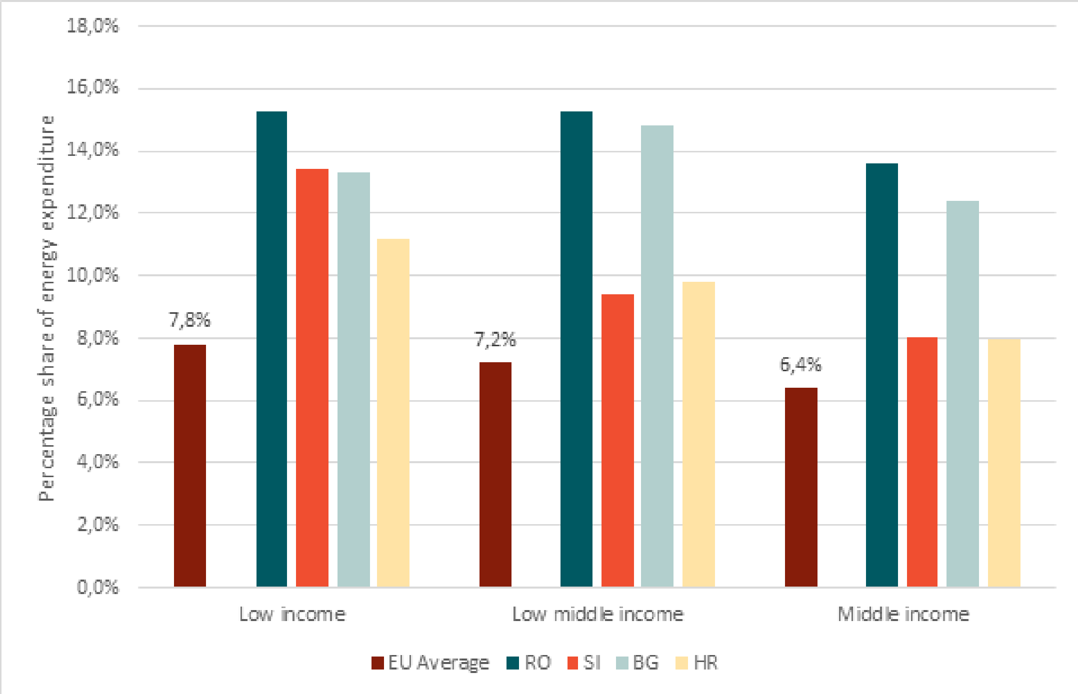


Figure 142: Share of energy expenditure in total expenditure by income groups for Romania, Slovenia, Bulgaria, and Croatia[96]

Source: DG ENER ad hoc data collection on household consumption expenditures

5.7 Energy expenditures in the transport sector

The previous sections covered energy expenditures, but households also dedicate a significant portion of their expenditures to transport fuel related costs. Again, there are significant differences in both the absolute expenditures and the share of transport expenditures across Member States. These differences are related to mobility shares e.g., the availability of public transport, transport infrastructures, car dependency, and so on, but also to the composition of fuel prices related to the level of taxation, for example. In 2020, low-income households spent an average of EUR 953 on transport fuel, accounting for 2.5% of their total expenditures.

For a number of Member States, particularly in Central and Eastern Europe, absolute expenditures for low-income households on transport fuel are very low (see Figure 143). This corresponds to a low percentage share of total expenditures often below 1%, except for Latvia where even absolute expenditures of only EUR 65 make up over 3% of total expenditures. High absolute expenditures can be seen in Luxemburg (EUR 585), Sweden (EUR 597), and France (EUR 666), but also in Cyprus (EUR 744) and

[95] Bulgaria records the highest portion of households in the EU that state that they are not able to keep their homes adequately warm with over 50% across all income groups. See: https://energy-poverty.ec.europa.eu/observing-energy-poverty/national-indicators_en.
[96] Year of data is as follows: Slovenia (2018), Croatia (2019), and Romania (2019). For all others 2020 data was available.

Malta (EUR 1053). For the latter two Member States, this corresponds to a high share of total expenditure between 6-10%. In Cyprus, the share of rural population is relatively high, meaning that even low-income households are dependent on private transport and high costs associated with motorized private transport. Among the EU, Malta has the third highest share of car ownership, again meaning that low-income households will be more likely to also own cars and have high absolute expenditures. In those countries where incomes are generally higher, high expenditures do not make up more than 4% of total expenditures. Extremely low transport fuel expenditures in Romania and Greece may be related to low levels of car ownership in the lowest income deciles.

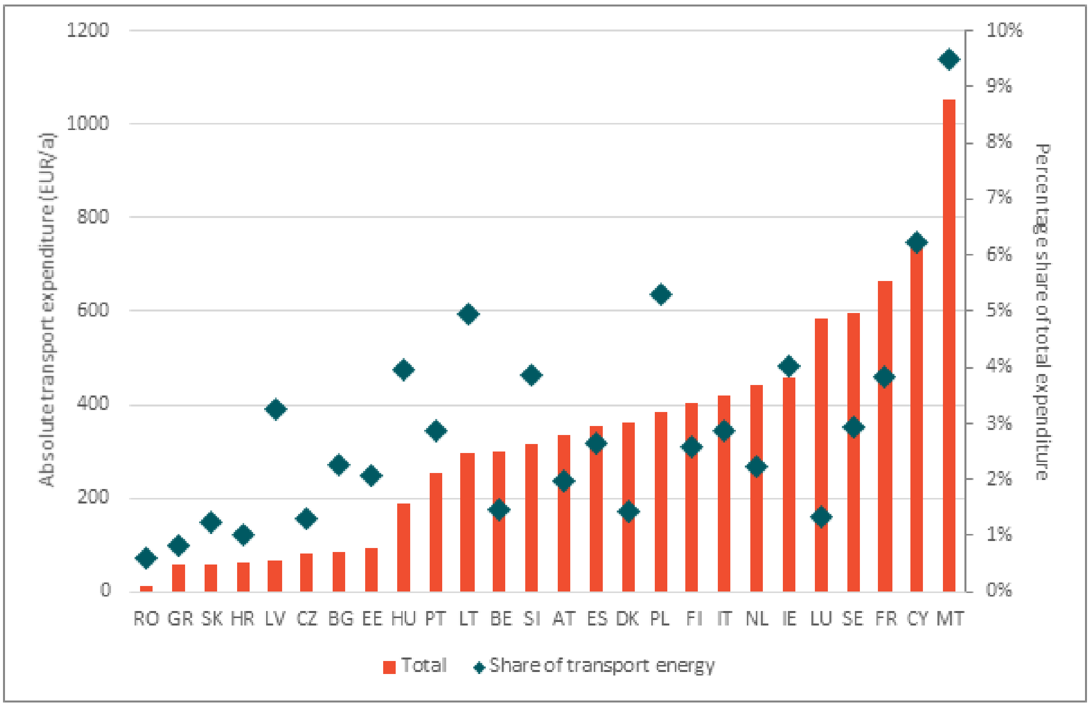


Figure 143: Absolute transport expenditures and share of transport expenditures for low-income households for Member States in the EU27[97]

Source: DG ENER ad hoc data collection on household consumption expenditures

In the majority of Member States, petrol plays the most important role in transport expenditures, which can be seen in Figure 144. The share is particularly high in Greece, Slovakia, and Hungary, but also in Denmark and the Netherlands. High diesel shares can be seen in France, Romania, and Latvia.[98] For Croatia and Finland, no disaggregated data were available.

[97] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). Germany did not deliver any transport related data. For all others 2020 data was available.
[98] The 100% share of diesel transport fuels in Portugal is likely due to an error in reporting.

Figure 144: Share of transport fuels in transport expenditures for low-income households of Member States in the EU27[99]

Source: DG ENER ad hoc data collection on household consumption expenditures

By comparison, absolute transport expenditures for middle-income households were higher than for low-income households (see Figure 145). In 2020, middle-income households spent an average of EUR 887 on transport, accounting for 6.4% of their total expenditures. This is related to the fact that the share of car ownership in low-income households tends to be much lower than in middle-income households that can afford motorized private mobility options. This leads to higher burdens for middle-income households in the transport sector. In particular, in Spain, Slovenia, and Italy the difference in absolute expenditures between low- and middle-income households was higher than in other Member States. These higher expenditures corresponded with either a similar share of transport expenditures of total expenditure or an increase. In Croatia, the share of transport expenditures increases from 1% for low-income households to 4% for middle-income households. This is likely tied to higher car ownership in higher income groups. Malta is the only Member State where the share of expenditures dedicated to transport decreases for middle-income households (from 9% to 7%). This could be related to that fact that car ownership is high overall and there are no significant jumps in ownership rates across income groups, meaning that higher income decreases the share of transport related expenditures.

The share of transport fuels is also slightly different for middle-income households than low-income groups (see Figure 146). Overall, the share of petrol fuels is higher. In Austria, for example the share of diesel was over 15% higher for middle-income households, while the petrol share was lower. Slovenia demonstrates a similar trend of higher diesel shares and lower petrol shares in middle-income households. This may be related to diesel cars being generally more expensive, but also more economical, when taking long or frequent journeys; thus, these are more suited to middle-income groups that travel more frequently by car. In some Member States, the opposite can be observed. In Romania, a direct shift of

[99] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). Germany did not deliver any transport related data. For all others 2020 data was available.

20% from diesel to petrol can be observed between the share of expenditures between low and middle-income households.[100]

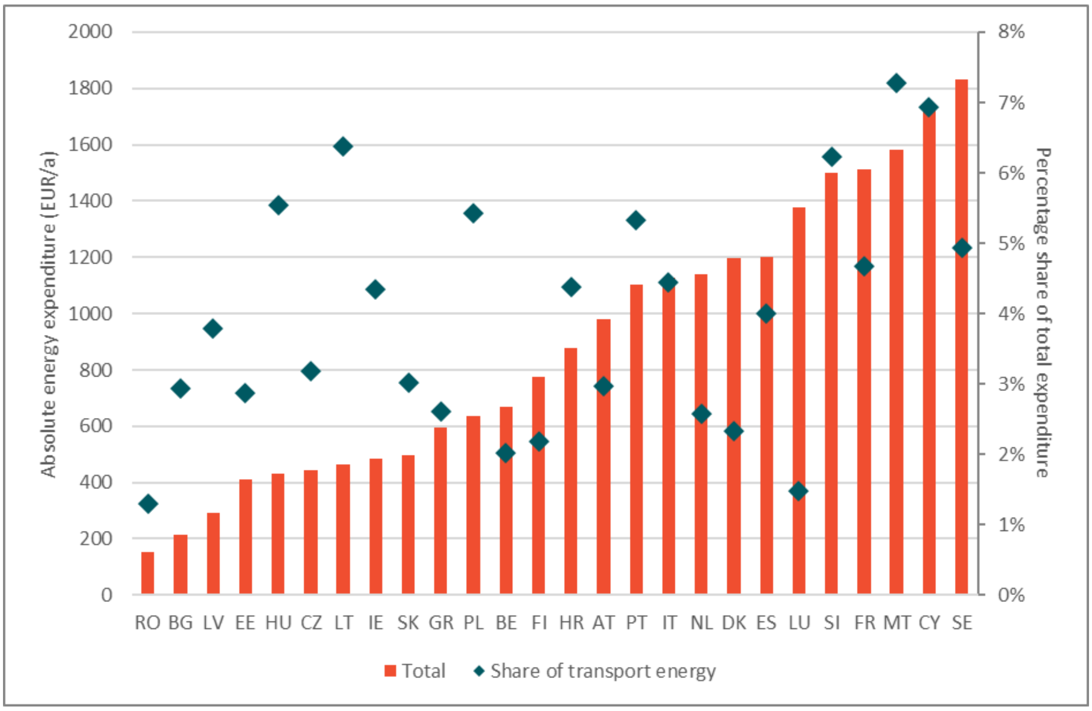


Figure 145: Absolute transport expenditures and share of transport expenditures for middle-income households for Member States in the EU27[101]

Source: DG ENER ad hoc data collection on household consumption expenditures

[100] In Malta the share of petrol and diesel shares were both higher for middle income households as the share of other fuels was almost 55% lower. This does not reflect the national distribution of transport fuels and may thus be an error in reporting.
[101] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). Germany did not deliver any transport related data. For all others 2020 data was available.

Figure 146: Share of transport fuels in transport expenditures for middle-income households of Member States in the EU27[102]

Source: DG ENER ad hoc data collection on household consumption expenditures

5.8 Change in energy expenditures in the Member States (2010-2020)

Figure 147 shows how the share of energy and transport expenditures in the final household consumption expenditure has changed between 2010 and 2020. These changes over time are shown differentiated for low-, low-middle, and middle-income households, respectively, and for both household energy expenditures (electricity, gas, heating, and other fuels) and transport fuels (diesel, petrol, other fuels). The yearly averages here are calculated based on the data available per year and is weighted according to the number of households and the conclusions drawn here are subject to this data availability.[103]

Within household energy expenditures (full lines), it is clear that across the ten-year timespan low-income households consistently spend the highest (of all income groups) share of their total consumption expenditure on energy, while middle-income households spend a consistently lower share. This relationship is inverted, when looking at transport expenditures, where middle-income households spend a higher share of their income on transport due to the factors mentioned above.

Between 2015 and 2019, a slight upward trend can be noted for all income groups for energy expenditures and a stable trend for transport expenditures. The slight downward trend may be due to limited data in 2020 and, as section 5.9 on rising energy prices shows, rises in energy prices mean spikes in energy consumption expenditures overall.

[102] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). Germany did not deliver any transport related data. For all others 2020 data was available.
[103] Data availability differs significantly across years and Member States.

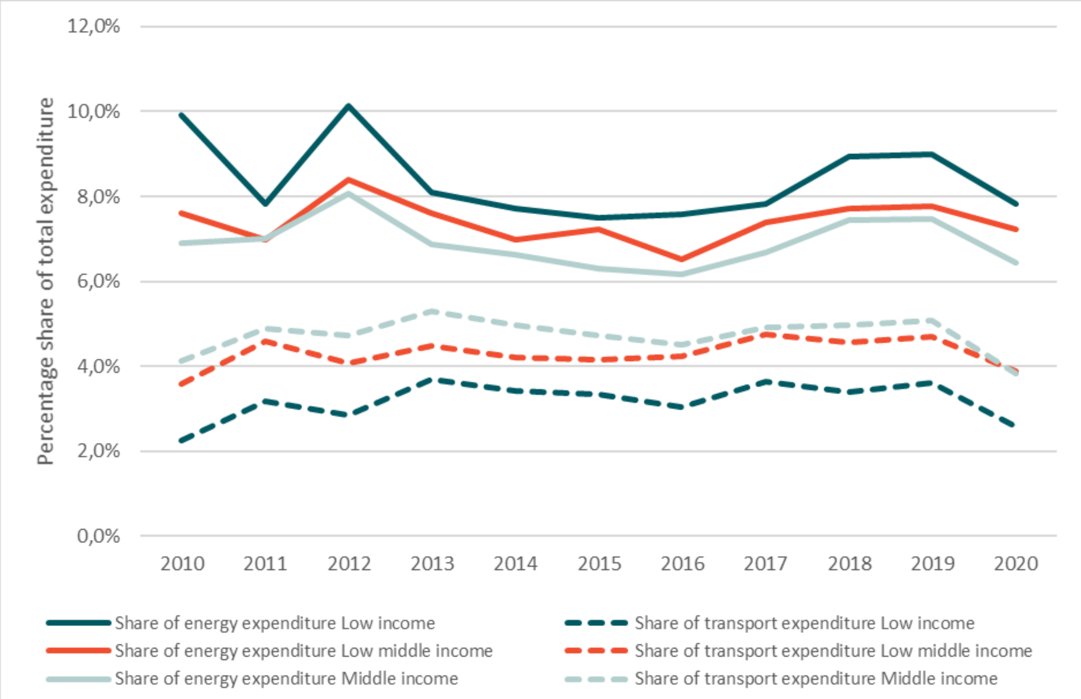


Figure 147: Expenditures on household energy (electricity, gas, heating, etc.) and transport energy (petrol, diesel, etc.) for the poorest, lower middle, and middle-income households by EU Member State 2010-2020[104]

Source: DG ENER ad hoc data collection on household consumption expenditures

Overall, data between 2010 and 2020 demonstrate that there has been a slight decrease in energy expenditures across household income groups. Particularly for low-income groups this has decreased by 2%. However, these changes are linked primarily to decreases between 2010-2015, as consumption expenditure changes between 2015-2020 were very small. For low-middle and middle-income groups there was almost no change in the share of energy related expenditures between 2010 and 2020. Changes in transport expenditures saw a slight upward trend between 2010 and 2020 of around 0.3%. Between 2015 and 2020, however, transport expenditure shares decreased again for all income groups. Only for middle-income groups was there a steady decrease in the share of transport expenditures across the entire period.

Table 4: Changes of share of expenditure on energy across Member States (2010-2020)

	2010	2015	2020	2010-2020	2015-2020
Low-income households	9.9%	7.5%	7.8%	-2.1%	0.3%
Low middle-income households	7.6%	7.2%	7.2%	-0.4%	0.0%
Middle-income households	6.9%	6.3%	6.4%	-0.5%	0.1%

Source: DG ENER ad hoc data collection on household consumption expenditures

Table 5: Changes of share of expenditure on transport energy across Member States (2010-2020)

	2010	2015	2020	2010-2020	2015-2020
Low-income households	2.2%	3.4%	2.6%	0.3%	-0.8%
Low middle-income households	3.6%	4.2%	3.9%	0.3%	-0.3%
Middle-income households	4.1%	4.7%	3.8%	-0.3%	-0.9%

[104] Year of data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

Source: DG ENER ad hoc data collection on household consumption expenditures

5.9 Impact of rising energy prices

Energy prices have increased substantially since early 2021 and skyrocketed following the Russian invasion of Ukraine in February 2022. This chapter focusses on the impact of the current energy prices on household expenditures and tries to provide a comparison between the current and the before-the-crisis situation of households that has been outlined in the previous chapters.

Due to the unavailability of recent, reliable expenditure data, we used energy expenditure and total consumption expenditure data for the year 2020 (or the most recent pre-crisis year) as a starting point[105]. The recent price increases of energy and other consumer goods (as captured in consumer inflation figures) lead to increased expenditures for these goods. Assuming that consumption patterns remain unchanged, increased expenditures for energy (including and excluding transport) as well as total consumption in 2022 can be estimated, using the harmonized index of consumer prices (HICP) for energy and for total consumption (all items)[106] and inflating previous values to the year 2022 (more specially to July 2022 values).

If energy (and overall) consumption decrease over time (in response to price changes), the price and consumption effect in higher household expenditures would need to be disentangled. Unfortunately, no data is not available to allow for such a decomposition, especially by income group. Therefore, for the purposes of this analysis, we thus assumed that higher prices lead to increased expenditure. This presents a limitation to the approach as the interrelation of energy quantity restrictions, price change, and consumption reduction cannot be reflected.

Nevertheless, and taking into account the limitations mentioned above, the following insights could be drawn:

- The share of energy expenditure (including and excluding transport) in total consumption expenditure has substantially increased, linked to the fact that energy prices have increased more than the overall price level.
- The increase of inflation is mainly driven by an increase in the prices of natural gas, liquid fuels and in some instances electricity (see Table 6). Which of the energy carriers mainly drive inflation varies by Member State, as does the extent of the price increase. Greece, Latvia, Estonia and Bulgaria experienced a more than fourfold increase in natural gas prices between July 2020 and July 2022. Electricity prices more than tripled in Estonia and more than doubled in the Netherlands, Italy and Cyprus. Liquid fuels were the main price driver in 12 Member States and increased by more than fifty percent in all Member States, except for Italy and Malta.
- For energy expenditure *without* transport fuels, higher prices present a substantially higher burden for households with low income, i.e. they lead to a more regressive distribution of the expenditure burden.
- For expenditure on energy *including* transport fuels, the additional burden is highest for higher income groups as they more often own a car and drive more.

[105] Data was used from the Household Budget Survey, including data provided by the Household Budget Working Group. We included all Member States for which data was available for the year 2015 and later. For Sweden and Portugal, data was only available for the year 2012 and 2010 respectively. Most recent data is as follows: Portugal (2010), Sweden (2012), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), Estonia (2016), Finland (2016), Lithuania (2016), Spain (2017), France (2017), Germany (2018), Denmark (2018), Slovenia (2018), Croatia (2019), Latvia (2019), Romania (2019), Slovakia (2019). For all others 2020 data was available.

[106] Eurostat (n.d.). Harmonised index of consumer prices (HICP).

Table 6: Harmonized index of consumer prices (HICP) - Classification of individual consumption by energy expenditures (COICOP) July 2022 compared to July 2020 (i.e. 07/2020 = 100)

	Electricity	Natural Gas	Liquid fuels and fuels for transport	Solid fuels	District heating	Transport	All-items HICP
Austria	115.99	179.17	206.30	162.10	120.90	130.70	112.51
Belgium	166.85	273.32	180.34	113.63	no data	120.70	111.90
Bulgaria	107.96	412.79	184.76	161.10	137.46	139.97	117.45
Croatia	110.83	125.19	175.19	106.68	94.29	127.61	115.72
Cyprus	216.40	153.75	173.97	113.15	no data	132.07	113.53
Czechia	129.04	152.31	170.69	143.96	118.39	134.73	120.39
Denmark	179.00	279.20	168.39	147.85	100.74	117.93	111.50
Estonia	373.08	411.79	176.52	179.93	161.22	142.47	129.21
Finland	140.72	no data	174.66	no data	105.96	124.10	110.01
France	111.59	181.90	164.04	114.49	163.44	118.52	108.42
Germany	120.00	155.68	168.87	153.52	136.83	116.65	111.84
Greece	156.83	480.52	170.40	108.26	no data	122.91	112.00
Hungary*	105.75	220.15	140.53	153.83	100	135.75	142.19
Ireland	155.71	168.26	177.07	137.14	no data	129.26	111.94
Italy	210.24	195.29	147.52	108.28	no data	119.86	109.41
Latvia	184.24	440.82	178.54	205.11	156.35	137.73	124.74
Lithuania	177.64	243.03	178.89	240.02	230.51	141.53	126.08
Luxembourg	102.42	160.37	190.03	138.97	158.76	139.83	112.94
Malta	100.00	no data	100.00	no data	no data	107.57	107.17
Netherlands	250.96	239.91	147.18	no data	126.11	121.09	113.21
Poland	115.00	138.30	178.55	235.82	116.32	138.83	119.52
Portugal	136.37	141.00	151.25	114.57	no data	118.52	110.65
Romania	143.94	205.04	177.55	126.38	127.49	133.45	117.30
Slovakia	106.88	107.91	164.46	124.67	114.77	132.97	116.10
Slovenia	129.11	158.34	181.11	140.22	160.23	133.80	113.88
Spain	189.49	128.97	164.72	no data	no data	125.32	113.86
Sweden	153.28	107.17	163.76	121.93	103.06	115.75	110.33
EU27 average	142.26	173.49	166.14	168.19	124.69	122.49	112.49

*Source: Source: Eurostat (2022), HICP - monthly data (index) [PRC_HICP_MIDX__custom_3462527]; *Note: Data for Hungary 08/2022 versus 07/2020.*

Notes: In blue = Maximum per Member State and consumption purpose

The impact of price increases on the shares of energy expenditure in total household expenditure is shown in Figure 148 to Figure 152 excluding transport fuels and in Figure 153 to Figure 157 including transport fuels. The figures show expenditure shares for the pre-crisis year 2020 (or the last available pre-crisis year) as well as for the high price situation in 2022, each shown by income quintiles for a set of countries in each figure.

Impact of price increases on energy expenditure without transport fuels

The impact of price increases on energy expenditure **without transport fuels** can be summarized as follows (compare Figure 148 to Figure 152). On average across EU Member States, the energy expenditure share increases by more than one third (relative change of 34%) due to the price spike, comparing expenditure shares of Member States for 2020 or the last year of data availability with expenditures shares in July 2022. The maximum increase is almost a doubling of the energy expenditure share in Estonia. A few countries do not show any increase in the share of energy expenditure (Malta and Hungary), implying that prices for energy did not increase more than prices for overall consumption goods.

In particular, Estonia, Belgium, Cyprus, Greece, the Netherlands and Lithuania show a higher than EU-average increase in the expenditure share of energy. A high increase in energy expenditure is a combination of the increase in prices for energy carriers and a high share of use of these energy carriers. Keeping in mind the share of final energy use as shown in Figure 128, we find such combinations of high share of energy use and high price increase:

a) for electricity in particular for Estonia, Bulgaria, Spain, Sweden and Cyprus,

b) for natural gas in particular for Belgium, Italy, Hungary and the Netherlands and

c) for solid fuels in particular for Poland.

The impact of price and expenditure increases differ by income group. Low-income households need to pay a higher share of their expenditure on energy and are substantially more affected than higher income groups.

The increase in EU-average share of energy expenditure in total consumption expenditure between 2020 (or latest year available) and year 2022 for different income groups is as follows:

- First income quintile: Increase by 2.9 percentage points (from 10% to 12%)
- Third income quintile: Increase by 2.2 percentage points (from 7% to 9%)
- Fifth income quintile: Increase by 1.6 percentage points (from 5% to 7%)

This implies that the increase is highly regressive e.g., the burden for low-income households is substantially higher.

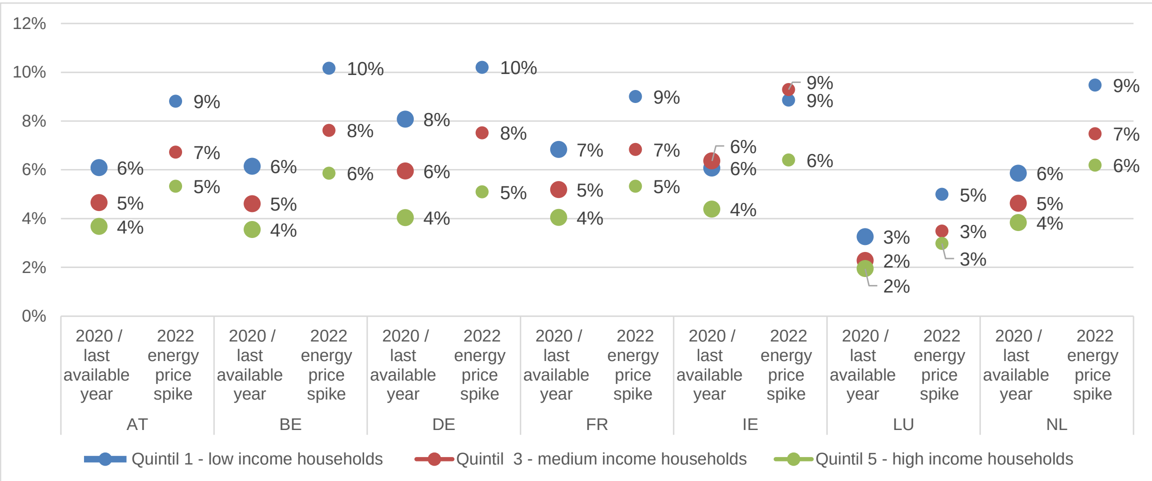


Figure 148: Share of energy expenditure (excluding transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - Austria, Belgium, Germany, France, Ireland, Luxembourg and Netherlands

Source: Own calculation based on ad hoc data collection on household consumption expenditures

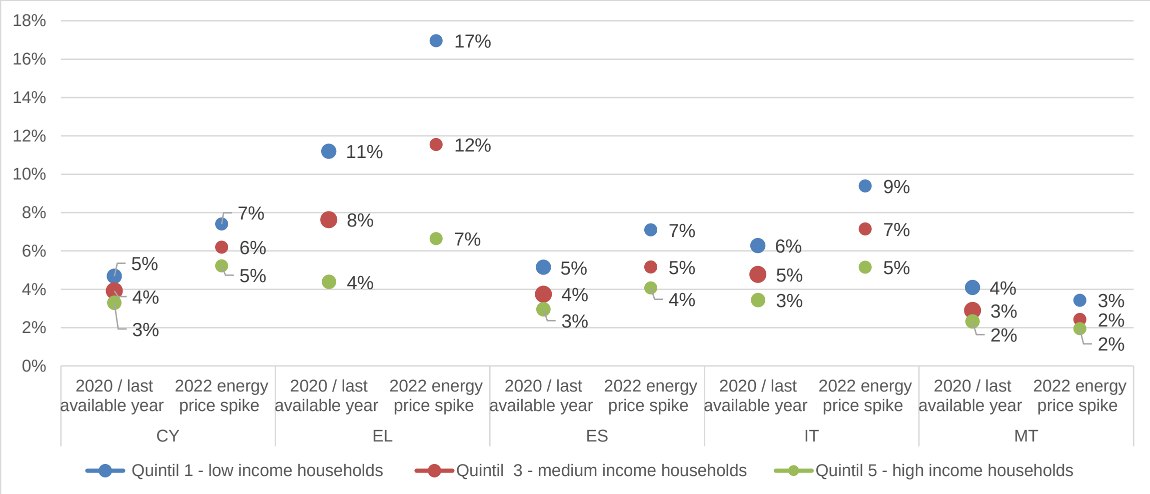


Figure 149: Share of energy expenditure (excluding transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - South European countries: Cyprus, Greece, Spain, Italy and Malta

Source: Own calculation based on ad hoc data collection on household consumption expenditures

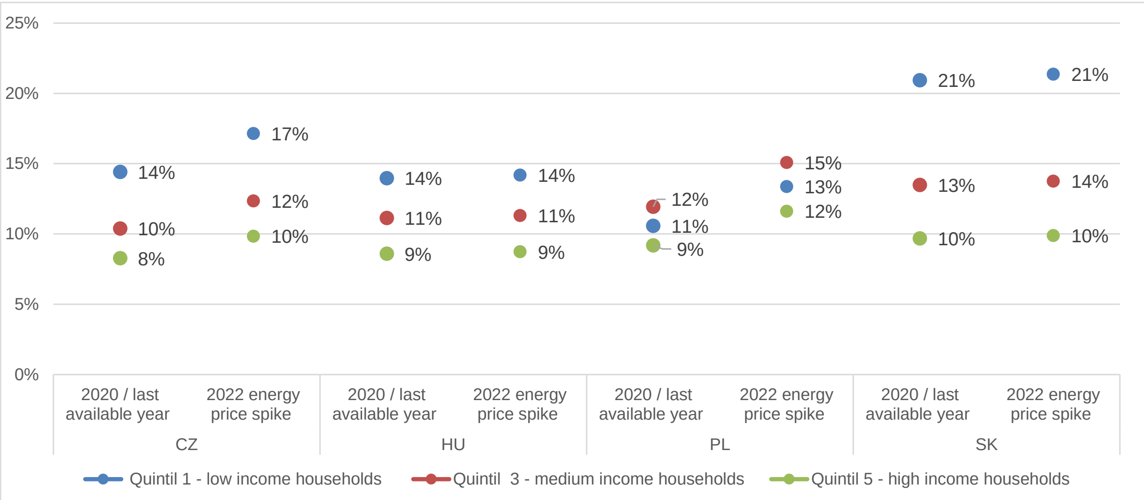


Figure 150: Share of energy expenditure (excluding transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - Czechia, Hungary, Poland, and Slovakia

Source: Own calculation based on ad hoc data collection on household consumption expenditures

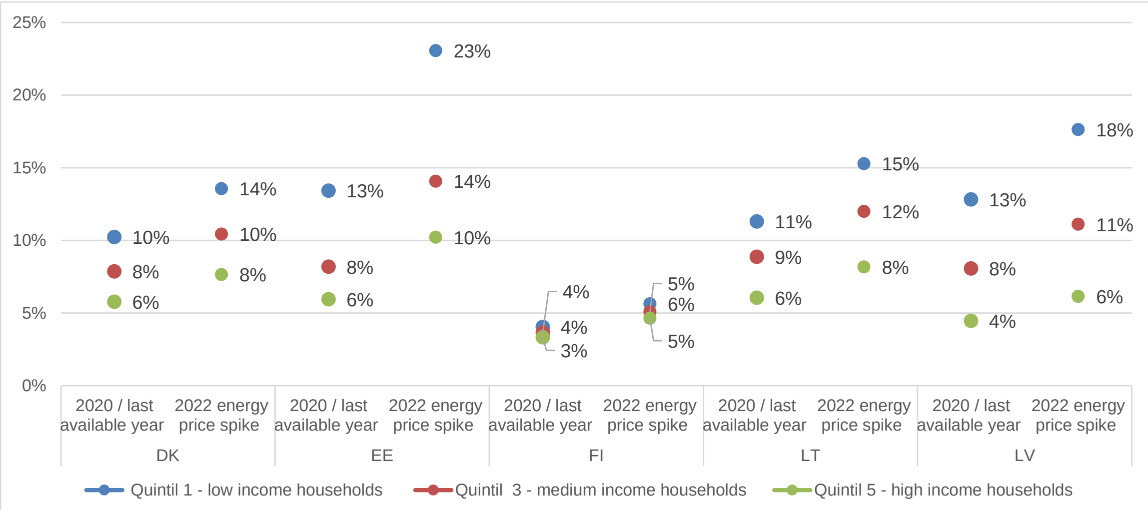


Figure 151: Share of energy expenditure (excluding transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - Nordic and Baltic countries: Denmark, Estonia, Finland, Lithuania and Latvia

Source: Own calculation based on ad hoc data collection on household consumption expenditures

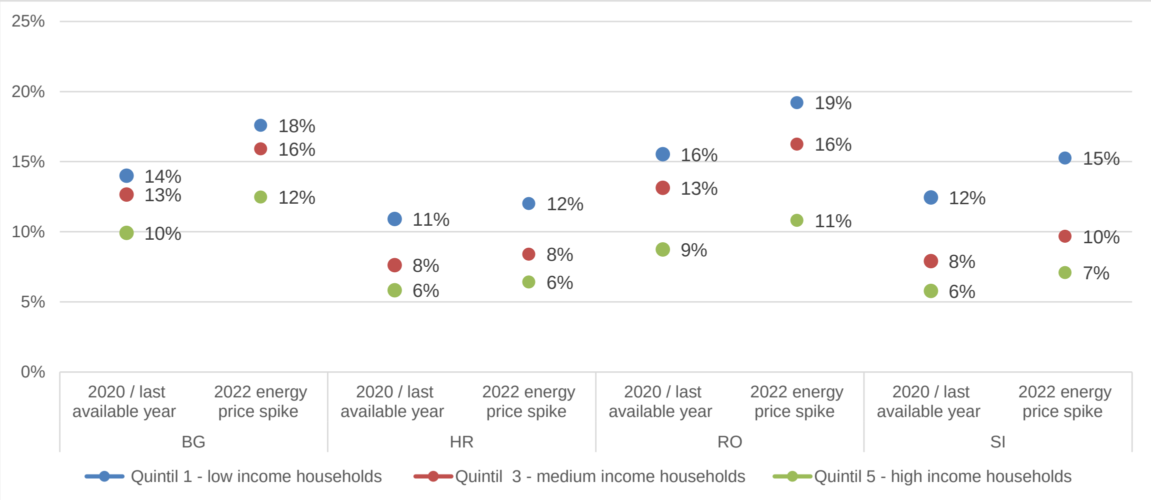


Figure 152: Share of energy expenditure (excluding transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - South East Europe: Bulgaria, Croatia, Romania and Slovenia

Source: Own calculation based on ad hoc data collection on household consumption expenditures

Impact of price increases on energy expenditure including transport fuels

The picture is slightly different when transport fuels are included (compare Figure 153 to Figure 157). Low-income households less often own or drive a car and thus have a lower share of transport fuel related costs. On average, across EU Member States, low-income households spend about 47% of their energy expenditure on transport fuels (ranging from 11% in Romania to 79% in Luxembourg). Medium income households spent about 63% of their energy expenditure on transport fuels (ranging from 31% in Romania to 90% in Luxembourg) and high-income households about 74% (ranging from 52% in Bulgaria to 88% in Malta).

Including transport fuels, we see energy expenditure shares of mostly below or around 20% before the price increase and expenditure shares of 25% to almost 40% following the price increase. The combination of a high share of liquid fuel use and a high increase in the price for liquid fuels drives the increase in expenditures shares, in particular in Ireland, Luxembourg, Cyprus and Belgium, but also in other Member States. Overall, the price increase for liquid fuels is between 50% and more than 100% in almost all Member States.

-
- Considering different income groups, the increase in EU-average share of energy expenditure in total consumption expenditure between 2020 (or latest year available) and year 2022 is as follows:
  - First income quintile: Increase by 5.6 percentage points (from 17% to 23%)
  - Third income quintile: Increase by 6.4 percentage points (from 19% to 26%)
  - Fifth income quintile: Increase by 6.7 percentage points (from 21% to 28%)

The increase is more evenly distributed than for energy expenditure only and thus not regressive. This is because the share of transport fuel expenditure is substantially lower in lower income households.

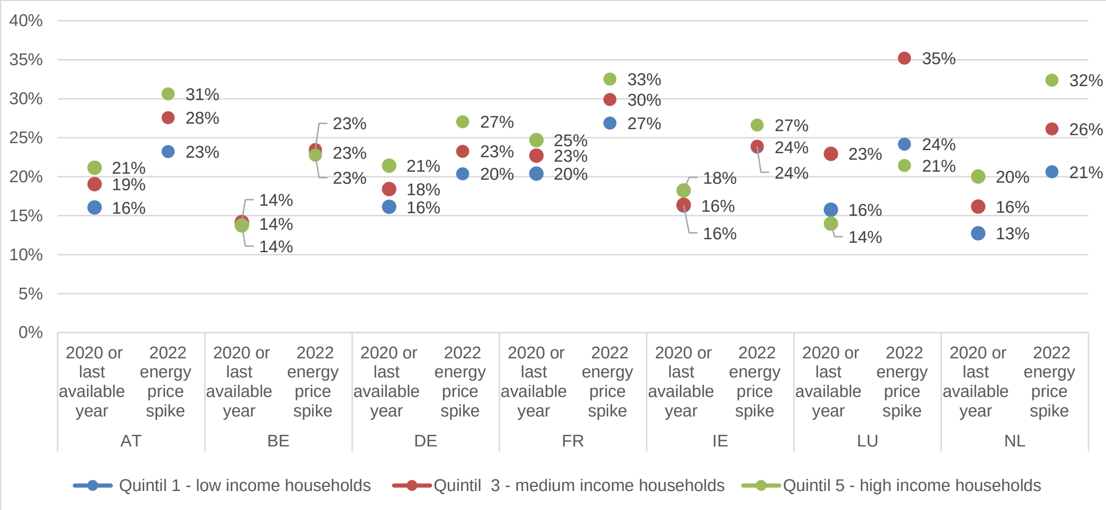


Figure 153: Share of energy expenditure (including transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - Austria, Belgium, Germany, France, Ireland, Luxembourg and Netherlands

Source: Own calculation based on ad hoc data collection on household consumption expenditures

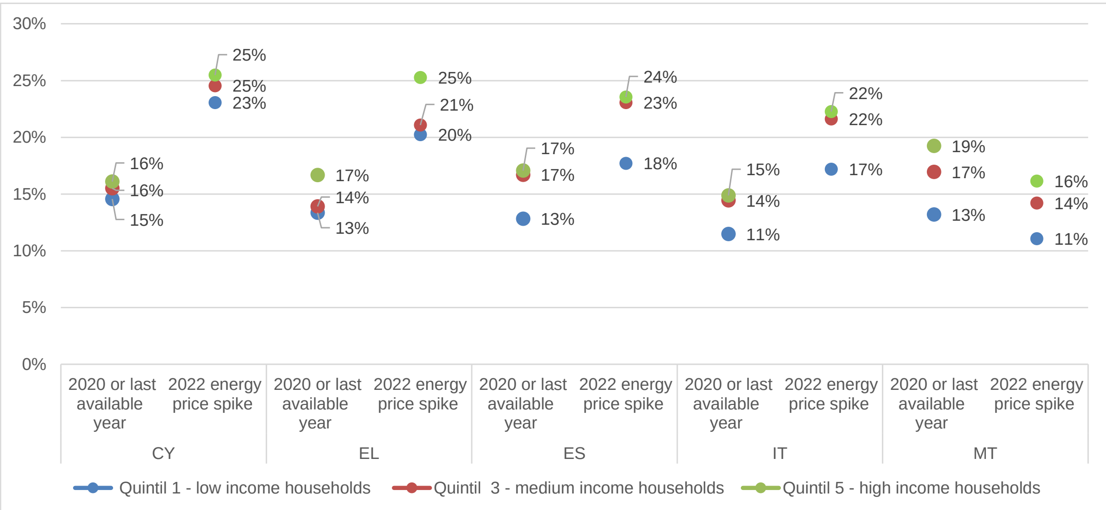


Figure 154: Share of energy expenditure (including transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - South European countries: Cyprus, Greece, Spain, Italy and Malta

Source: Own calculation based on ad hoc data collection on household consumption expenditures

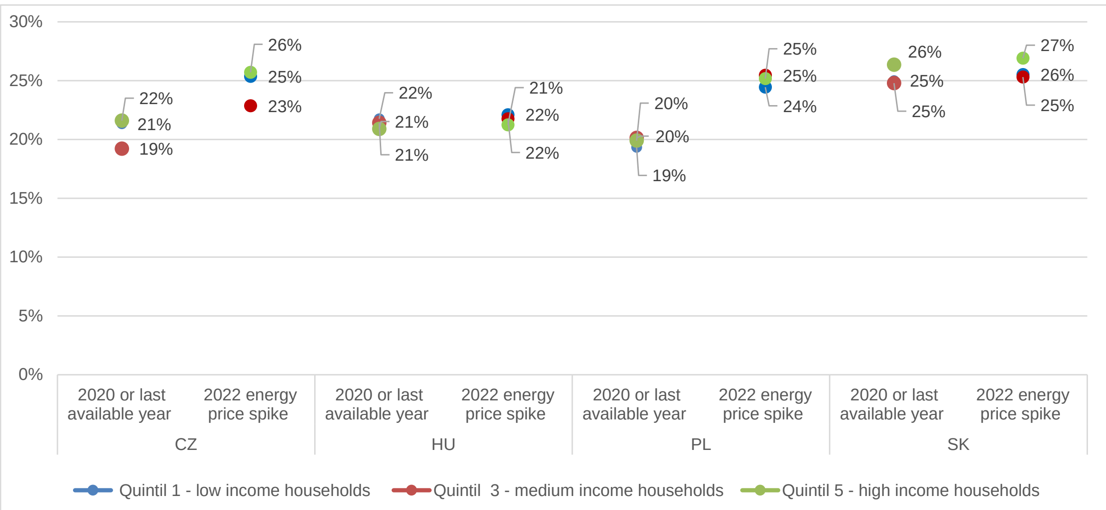


Figure 155: Share of energy expenditure (including transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - Czechia, Hungary, Poland, Slovakia

Source: Own calculation based on ad hoc data collection on household consumption expenditures

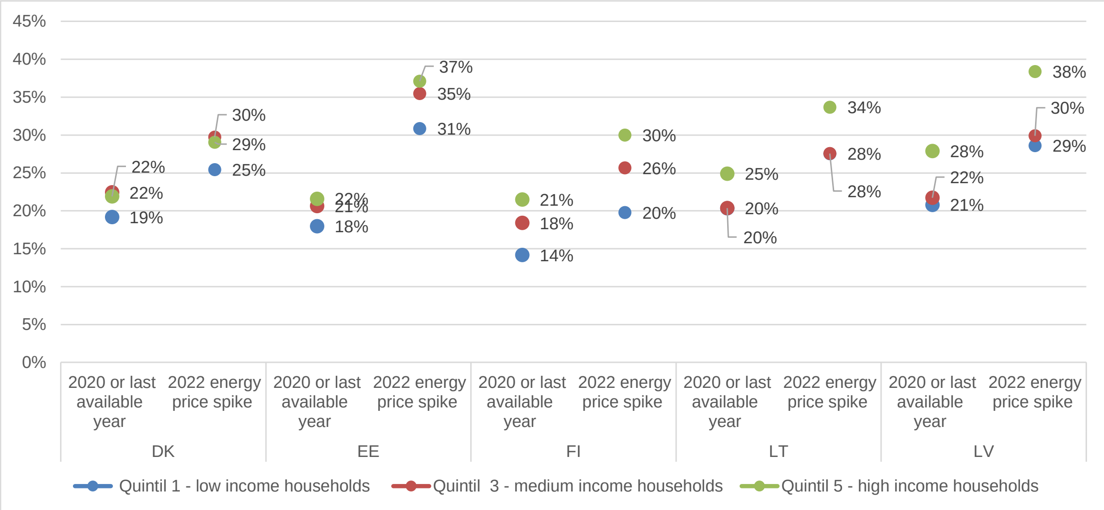


Figure 156: Share of energy expenditure (including transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - Nordic and Baltic countries: Denmark, Estonia, Finland, Lithuania and Latvia

Source: Own calculation based on ad hoc data collection on household consumption expenditures

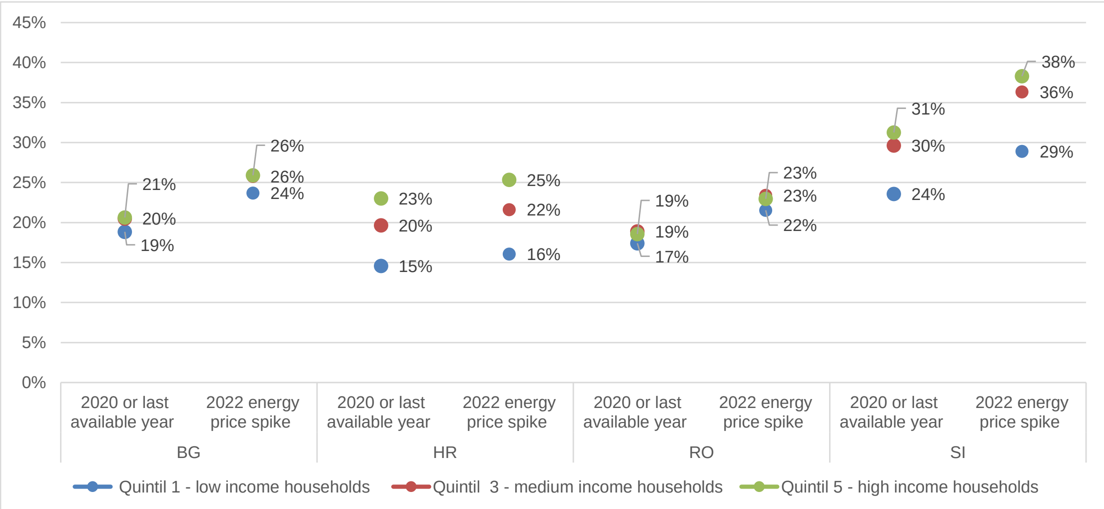


Figure 157: Share of energy expenditure (including transport fuels) in total consumption expenditure - pre-crisis and crisis price levels - South East Europe: Bulgaria, Croatia, Romania and Slovenia

Source: own calculation based on ad hoc data collection on household consumption expenditures

5.10 Rebound effects and elasticities

The term “rebound effect” has been used in the literature of energy economics primarily to describe changes in households’ energy use behaviour, induced by energy-saving goods and services. A distinction is made between the direct and the indirect rebound effect: Households change their behaviour after implementing energy saving measures by expanding their energy consumption (direct rebound effect). The additional income that freed up by energy cost savings can be used for other energy-intensive consumption (indirect rebound effect)[107].

The following analysis provides an overview of household consumption expenditures, broken down by different consumption groups and aggregated by region. For a more detailed analysis by Member States, see Chapters 5.2-5.8 above. Assuming that total expenditures remain at a fixed level as energy prices rise, for example because of household budget constraints, households have to save money to stay within budget. Consumption patterns vary between the EU regions and therefore the opportunity to reduce consumptions costs varies as well. Figure 158shows expenditure patterns for four EU regions (for more detail on MS also see Figure 129). The share of energy expenditure is low compared to other consumption categories. Higher energy expenditure could be compensated by saving energy or by reducing expenditure on other consumer goods, e.g. purchase of clothing or furniture (summarized here by “others”). Other categories, such as housing costs are less flexible, and expenditure (and consumption) could not be reduced. In addition, households with low available income or low overall budget might already have limited their expenditure in various categories and are less flexible or not able to reduce expenditure further without compensating on their daily needs.

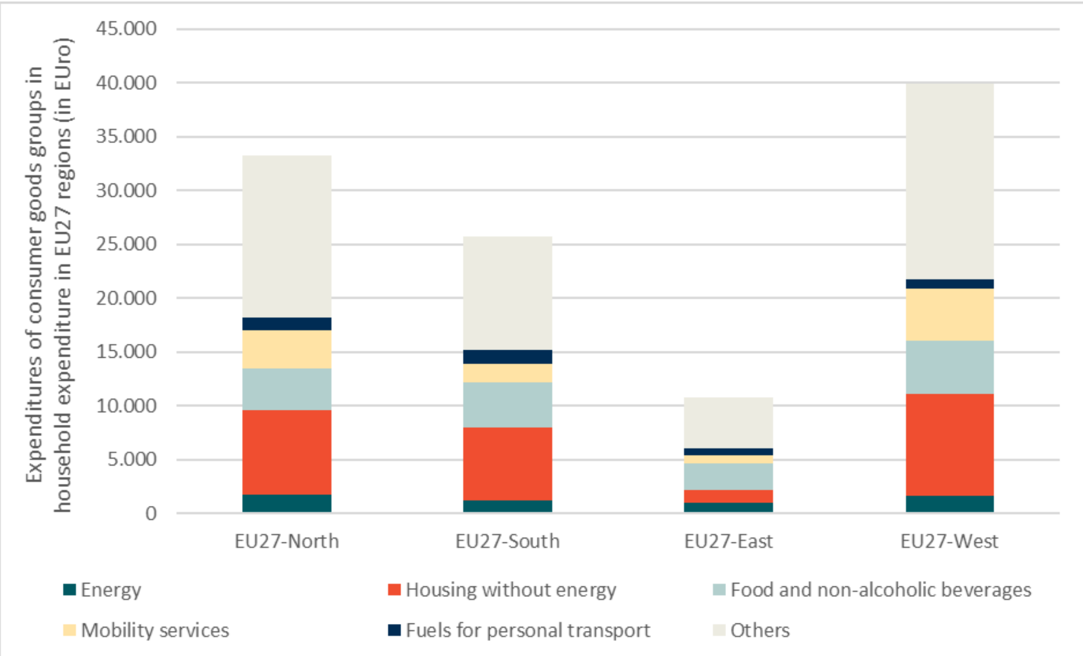


Figure 158: Household expenditures of consumer goods in EU27 regions

Source: own calculation based on ad hoc data collection on household consumption expenditures

Notes: EU North = DK, FI, IE, SE; EU South = CY, ES, EL, IT, MT, PT; EU East = BG, CZ, EE, HR; HU, LT, LV, PL, RO, SI, SK; EU West = AT, BE, DE, FR, LU, NL

[107] IRGC (2013): The Rebound Effect: Implications of Consumer Behaviour for Robust Energy Policies. A review of the literature on the rebound effect in energy efficiency and report from expert workshops.

Generally, changes in energy consumption patterns and behaviour (energy demand) due to an increase (or spike) in energy prices can be calculated through price elasticities. Price elasticities indicate how sensitive the demand for a particular good reacts to changes in the price of the same good. It measures the percentage change in demand relative to the percentage change in price. Demand is considered to be elastic if a 1% price increase reduces demand by more than one percentage point. If the decrease in demand is less than one percent, demand is considered inelastic[108,109].

While short-term price elasticities lead to behavioural changes within a year, long-term price elasticities change demand over a period of five to ten or even more than ten years[110]. According to Huntington et al.[111], price elasticities differ significantly by energy source. Held (2017)[112] and DIW (2019) show that demand for fossil heating fuels is more price elastic than for electricity. Long-term price elasticities are larger than short-term ones.

The following Table 7 provides an overview of the bandwidths of price elasticities of energy demand as discussed in the relevant literature. This overview only includes data from literature that compared EU Member States or other industrialized countries. Overall, it can be noted that price elasticities for electricity are low (relatively inelastic). For most households, electricity provides a basic good that cannot be reduced drastically in the short term. In the longer term, investment in energy efficient appliances and lighting help to save electricity. The difference between short term and long-term elasticities is even more pronounced for natural gas use. Reducing natural gas use for heating requires installation of a new heating system or an energy retrofit of the building which most often is not possible in the short term but only in the longer term.

Table 7: Bandwidths of price elasticity of demand estimates for electricity, heating, and fuels on household level

Energy source	Price elasticity of demand - short term	Price elasticity of demand - long term
Electricity	-0.2 to -0.4	-0.32 to -0.66
Natural gas	-0.1	-0.7
Transport fuels	-0.1 to -0.7	-0.3 to -0.6

Source: Own compilation based on Pothen und Tovar Reanos (2018)[113], Frondel and Vance (2018)[114], Held (2017)[115], Schulte and Heindl (2017)[116], de Yong et al. (2010)[117], Büchs et al. (2021)[118], Douenne (2018)[119], Prognos (2013)[120], Edenhofer et al. (2019)[121]

In light of the goals of European energy policy, which aims at increasing energy efficiency and switching to CO_2-free energy sources, the distinction between own-price elasticity (energy efficiency) and cross-

108 DIW (2019): CO2 pricing in the heat and transport sectors: discussion of effects and alternative relief options.
109 >1 relatively elastic; 0 neutral <1 relatively inelastic.
110 DIW 2019
111 Huntington et al. (2019): Review of key international demand elasticities for major industrializing economies. In: Energy Policy, Vol. 133. https://doi.org/10.1016/j.enpol.2019.110878
112 Held, B (2017): Impacts of internalizing external costs of consumption.
113 Pothen, F.; Reanos, T. (2018): The Distribution of Material Footprints in Germany. In: Ecological Economics, Vol. 153, p. 237-251.
114 Frondel, M. und Vance, C. (2018): Drivers' response to fuel taxes and efficiency standards: evidence from Germany.
115 S. Footnote 78
116 Schulte, I.; Heindl, P. (2017): Price and income elasticities of residential energy demand in Germany. In: Energy Policy, Vol. 102, issue C, 512-528.
117 de Yong et al. (2010): Price sensitivity of European road freight transport - towards a better understanding of existing results.
118 Büchs, M., Ivanova, D., Schnepf, S. V. (2021): Fairness, effectiveness, and needs satisfaction: new options for designing climate policies. In: Environmental Research Letters. Jg. 16, Nr. 124026.
119 Douenne, T. (2018): The vertical and horizontal distributive effects of energy taxes: A case study of a French policy.
120 Prognos (2013): Endbericht: Endenergieeinsparziel gem. Art. 7 EED und Abschätzung der durch politische Maßnahmen erreichbaren Energieeinsparungen.
121 Edenhofer, O; Flachsland, C.; Kalkuhl, M.; Knopf, B.; Pahle, M. (2019): Bewertung des Klimapakets und nächste Schritte CO2-Preis, sozialer Ausgleich, Europa, Monitoring.

price elasticity (switching to renewables) is very important. In terms of cross-price elasticities, a review of the literature provides little information, indicating that further research in this area should be conducted, while for (own-) price elasticities, comprehensive panel analyses and country comparisons are available.

To ensure a reliable estimation of the effect of a change in behaviour, it would be useful to differentiate the observations for different household types in all Member States, since, for example, the change in heating energy consumption in response to a price increase depends on numerous factors.

The following aspects are relevant:

- Households can only react to a price change if they are aware of prices they pay and their own energy consumption. Awareness could be raised by feedback mechanisms and information campaigns Price elasticities can therefore be expected to be higher if prices/costs are communicated transparently. In addition, providing smart meters to European households could further raise their awareness of the amount of energy (electricity) consumed.
- Knowledge of future price developments: The likelihood that households will invest in energy-efficient building retrofits due to price changes increases when a reliable and increasing price path is provided. Therefore, long-term price elasticities can be expected to be higher if a long-term, clearly communicated and increasing price path, including information on long-term policies, characterizes the price development.
- In tenant-occupied households, the possibilities to change the energy quality of the building envelope as well as the heating system are usually very limited, so it can be expected that the long-term price elasticities are significantly lower than in owner-occupied buildings, unless targeted policies are adopted by Member States.
- Changes in heating behaviour due to price changes may vary depending on the household's income: On the one hand, low-income households often already keep their heating energy consumption low and thus have less potential for further reductions (lower price elasticity). Without further adjustment possibilities, they will suffer in particular from additional costs and are increasingly at risk of energy poverty. On the other hand, households with higher incomes are likely to have more extensive opportunities to respond to price increases by investing in the energy quality of the building or reducing consumption (higher long term price elasticities). At the same time, they might simply absorb the additional expenditure, at least in the short term. However, these aspects have hardly been considered in the existing literature.
- There is a large number of studies on fuel price elasticities of (passenger) transport demand. These mostly find short-term elasticities, which are mostly concentrated in a range between -0.2 and -0.3, and higher values for long term elasticities. In the case of mobility behaviour (passenger car use), consumers react more strongly to price changes caused by taxes than to price increases caused by the market[122]. One of the reasons for this is that consumers assume that price increases due to taxes will also increase the price level for fuels in the long run, and are thus more likely to respond by adjusting. In a study for Sweden, Andersson[123] finds that the introduction of a CO_2 price has had about three times the impact on fuel consumption than would

[122] Li, S.; Linn, J.; Muehlegger, E. (2012): Gasoline taxes and consumer behaviour.
[123] Andersson, J. (2019): Carbon Taxes and CO2 Emissions: Sweden as a Case Study. In: American Economic Journal: Economic Policy, Vol. 11, no. 4, DOI: 10.1257/pol.20170144

have been expected with the corresponding increase in fuel costs. Bajo-Buenestado[124] also finds, based on Spanish data, that tax increases have a larger impact than market price fluctuations.

[124] Bajo-Buenestado, R. (2016): Evidence of asymmetric behavioral responses to changes in gasoline prices and taxes for different fuel types. In: Energy Policy, 2016, vol. 96, issue C, 119-130. DOI: 10.1016/j.enpol.2016.05.028

6 Industry energy costs

Summary of main findings

At the time of writing (October 2022), complete and reliable data on energy prices and costs for EU industry is only available up to 2019, while partial data is available for 2020 and 2021. Therefore, publicly available statistics do not fully capture neither the effects of the COVID-19 pandemic nor the energy crisis starting in 2021. We have therefore tried to collect data directly from energy-intensive industries (EIIs), supplemented with publicly available sources, to try to draw general conclusions on the impacts of these significant events on European industries.

Impact of COVID-19 pandemic and the war in Ukraine

- The pandemic initially led to demand reductions and staff shortages because of widespread lockdowns. However, industrial production and trade initially rebounded in 2021 to levels higher than pre-COVID times. The overall sentiment was that while Covid-19 was challenging, the challenges faced by industry in the current energy crisis as a result of the Russian invasion of Ukraine is more severe.
- Prices for **natural gas** increased by 2-3 times in Q1 2022 as compared to 2021 across six industrial sectors surveyed: *Aluminium, Ferro-alloys and silicon*, Zinc, *Ceramics*, *Container glass* and *Fertilisers*. **Electricity prices** also soared and almost tripled for *Primary aluminium* by Q1 2022.
- The full effect of the energy crisis is currently partially cushioned by the fact that some companies still have running fixed-price energy contracts or other hedging strategies in place. Whether or not fixed contracts were negotiated prior to the crises, the ability to secure longer-term energy contracts, and the ability to hedge energy costs at more favourable conditions largely determine the differences in energy prices paid by European companies.
- Higher energy prices have translated in higher absolute and relative energy costs in the total production costs; average energy cost share has increased by 20-55% between 2021 and Q1 2022.
- The energy crisis demonstrated that energy prices still play a decisive role in several sectors' competitiveness. As a direct result of soaring energy prices, production curtailment and plant shutdowns have been widespread in the *Aluminium, Ferro-alloys and silicon, Zinc, Fertilisers, Iron and steel,* and *Chemical* (chlorine production) sectors.
- In some sectors, it has been possible to pass on, at least partially, the increase in energy costs to consumers. The *Container glass* sector has been able to avoid close downs and production curtailments by partially passing on the increase in energy costs in their product prices. Several plants in the *Ceramics* and *Pulp and paper* sectors, despite increases of product prices in the sector, were not able to avoid production curtailments or shutdowns.
- Other measures taken by the industry to cope with the impacts resulting from the Russian invasion of Ukraine include the shifting of production hours to coincide with the lower electricity prices on the spot market, personnel lay-offs, or implementing mandatory unpaid leave or downtime (with reduced salary), and optimisation of processes and logistics.
- There are many hedging strategies available to the industry against energy price volatility, with power purchase agreements (PPAs) for electricity from renewable (RES) power plants are emerging as a significant tool for further developing investment in renewables and securing long term price stability for industries.
- EU located industries are steadily increase the use of RES-PPAs over the last 7 years, the EU RES PPA market has grown from 0.5GW in 2014 to 24W in 2021. In 2021, the PPA market grew by 8.8

GW. The key regions of RES PPA in EU are: i) Iberia (Solar), ii) Germany (Solar and Wind), Belgium and Luxembourg (Wind) and Nordics (Wind).

Long-term trends in energy costs in EU industry

- The average share of energy in production costs of EU27 industry sectors decreased from 2.3% in 2010 to 1.7% in 2016, followed by a period of stagnation up to 2019. Luxembourg has the highest share, which ranges from 7% to 11% and Ireland the lowest share of around 0.5% since 2015.
- Energy cost shares fell in almost every manufacturing sector between 2010 and 2019, including EIIs; the largest decline can be observed in the *Cement*, *lime and plaster* sector – from close to 19% in 2010 to 13.6% in 2019.
- Among non-manufacturing sectors, energy cost shares were highest in *Land transport* (39%), *Air transport* (27%), *Electricity, gas and steam* (20%), *Mining of metal ores* (18%), and *Other mining* (8%).
- Overall, industrial energy purchases within EU27 reduced by 1% over 2015-2019, despite an increase of production output. The decomposition analysis showed that this was mainly due to an *improvement in energy intensity*.
- The most energy intensive sectors reduced, while the least energy intensive sectors increased their energy costs. The increase in the latter is due to higher energy prices, mainly as a result of changes in energy mix and changes in energy prices, particularly for electricity.
- The decomposition analysis also showed that changes in energy costs only have a small contribution to the changes of total production costs of the EU industry. In addition, the share of energy costs to total production costs decreased in 2019 compared to 2015 for almost all analysed sectors.
- Most EU sectors studied maintained an average gross operation surplus (GOS) share between 5-15%, as observed in previous editions of this study. The highest GOSs as shares of production costs between 2010-2019 recorded were *Pharmaceuticals* (22%) and *Cement* (23%); the lowest were recorded in *Non-ferrous metals* (7.6%), Iron, *and steel* (4%).
- Generally, the GOSs for between manufacturing and non-manufacturing sectors are on par, averaging between 5-20%, with the outliers being *Oil and gas* (up to 140%) and *Mining of metal ores* sectors (up to 90%).
- The average EU27 profitability of between 10% and 15% is lower than most of the EU's main trading partners, which have an average GOS share between 15% and 25%, although it is largely similar to that of Switzerland and Norway, both of which have direct access to the EU Single Market.

6.1 Introduction

Chapter 6.2 presents the results from the analysis of data received from 60 plants across six industrial sectors up to Q1 2022. The sectors are *Aluminium, Ferro-alloys and silicon*, Z*inc, Ceramics*, *Container glass* and *Fertilisers.* This section is followed by the outcome of the analysis on the energy prices and costs for industry using highly aggregated statistical information (top-down approach), similar to previous editions of the report. Chapter 6.3 presents the overall impact of energy costs on the economy of the EU and its Member States. Chapter 6.4 analyses energy costs of the industry sector with respect to total operational production costs using data received from both bottom-up and top-down approaches. Chapter 6.5 consider the energy intensity of industries and Chapter 6.6 examines the drivers of energy costs of industries. Chapter 6.7 compares indicators that can influence the international competitiveness of EU industry with regards to energy costs in relation to non-EU G20 countries plus Switzerland, Norway and Iceland. Finally, Chapter 6.8 discusses the benefits of price hedging arrangements for companies from a broader perspective, with a focus on PPAs for renewable energy sources.

6.2 Overview of selected Energy Intensive Industries (EIIs)

The evolution of energy prices and costs and the impact on the competitiveness of selected EIIs is analysed in detail with data collected at plant level via a dedicated questionnaire. In addition, we used public statistics and/or input from industry associations to analyse these sectors' trade situations and to provide context on their relative exposure to international trade dynamics. Finally, specific input was requested from industry associations on the impacts of COVID-19 and the Russian invasion of Ukraine, complemented with public information on the impacts of these two events. The bottom-up analysis covers the entire EU with a focus on the period 2016 – 2021; up to Q1 2022 if data was available.

While we sent the questionnaire to 14 energy-intensive sectors and their industry association, only three sectors provided sufficient data for a representative analysis of their energy costs: *Aluminium, Ferro-alloys and silicon*, and *Zinc*. For *Aluminium*, sufficient data was even available to analyse the sectors in three value chain segments that have distinct different energy structures: primary, secondary and downstream. For three other sectors, sufficient responses were received to show findings in a confidential and anonymous manner but not enough to be representative of the sector: *Ceramics, container glass* and *Fertilisers.*

The responses (from 60 plants across six industrial sectors) cover various aspects of EU energy-intensive industries:

- **Natural gas-intensive sectors** (e.g. *Fertilisers*), **electricity-intensive sectors** (e.g. *Primary aluminium, Ferro-alloys and silicon, Zinc*) and **sectors where both natural gas and electricity are significant** in the production costs (e.g *Ceramics, Container glass)*;
- Sectors **concentrated** in European regions (e.g. *Zinc* is mainly located in North Western Europe and Southern Europe) or **geographically dispersed** in Europe (e.g. *Ferro-alloys and silicon* and *Downstream aluminium*);
- **Net importer** sectors (e.g. *aluminium*, *Ferro-alloys and silicon*) and **net exporter** sectors (e.g. *Zinc*) with different levels of exposure to international competition.

Table 8 shows the representativeness and geographical scope of the responses over three European regions[125]. The EU representativeness of the surveyed plants samples in the Primary *aluminium, Secondary aluminium, Downstream aluminium, Ferro-alloys and silicon* and *Zinc* sectors ranges from 25% to 64% of their sector's production output. For these sectors, the combination of the results of the surveyed plants can be considered to be presentative of an average installation in the EU.

Table 8: Overview of plants participating in the study

Sector	Number of plants by geographical region(1)				Representativeness in 2021(2)
	Central Eastern Europe	North Western Europe	Southern Europe	**Total**	Share of output (O) or turnover (T)
Primary aluminium	1	3	2	**6**	54% (O)
Secondary aluminium	1	2	2	**5**	25% (O)
Downstream aluminium	7	17	4	**28**	27% (O)
Ferro-alloys and silicon	2	2	2	**6**	64% (O)
Zinc(3)	-	5		**5**	50% (O)
Ceramics(3)	-	-	*3*	***3***	*<5% (T)*
Container glass(3)	-	-	*4*	***4***	*<5% (O)*
Fertilisers(3)	*2*	*1*	-	***3***	*N/A*

(1) Central-Eastern Europe: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia; North-Western Europe: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden, the UK; Southern Europe: Cyprus, Greece, Italy, Malta, Portugal, Spain. Non-EU.

(2) For illustrative purpose, figures are shown for 2021. Estimates of the representativeness may vary from year to year although with a similar order of magnitude. For Fertilisers, the representativeness could not be shown to maintain anonymity of the respondents.

(3) For the Zinc sector, data for two more plants were received in a different region than North Western Europe - one in SE and one in a non-EU NWE country. However, these have not been included in the analysis due to an insufficient sample size to maintain data confidentiality.

(4) For the sectors in italic, only a very limited number of companies were willing to provide data, sufficient to show findings in a confidential and anonymous manner but not to be representative of the sector.

Note: for some sectors, data was also received for 1 or 2 plants in non-EU North Western Europe (UK, Norway, Iceland). These have not been included in the analysis due to an insufficient sample size to maintain data confidentiality.

Results

Cross-sectorial findings

Figure 1 shows the average and range in electricity price paid by the surveyed plants per selected sector and their average and range in electricity intensity for 2021 on a logarithmic scale. In the previous editions of this study, the inverse correlation between a high electricity intensity (and thus generally high electricity consumption) and low average prices identified still holds true in 2021 to a certain degree. These could be attributed to various factors:

i) larger consumers of electricity are directly connected to the grids and thus do not have to pay the distribution grid fees

ii) larger consumer have more bargaining power to negotiate their prices and employ hedging strategies

[125] Sectorial results are aggregated at a regional level to respect data confidentiality and anonymity. For some sectors, data was also received for 1 or 2 plants in non-EU North-western Europe (UK, Norway, Iceland). These have not been included in the analysis due to an insufficient sample size to maintain data confidentiality.

iii) larger consumers of electricity are sometimes exempted from specific taxes and levies on electricity prices and
iv) larger consumers of some industries can adapt their manufacturing processes to better exploit cheaper, baseload electricity (e.g. produce at night when prices are lower).

However, as electricity prices have been rapidly rising since 2021, *Ferro-alloys and silicon* already show a deviation from this inverse correlation. This is even more visible with the electricity prices that the surveyed plants paid in Q1 2022. **Overall, electricity prices paid by plants soared and almost tripled for *Primary aluminium*, while that sector is the most electricity-intensive of the surveyed sectors.** For *Zinc*, another electricity-intensive sector, the increase in electricity prices between 2021 and Q1 2022 is more limited. **Some of differences between sectors in electricity price development and deviation from the inverse correlation can be explained by the presence of fixed electricity contracts or other hedging strategies such as PPAs.** This translates into a widening of the range in electricity prices paid by the surveyed companies for the sectors for which sufficient data was collected (see sector reports in Annex B for more detail).

Generally, plants that pay electricity prices at the upper range in a sector have a variable contract, whereas plants that pay relatively low electricity prices have a fixed electricity contract. For example, *Primary aluminium* plants paid a significantly lower electricity price than plants of the *secondary* and *downstream Aluminium* segments. As an electro-intensive industry, for *Primary Aluminium* plants it is crucial to secure electricity supply at a low cost. Consequently, the majority of the *Primary Aluminium* plants have fixed electricity contracts, while most of the plants in the secondary and downstream *Aluminium* sectors have short-term contracts of variable rates, exposing them more to market price fluctuations. However, this does not hold true for all plants as **the price paid also depends on when the fixed contract was formed**[126]. In the *Zinc* sector, the **difference in electricity prices paid by individual plants reflects the degree to which they have secured longer-term contracts or hedged the price of electricity at more favourable conditions than the electricity spot market**.

[126] The surveyed plants were only asked about their electricity contract status as of June 2022, not their contract status during 2021. If these contracts were only formed close to June 2022 and did not have fixed contracts before or their fixed contract expired after the current energy crisis has started, they would show similar prices in 2021 as plants without a fixed contract.

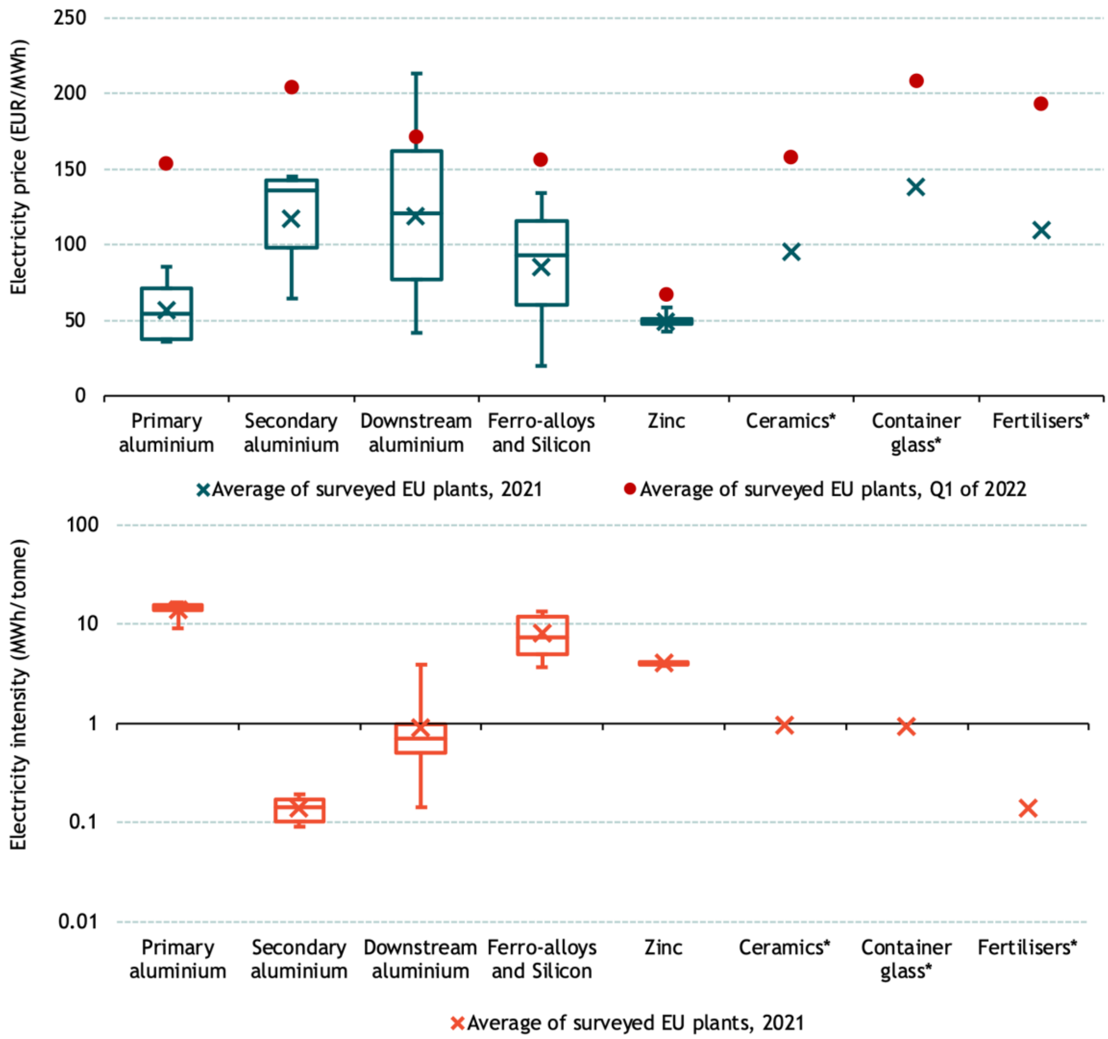


Figure 159: Electricity prices (above) and electricity intensity (below) per sector based on collected plant data for 2021 and Q1 2022; ranges for 2021 only

Source: Own elaboration based on data from industrial plant operators.

**For the sectors Ceramics, Container glass and Fertilisers, only average values of EU plants can be shown to ensure data confidentiality due to the limited number of responses received.*

The results for the **natural gas prices** paid by the surveyed plants per sector and natural gas intensity in Figure 2 show similar results as for electricity. **Surveyed plants in sectors with a high natural gas intensity paid a relatively lower price for natural gas compared to sectors with relatively low intensities.** This can also be due to gas intensive sectors having secured fixed price contracts before the war in Ukraine. Notably, sectors that paid lower electricity prices in 2021 on average also paid higher natural gas prices.

Figure 2 further shows that the **average natural gas price increase reached 2-3 times in every sector in Q1 2022 compared to 2021.** Similar to electricity, many plants with natural gas prices at the lower end of the range have fixed natural gas contracts; those at the higher end have variable contracts. Some sector-specific observations include the following:

- During 2021 and 2022Q1, *Primary aluminium* experienced prices significantly higher than those of *Secondary aluminium* do. Some of the *Secondary aluminium* plants with the lowest natural gas prices had fixed or combined contracts with durations of more than a year, onsite gas storage or invested in demand flexibility for gas. On the other hand, from the *Primary aluminium* sample, only one plant benefited from onsite gas storage and combined contracts for natural gas, which was reflected in having lower prices than the rest of the plants in the sample.

- In the case of *Downstream Aluminium* plants, the increase of natural gas prices of Q1 2022 compared to the previous year was different depending on the location of the plants: plants in the NWE region had a lower price increase than those in the CE and SE regions, even though there were no significant differences in their types of contracts.
- For fertiliser plants, although we could not gather sufficient data to display results in this report, the gas prices that could be determined for the surveyed plants do fall within the same range as the other sectors. Furthermore, a similar rate of increase that is experienced across the other sectors can also be observed between 2021 and Q1 2022.

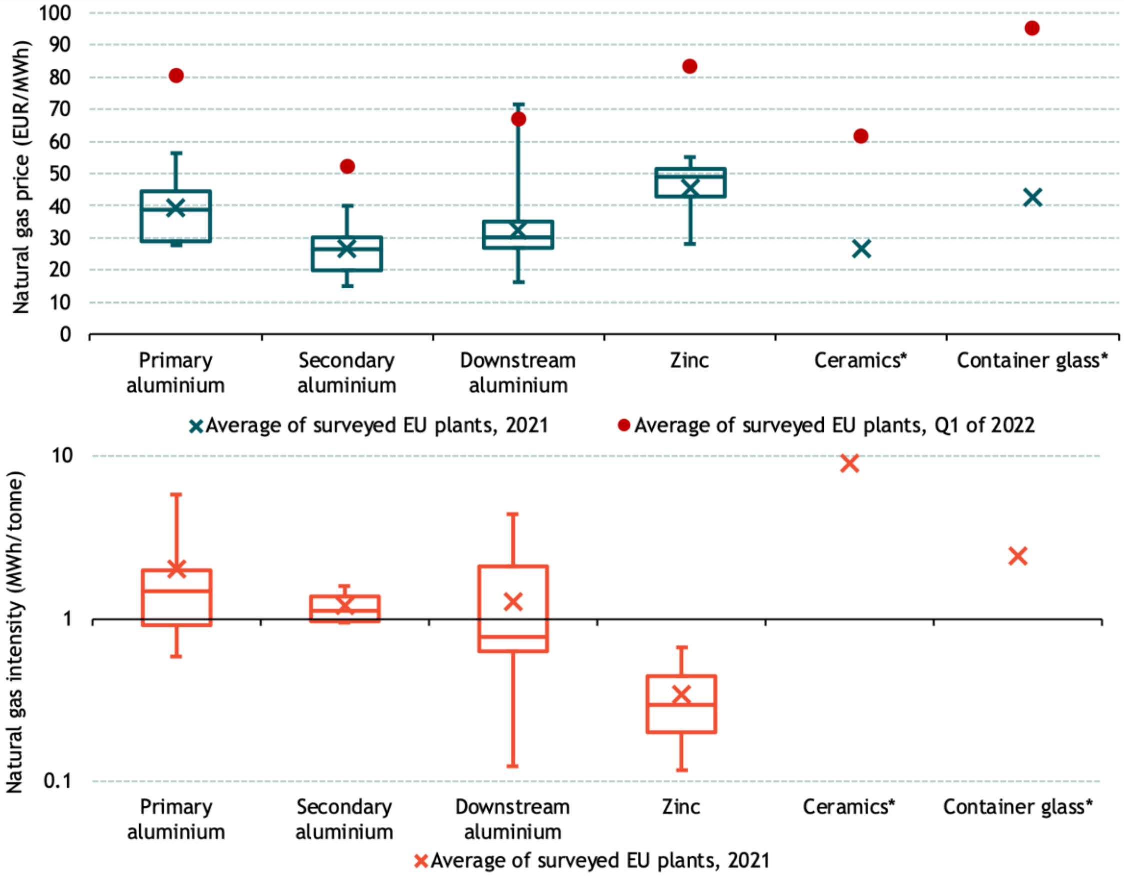


Figure 160: Natural gas prices (above) and natural gas intensity (below) per sector based on collected plant data for 2021 and the first quarter of 2022, and ranges for 2021 only

Source: Own elaboration based on data from industrial plant operators.

**For the sectors Ceramics and Container glass, only average values of EU plants can be shown to ensure data confidentiality due to the limited number of responses received.*

Value for the sectors Ferro-alloys and Silicon and Fertilisers could not be shown due to insufficient responses to ensure data confidentitility.

The much higher prices for electricity and natural gas in Q1 2022 across all sectors as displayed in Figure 1 and Figure 2 show that companies are directly experiencing the result of the current energy crisis. A few surveyed plants with lower prices indicated that they still have fixed contracts as of June 2022, but with a remaining duration of a year or less. With electricity and natural prices having increased further since Q1 2022 as shown in the previous chapters, and fixed contracts with lower prices set to expire within a year, the average electricity and natural prices in the selected energy-intensive sectors would increase further.

Overview of the results of selected EU EIIs

Table 9 shows the average electricity prices and costs as well as electricity costs shares in production costs of the surveyed plants in the selected EIIs in the EU. Table 10shows the same for natural gas.

Table 9: Electricity prices & costs in selected EII sectors - simple EU averages, 2021 and Q1 2022

Sector	Electricity prices (€/MWh)		Electricity costs per production quantity (€/tonne)		Electricity costs as a share of production costs		Electricity intensity (MWh/tonne)	
	2021	Q1 2022	2021	Q1 2022	2021	Q1 2022	2021	Q1 2022
Primary aluminium	56.79	153.68	753	1396	32.2%	49.1%	13.97	13.03
Secondary aluminium	117.32	204.81	16	26	N/A	N/A	0.14	0.13
Downstream aluminium	119.20	171.68	90.38	152.02	3.1%	4.2%	0.88	0.92
Ferro-alloys and silicon	85.41	156.77	634.45	1086.28	37.9%	49.4%	8.13	8.18
Zinc	49.60	67.30	195.14	277.63	20.3%	27.4%	3.96	4.21
Ceramics	95.21	158.51	63.23	N/A	N/A	N/A	0.94	N/A
Container glass	138.41	208.24	152.96	222.10	10%	10.5%	0.91	0.86
Fertilisers	109.91	193.76	16.95	N/A	6.4%	N/A	0.15	N/A

Source: Own elaboration based on data from industrial plant operators. Values for some sectors cannot be presented due to insufficient responses to ensure data confidentiality. The indicators that are calculated using the simple averages of the plants for which the information is available. Hwever, the questionnaire replies available per sector for the calculation of electricity prices, electricity costs per production quantity, and the electricity costs as a share of production costs not the same. As a consequence, the electricity price times the electricity intensity does not necessarily match the electricity costs per production quantity.

Table 10: Natural gas or fuel prices & costs in selected EII sectors - simple EU averages, 2021 and Q1 2022

Sector	Natural gas prices (€/MWh)		Natural gas costs per production quantity (€/tonne)		Natural gas costs as a share of production costs		Natural gas intensity (MWh/tonne)	
	2021	Q1 2022	2021	Q1 2022	2021	Q1 2022	2021	Q1 2022
Primary aluminium	39.17	80.19	68	214	2.1%	4.0%	2.04	3.44
Secondary aluminium	26.33	52.19	32	62	N/A	N/A	1.20	1.19
Downstream aluminium	32.38	66.72	39.54	93.32	1.4%	2.6%	1.27	1.40
Ferro-alloys and silicon	N/A	N/A	0.45	0.70	0.02%	0.02%	0.01	0.01
Zinc	16.70	33.95	16.70	33.95	1.9%	N/A	0.34	0.36
Ceramics	26.55	61.33	1,142.86	N/A	37.1%	N/A	9.13	N/A
Container glass	42.45	95.06	92.50	254.48	12.9%	17.2%	2.43	2.35
Fertiliser	Not available due to insufficient responses							

Source: Own elaboration based on data from industrial plant operators. Value for the sectors Ferro-alloys and Silicon and Fertilisers could not be shown due to insufficient responses to ensure data confidentility. The indicators that are calculated using the simple averages of the plants for which the information is available. Hwever, the questionnaire replies available per sector for the calculation of natural gas prices, natural gas costs per production quantity, and the natural gas costs as a share of production costs not the same. As a consequence, the natural gas price times the natural gas intensity does not necessarily match the natural gas costs per production quantity.

The tables show that:

- **The higher energy prices paid by the surveyed companies on average have also translated in higher absolute and relative energy costs in production costs.** Notably, the energy costs in 2021 are already higher than the previous years (see sector reports in Annex B). An analysis of the energy costs in iron and steel producers based on publicly available information in Box 6-1 shows the same trend as the selected sectors with surveyed plants.
- **Plants operating in electricity-intensive sectors paid lower electricity prices than for plants in less-electricity intensive sectors.** In 2021, the average electricity prices for plants in electricity-intensive sectors (*Primary aluminium, Ferro-alloys and silicon*, *Zinc*) ranged from 50-85 EUR/MWh. This is lower than the average electricity prices of 95-140 EUR/MWh for plants in less electricity-intensive (*Ceramics, Secondary* and *Downstream aluminium, Fertilisers, Container glass*).
- **Electricity prices soared for all sectors in Q1 2022.** The average electricity price increased to a range of 153-208 EUR/MWh for all sectors except for *Zinc*, which showed an average of 67 EUR/MWh. The lower average price of electricity experienced by the surveyed zinc plants in Q1 2022 could perhaps be explained by the fact that the majority of them have **power purchase agreements in place.**
- **Generally, plants operating in gas-intensive sector for e.g. *Ceramics* paid lower gas prices than for plants in less-gas intensive sectors.** Ceramics plants paid around 27 EUR/MWh, which is lower than most other sectors that had prices around 30-45 EUR/MWh in 2021. This could perhaps be explained by the fact that two out of three sampled *Ceramics* plants still had an existing gas contract as of June 2022, although they indicated that these would be expiring in less than a year.
- **Average natural gas price paid by the surveyed plants more or less doubled in every sector to 52-95 EUR/MWh in Q1 2022.**

The energy costs shares in production costs vary widely across sectors:

- The **highest energy cost share** (electricity and natural gas costs combined) was found in the electro intensive sectors such as ***Ferro-alloys and silicon* (37.9%), *Primary aluminium* (34.3%), and in the gas intensive sector *Ceramics* (37.1%),** based on available data for 2021 across studied sectors.
- These are followed by the electro-intensive sector *Zinc* (22.2%) and the sector *Container glass* (22.9%) that has both a relative high gas and electricity intensity.
- **Between 2021 and Q1 2022, the average energy costs shares in these sectors increased by 20-55%, increasing the importance of energy costs in the total production costs.** However, this increase was less than the increase in the energy costs per production quantity in some sectors such as *Primary aluminium* and *Ferro-alloys and silicon*. In these sectors, **the raw material costs also increased, dampening the relative increase of energy cost share in the total production costs.**

- The 2020 edition of this study showed that *Fertilisers* had the highest energy cost shares (71%) in 2018. This considers the cost shares of natural gas (as both feedstock and fuel) and electricity combined. While there is insufficient data to show the energy cost shares for *Fertilisers* plants in this edition, **the industry association FertilizerEurope indicated that the record high gas prices have resulted in the natural gas cost shares rising to up to 90% of the production costs[127].** With gas and electricity prices having increased further, the trend among the other energy-intensive sectors would imply that the average energy cost share in *Fertilisers* has also increased in Q1 2022.

In addition to energy costs, **the exposure to international trade is also an important determinant of a sector's competitiveness.** The higher the exposure to imports from and/or exports to outside the EU, the larger the impact of changes in energy costs could have on the competitiveness of EU plants.

- Table 4 shows the exposure of the studied energy-intensive sectors to the EU market (import exposure) and market outside the EU (export exposure). This is based on the average of 2019 to 2021 to balances out the impacts of COVID-19. **Overall, international trade experienced a downturn in 2020 but rebounded in 2021 to levels higher than 2019[128].**
- Table 4 indicates that the exposure of most of the sectors studied is high or very high, highlighting the **potential significance of energy costs for affecting the competitiveness and profitability of these sectors.**

Table 11: Exposure of EU selected energy-intensive industries to international trade - average of 2019-2021

Sector	Gross exports (M€)	Gross imports (M€)	Production value (M€)	Internal consumption (M€)	Import exposure(1)	Export exposure(2)	Exposure to international trade(3)
Unwrought aluminium (primary and secondary aluminium)	1,609	18,786	12,139	29,316	64%	13%	High
Downstream aluminium	3,361	2,737	2,741	2,117	129%	123%	Very high
Ferro-alloys and silicon	1,399	7,668	947	7,216	106%	148%	Very high
Zinc	1,313	926	1,774	1,387	67%	74%	Very high
Ceramics	9,546	1,730	17,378	9,562	18%	55%	High
Container glass	2,573	1,664	8,936	8,027	21%	29%	Medium
Fertilisers	2,899	4,784	823	2,707	177%	352%	Very high

Source: Own elaboration based on Eurostat Comext and/or Europroms

(1) Share of internal consumption served by extra-EU imports

(2) Share of production dedicated to extra-EU exports

(3) The exposure to international trade are assessed as follows: medium = import and export < 30%, high = import or export > 30%, very high = import and export > 60%. The 30% threshold is based on the trade intensity criteria used by the

[127] Based on bilateral exchanges with FertilizerEurope and https://www.fertilizerseurope.com/wp-content/uploads/2022/08/Fertilizers-Europe-Press-release_Europe-fert-industry-victim-of-EU-energy-chaos-1.pdf.
[128] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Impact_of_COVID-19_on_international_trade_by_product_group

European Commission in the assessment of sectors at significant risk of carbon leakage in the EU ETS Phase 3 (2013-2020). The 60% threshold is twice the 30% threshold as an indicator for a very high trade exposure.

Note: the values shown in this table may be different from the ones in Annex B as the ones in this table are based on Eurostat Comext and/or Europroms, whereas the values in Annex B are sometimes based on data from the industry association.

Besides energy costs and exposure to international trade, other aspects such as **raw material and personnel costs, market concentration, and product differentiation are also key factors that determine the competitiveness of a company:**

- Specifically on production costs, it is the **relative costs changes compared to non-EU competitors that determine the competitive position of EU firms**. For example, if energy costs of EU plants increase at the same rate as their non-EU competitors, there would be no change in competitiveness.
- A detailed analysis of energy costs and the sectors' market and trade developments is included in Annex B for the three sectors where detailed data could be collected: *Aluminium, Ferro-alloys and silicon* and *Zinc*. The analysis shows that, overall, **energy costs played a decisive role in decreasing competitiveness in the most recent years.** Sharp increases in electricity prices and costs for *Primary aluminium*, and *Ferro-alloys and silicon* since 2020 reduced the sectors' profitability, despite a simultaneous rise in selling prices. Data for Q1 2022 show that electricity costs almost doubled as compared to 2021, which paired with decreasing market prices, led to production costs being higher than market prices.
- For other sectors (e.g. *Zinc*), trading prices are mainly based on the London Metal Exchange (LME), i.e. all zinc is sold roughly at the same price internationally. **The profitability and competitiveness of these plants is therefore determined by the internal cost structure of these plants.**
- Further, there are other identified factors which could influence a sector's profitability and competitiveness, for example, in *Downstream aluminium*, operating costs are dominated by unwrought aluminium purchases, accounting for at least half of downstream transformer's total production costs.
- Since the start of the energy crisis in 2021, energy cost developments did play a decisive role in the actual competitiveness of sectors based on the analysis of the development of the trade balance. Representatives from a wide range of energy-intensive industries have indicated that the impact of the volatility and extremely high levels of gas and electricity prices cannot be sustained and threaten the competitiveness of European companies[129]. This edition of the report therefore particularly focuses on the impact of the Russian invasion of Ukraine on the various sectors in the next section.

Box 6-1 Energy costs in the iron and steel sector

Steelmaking is a carbon- and energy-intensive process. In the EU, steel is manufactured via two main production routes:[130] • Primary steelmaking – using blast furnaces (which run on coal or coke) and basic oxygen furnaces (BF-BOF) to turn iron ore into steel – is an energy- and carbon-intensive process, which accounts for about 60% of EU steel production.

[129] CEFIC (2022). Statement by the Energy Intensive Industries ahead of the Extraordinary Energy Council of 30 September 2022.
[130] Eurofer (2020). What is steel and how is steel made?

- Secondary steelmaking using electric arc furnace (EAF) to produce steel mainly from steel scrap, which is characterised by a high electricity consumption and account for the remaining 40% of EU steel production.

A 2020 study by the Joint Research Centre showed that steel plants in the EU27 have, on average, the highest or second highest production costs compared to major non-EU competitors[131]. Energy costs were found to play a potentially significant role in determining competitiveness, usually representing between 11% and 20% of total production costs.

However, with the rapidly rising energy prices since 2021, energy costs have become a key determining factor in competitiveness. Figure 3 shows the average share of energy costs in production costs for both steelmaking routes. This is based on German and Italian plants, the only EU plants for which data is available in the Global Steel Cost Tracker of TransitionZero[132]. Overall, the energy cost share in steelmaking has been relatively stable until 2020, when it fell to a 7-year minimum. This is followed by an increase in 2021 to peak levels of 20% for BF-BOF-based steelmaking and 25% for EAF-based steelmaking (see Annex B for more details). As a result of this increase in energy costs, the cost of steelmaking is now the highest in Germany and Italy compared to all major steel producing countries outside the EU such as Japan, the United States, China, India and Russia[133]. The energy prices increase in 2022 further deteriorated the competitiveness of the steel plants in Germany and Italy.

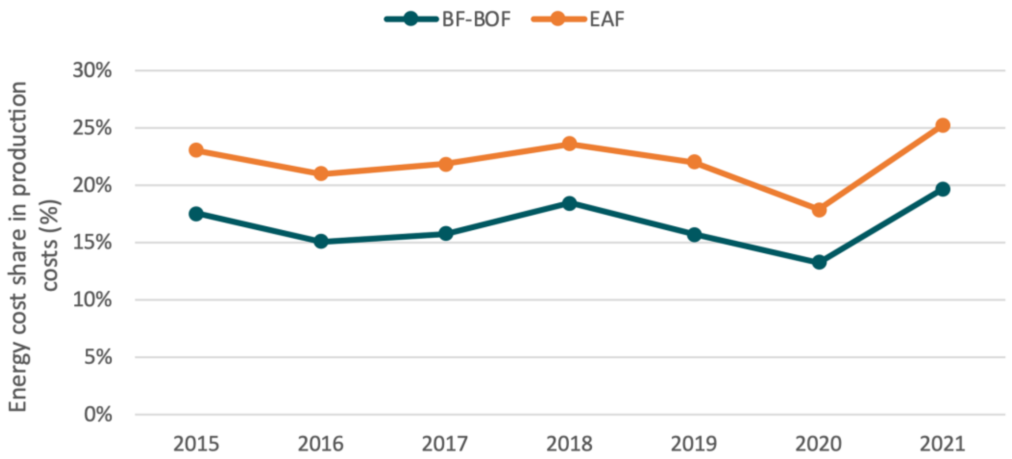


Figure 161: Energy costs as a share of production costs by type of steelmaking, simple average of German and Italian plants[134]

Source: Own elaboration based on data from TransitionZero

6.2.1 Impact of COVID-19 and the Russian invasion of Ukraine on the selected EIIs

The 2020 edition of this study already gathered informal feedback on the possible impact of COVID-19 on energy costs and their economic consequences for industry. At that time, European industries experienced a significantly lower demand for products, reducing sales revenues and triggering reductions of production output. However, the 2020 edition also found that COVID-19 lockdowns led to a very

[131] Medarac et al., (2020). Production costs from iron and steel industry in the EU and third countries. Doi:10.2760/705636.
[132] TransitionZero (n.d.). Global Steel Cost Tracker.
[133] The Global Steel Cost Tracker of TransisionZero is not based on data collected directly from companies, but models the production costs of steelmaking plants based on publicly available data on iron and steel plants and from international statistics. Energy costs of individual plants may therefore be lower in practice if they have long-term contracts for energy and/or materials. Nonetheless, the average costs do provide valuable insights in the impact of energy costs in the iron and steel sector. (TransitionZero and Global Efficiency Intelligence, 2022. Global steel production costs.)
[134] Differences between the German and Italian plants are minimal and therefore not analysed separately.

significant fall in energy prices during the first half of 2020, which is also reflected in the decreasing share of energy costs versus production costs of the selected EIIs. In many of the sectors covered, the energy cost shares reached a record low point in 2020 (see Annex B for more details), except *downstream aluminium*.

As the European economy recovered from the COVID-19 pandemic, **both industrial production and trade rebounded in 2021 to levels higher than pre-COVID[135].** Therefore, most surveyed plants and informal feedback from the industry associations indicated that, while COVID-19 was challenging, particularly at the start of the pandemic with demand dropping and staff shortages, these difficulties pale in comparison with the challenges plants are currently facing due to the energy crisis. **The soaring prices for electricity and gas since 2021 have resulted in production curtailment and (temporary) shutdowns of plants in various energy-intensive sectors.** Others have been able to pass on some of the cost increases so far, but in light of international competition are facing challenges to further do so.

This section provides a snapshot of the impact of these two crises for various energy-intensive sectors, primarily based on publicly available information, complemented with feedback from the sector associations and insights from the surveyed plants. The findings are presented in the following order:

- Selected energy-intensive sectors for which a detailed analysis could be conducted based on the surveyed plants: *Aluminium, Ferro-alloys and silicon, Zinc*;
- Selected energy-intensive sectors with information from only 3-4 surveyed plants: *Container glass, Ceramics, Fertilisers*; and
- Other energy-intensive sectors for which public information could be found on the impact of the energy crisis: *Chemicals, Iron and steel, Paper and cardboard*.

Aluminium

Key takeaways:

- To cope with the rising energy prices, surveyed aluminium plants have adopted various measures, such as the reduction or a complete halt of their electrolytic aluminium furnaces (in the case of *Primary aluminium*), and raising the sales prices of their products (in the case of *Secondary aluminium* and *Downstream aluminium* segments).
- Other measures implemented by aluminium plants include personnel lay-offs or mandatory unpaid leave, reducing planned investments to a minimum, and optimisation of processes and logistics to reduce costs.

The majority of the aluminium plants participating in the survey reported that the COVID-19 crisis had a negative impact due to increased energy prices (both electricity and natural gas). This mainly occurred towards the end of the COVID-19 crisis, when some surveyed plants reported that they were starting to recover their activities. After February 2022, the price of energy products rose even further; increased tensions in the supply chain of raw materials caused shortages and inflation of prices of raw materials, transport and logistics costs.

135 Eurostat (2022). Impact of Covid-19 crisis on industrial production.; Eurostat (2022). Impact of Covid-19 crisis on international trade by product group.

The aluminium plants participating in the survey have adopted different measures. *Primary aluminium* plants reported reducing or completely halting their electrolytic aluminium furnaces since September 2021 to reduce their levels of electricity consumption. Some of these plants also reported relying on scrap to continue their casthouse operations. Without the heat coming from the liquid primary aluminium (from the electrolysis department), plants now use more natural gas for smelting in the casthouses. Companies from *Secondary aluminium* and *Downstream aluminium* segments reported raising their product prices as a measure to deal with the increased prices of energy, raw material, transport and logistics. For *Downstream aluminium* plants, this has further reduced demand for their product.

Overall, the surveyed companies in all segments of aluminium's value chain reported lay-offs of personnel or introducing mandatory unpaid leave to reduce personnel costs. Aluminium companies also reported a reduction of planned investments to minimum levels, optimization of processes and logistics to reduce costs and expenses at all levels of the plants.

Ferro-alloys and silicon

Key takeaways:

- The impact of the Russian invasion in Ukraine on the sector was harder than the COVID-19 crisis. The sector facing an increase in energy prices, as well as experiencing raw material shortages and price inflation as both Ukraine and Russia were sources for raw materials and ferro-alloy products.
- By Q1 2022, the situation on raw materials stabilised, although ferro-alloy prices began to plummet, reaching a point below production costs. Concurrently, the energy prices continued to soar, leading to drastic reductions in production output for some of the surveyed plants.
- At the beginning of September 2022, 27% of the ferro-alloys and silicon production capacities in EU27 have been curtailed, which has consequently led to a closure of 40% of the furnaces. Curtailments have since increased further.

The majority plants of the *Ferro-alloys and silicon* sector participating in the survey reported that the COVID-19 crisis impacted them negatively due to increased electricity prices. They indicated that this mainly occurred towards the end of the COVID-19 crisis when global demand rebounded. However, some plants indicated that they were able to continue their production output at their usual levels during the pandemic. However, since the start of the Russian invasion in Ukraine, the price of energy products rose even further, together with increased tensions in the supply chain of raw materials causing shortages and inflation of prices.

Ukraine and Russia are direct or indirect sources of raw materials and ferro-alloy products. Since the start of the war, ferro-alloy prices skyrocketed due to concerns of supply chain disruptions for these materials. Some plants reported increasing their stock of raw materials and searching for alternatives in case of future material shortages. By Q1 2022, the situation on raw materials stabilised and ferro-alloy prices began to plummet, reaching a point below production costs. At the same time, the energy prices continued to soar, causing drastic reductions in production output for some of the surveyed plants.

According to the industry association Euroalliages, the consequences of 2022 energy prices have been dramatic. A survey conducted with Euroalliages members in September 2022 indicated that 27% of the silicon and ferro-alloys production capacities have been curtailed in the EU27. In terms of the number of furnaces having fully closed down, these curtailments have affected 40% of the furnaces in the EU. Euroalliages indicated that since the completion of the survey, curtailments have increased further.

Zinc

Key takeaways:

- Demand for zinc reduced during COVID-19, leading to an increase in zinc stockpiles. Zinc plants have also been severely impacted by increase in energy prices triggered by the Russian invasion of Ukraine, and they are coupling production with electricity spot prices throughout the day.
- In the longer term, the production volume for zinc remains uncertain as it will depend on energy prices and zinc demand.
- Three primary smelters have closed, i.e. placed on care-and-maintenance, since 1 September 2022, namely Nrystar Budel (NL), Glencore Porto Vesme (IT) and Glencore (DE).

The surveyed zinc companies indicated that they were able to continue their operations during COVID-19, despite experiencing some staffing problems. However, zinc consumers did stop their operations, resulting in depressed demand and large stockpiles of zinc. Some surveyed zinc companies also indicated that the COVID-19 crisis also led to an increase of their energy costs. Zinc prices are globally traded based on the prices from the London Metal Exchange. This means that there is a possibility that any increase in energy costs may have to be partially or fully absorbed by the zinc plants, as they are not able to pass on these costs to zinc consumers.

The Russian invasion of Ukraine had severe impact on the zinc companies. Some surveyed plants have reported an uncertainty in the planning of the production volume in the long term, which would hinge on the developments in the energy prices as well as the demand for zinc products in the market.

The International Zinc Association indicated that some plants have been applying daily peak shaving to manage the rising energy costs, i.e. temporarily stopping production when electricity spot price increases during the day. Plants have been reducing their running capacity by about 15% this way, with output losses amounting to an estimated range of 60-240 thousand tonnes (kt) so far. Further reduction of output would lead to longer-term closures. Typically, zinc plants can lower the output to 25-35% of the nominal capacity without causing reversal of the electrolysis, which would create hydrogen gas release and the risk of explosions. Any further reduction of output would require the emptying of electrolyte from the whole circuit — a process that would take several weeks. Restarting this process after a complete shutdown would also take several weeks and in addition, negatively affect the yield of electrolysis for several months. Therefore, a complete shutdown is only considered if the duration of the shutdown is expected to last for at least 4-6 months.

At the point of writing this report, there are two primary smelters that are currently closed, i.e. placed on care-and-maintenance. Nyrstar Budel in the Netherlands with an annual production capacity of 270 kt[136] has been closed since 1 September 2022 and Glencore's Porto Vesme plant in Italy with an annual production capacity of 150 kt since Q4 2021[137]. As of 1 November 2022, Glencore is closing its zinc plant in Germany with an annual production capacity of 165 kt.[138]

Container glass

Key takeaways:

- Production costs increased for the container glass sector as a result of increases in the cost of raw materials, packaging, transportation, inflation and the high gas prices, which is 14-16 times higher than pre-crises levels. Gas prices currently make up 24% of the production costs for the sector.
- Nonetheless, none of the 162 factories in Europe have closed down (as of October 2022).

Despite the market challenges posed by COVID-19 and rising energy prices, the container glass industry experienced a record growth in its production in 2021, driven by high market demand.[139] Based on data released by the industry association European Container Glass Federation (FEVE), the container glass industry is continuing its recovery from a 2020 decline, and has recorded a highest-ever production growth of 5% for food and beverage glass packaging in 2021, as compared to 2020 figures[140]. However, the industry is worried that the increase in demand may not be sufficient to compensate for the rise in production costs.

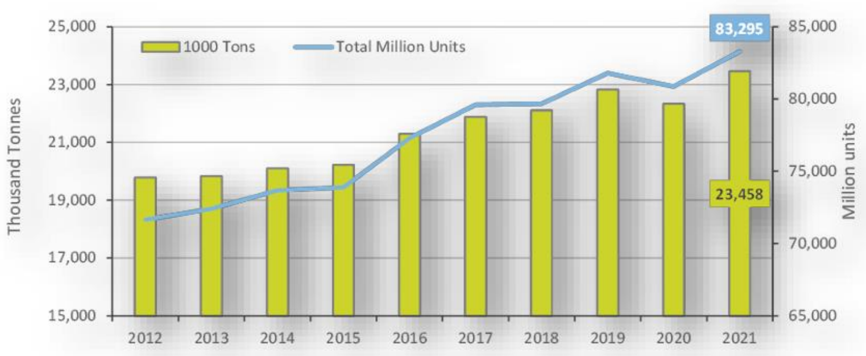


Figure 162: Production data of the container glass industry in Europe from 2012 - 2021

Source: FEVE[141]

Glass container manufacturers have expressed their worries regarding the continuously increasing energy costs, as their gas prices in September 2022 came to be 14-15 times higher than pre-crisis levels.[142] According to FEVE, the energy costs in the sector make up 24% of the production costs. This corresponds

136 Nyrstar (2022). Nyrstar Budel's zinksmeltactiviteiten worden op care and maintenance gezet.
137 Desai (2021). Glencore's Portovesme zinc operation to enter care and maintenance.
138 Reuters (2022). Glencore to place Nordenham zinc smelter on care and maintenance from Nov 1.
139 Feve (2022). EU Container glass industry records highest ever growth in production.
140 Feve (2022). EU Container glass industry records highest ever growth in production.
141 Feve (2022). Press release: EU container glass industry records highest ever growth in production.
142 Areni Global (2022). How the energy crisis threatens the future of the glass bottle.

to the data received from the surveyed plants located in Southern Europe, where the share of the energy costs in production costs increased even further in Q1 2022. In an attempt to prevent the disruptive option of shutting down their furnaces, glass container manufacturers have chosen to raise the price of their products. For example, the German Brewers' Association indicated in May 2022 that some breweries have to pay 80% more for new glass bottles than a year ago[143]. Half of the surveyed plants in this study also indicated that there was an increase in the market price of container glass during the period of the COVID-19 crisis and the Russian invasion of Ukraine. The main factors are attributed to the general increase in production costs resulting from the rising costs of energy, raw materials, packaging, transportation as well as inflation.

Nonetheless, none of the 162 factories in Europe has been closed down as of October 2022[144]. Glass containers are produced in furnaces that work permanently for 10-15 years as glass needs to remain in liquid form at around 1400°C during the production stages. Shutting down the glass furnaces, which primarily run on natural gas, even for a single day in this long-term process, would lead to the complete destruction of glass and irreversible damage to the furnace installation[145].

Ceramics

Key takeaways:

- The ceramics sector has experienced a tripling of energy bills as compared to pre-crises levels.
- To cope with the increase in energy costs, some plants have shifted their production to hours with lower energy tariffs and more favourable temperature conditions, while others have passed on some of the costs to the consumer.
- Production curtailments and temporary shutdowns have occurred in several EU countries.

The ceramics industry has indicated that the current energy crisis has an extremely dramatic impact on its sector. According to the European Ceramic Industry Association (*Cerame-unie*), the energy bill of an average ceramics producer has tripled within a year and a half, from around 20-30% of its production costs to about 60%-70%[146]. Some companies have been able to reduce their energy costs by shifting their production to hours with lower energy tariffs and more favourable temperature conditions, while others are planning to invest in new ovens[147]. Some companies did pass on some of the energy price increase to their customers. For example, The Iris Ceramica Group—one of the leading Italian companies in the sector—introduced an energy surcharge of 3% on invoices due to the increase in gas prices[148]. However, not all companies have been able to mitigate the increase in energy costs. Cerame-unie indicated that the curtailment of production and even temporary shutdowns have taken place in several countries[149]. For example, the Portuguese tile company CINCA was forced to shut down for a month and a half in 2022 because gas bills went from 300 000 euro to almost 1.5 million euro per month[150]. The industry association

[143] Schwertheim (2022). Glass bottle prices soar 80% for German beer brewers amid production and transport crises.
[144] Areni Global (2022). How the energy crisis threatens the future of the glass bottle.
[145] Feve (2022). FEVE paper addressing the risk of energy shortages in the container glass industry.
[146] https://cerameunie.eu/media/5imjwnj2/22-09-08-press-release-energy-crisis.pdf
[147] Berlenga and Sterling (2022). Early starts, new ovens as ceramics industry feels energy pinch.
[148] Jewkes et al. (2021). Gas price surge pushes Europe's ceramics industry to breaking point.
[149] Cerame Unie (2022, 8 September). Press release.
[150] Soares (2022). Portuguese ceramic industry takes a dent as energy crisis looms.

has indicated that the actions that the sector can take are insufficient to cope with the rising energy costs[151].

Fertilisers

Key takeaways:

- The increase in energy prices, especially in gas prices, have resulted in energy costs making up 60-80% of the total production cost of fertiliser plants. This has led to a 70% curtailment of European production capacity.
- There has been a negative impact on personnel, with staff sent into technical unemployment, lay-offs, and to be up on downtime where they receive 40% of their average salary.
- Fertilisers have been reducing ammonia production and importing them from outside the EU due to the rising cost of ammonia, a key material for the manufacturing of fertilisers.

Ammonia is produced from nitrogen as well as hydrogen which is typically produced from natural gas today; although hydrogen can also be produced from renewable energy – an option that is currently being explored commercially. However, for the time being, natural gas remains as a main raw material to produce ammonia – the basic component for all mineral nitrogen fertilisers. An increase in the natural gas prices therefore affects both energy and material costs of fertiliser plants, making up about 60-80% of total production cost[152].

Based on the responses of the sampled plants as well as market reports, the current energy crisis has forced many plants to reduce, suspend or to permanently cease production[153], which has a negative impact on their personnel as well. Fertilizers Europe – the association representing the majority of European fertiliser producers – indicated that as of August 2022, around 70% of European production capacity has been curtailed[154]. Production stops of fertilisers have taken place across the whole of Europe as shown in Figure 5. For example, Azomures – the largest natural gas consumer in Romania – has suspended its ammonia production since June 2022 and announced in September 2022 that they would reallocate or send 200 of its 1000 employees into technical unemployment[155]. Similarly, Achema – Lithuania's largest fertiliser producer – has stopped its fertiliser production as of September 2022 with 5% of its 1250 employees expected to be laid off and some other employees to be on downtime with 40% of their average salary[156]. The significant curtailment in European fertiliser production shows that producers have very limited means to mitigate the soaring gas prices in the current energy crisis; one respondent also mentioned that it was not possible to pass on the entire energy price increase to the consumers. This is why Fertilizers Europe has called for crisis management policies for the European fertiliser industry[157].

[151] Cerame Unie (2022, 8 September). Press release.
[152] Fertilizers Europe (2019). Energy costs.
[153] Hodges (2022). Food costs and interest rates rise as energy and fertilizer supplies are hit by the invasion.
[154] Fertilizers Europe (2022). Europe's fertilizer industry victim of EU's energy chaos.
[155] Chirileasa (2022). Romanian fertilizers maker Azomures reduces its activity again.
[156] Achema (2020). „Achemos" sunkūs sprendimai yra privalomi.
[157] Fertilizers Europe (2022). Europe's fertilizer industry victim of EU's energy chaos.

Since then, some plants have reduced ammonia production and resorted to importing it in order to meet the demand of their customers. For example, BASF — one of the world's largest chemicals producer — has significantly reduced its own ammonia production and purchase ammonia from others for their fertiliser production[158]. Yara — one of the world's largest fertiliser producers — stated that, following the curtailment of their European production due to the higher gas prices, they are importing ammonia to meet European demand[159].

[158] Burger (2022). BASF readies more ammonia production cuts in gas supply crunch.
[159] Rasmussen and Solsvik (2022). Yara cuts cast doubt on Europe's fertiliser production.

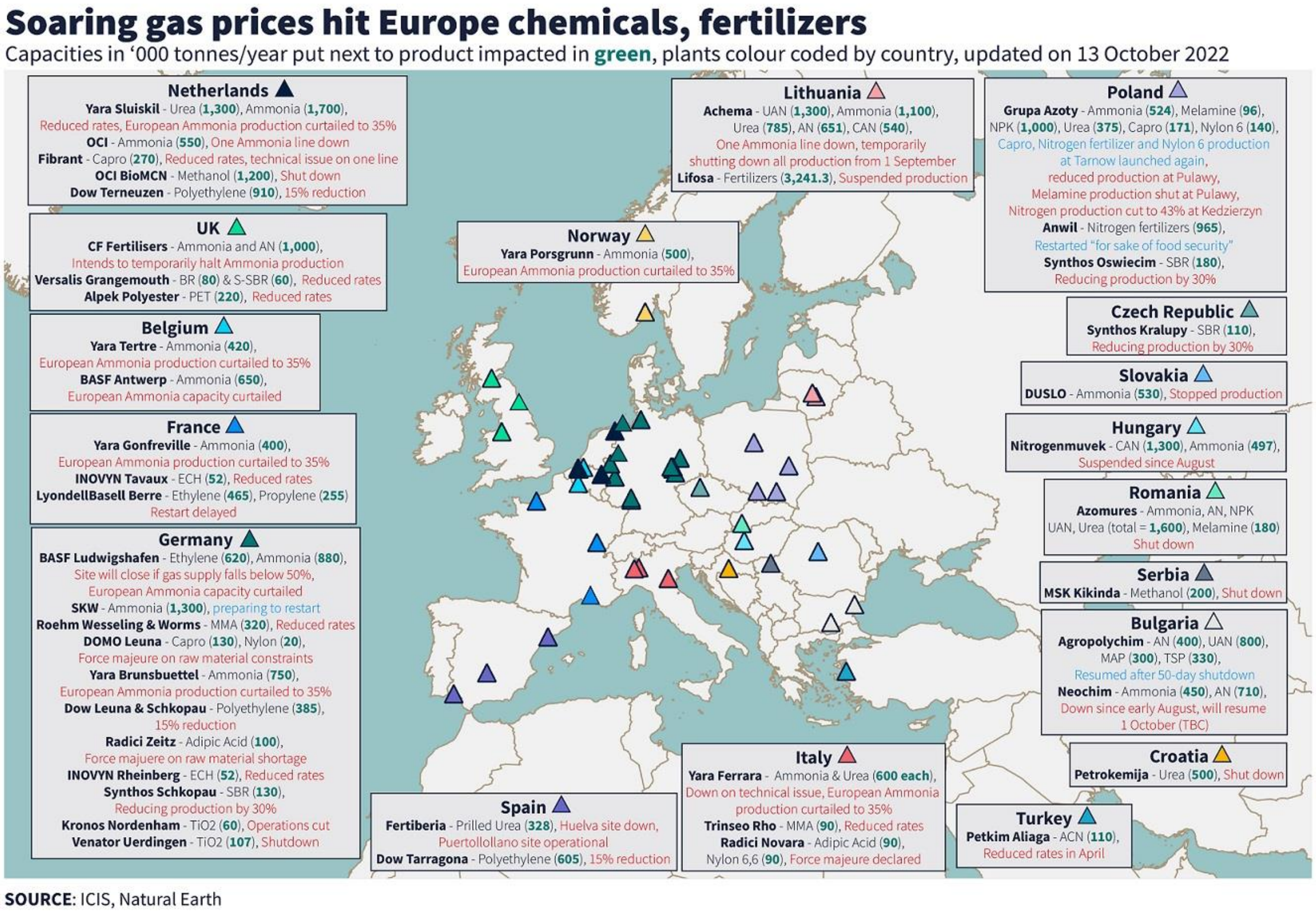


Figure 163: Overview of production curtailment of fertilisers across Europe as of October 2022

Source: ICIS, Map of shut capacities, October 2022.

Chemicals

Key takeaways:

- Europe is now the region with the highest costs for producing many chemicals.
- EU is now a net importer of chemicals rather than being a net exporter.
- Curtailments in the production of chemicals have been observed in various sub-sectors such as inorganic chemicals and chlorine; production curtailment or shutdowns in the petrochemical sector have not been reported, although market analysts reported that considerations to do so are underway.

According to the chemical industry, the costs of fuels and power consumption are major factors that determine the competitiveness of the EU chemical industries in the global market.[160] The chemical sector does not only consume fuels for energy but also uses it as key raw materials. Cefic — the European Chemical Industry Council — has therefore indicated that the high gas and electricity prices are a threat to the competitiveness of the chemical industry.

Market analysts have observed that in the first half of 2022, imports of inorganic chemicals (a major chemical subsector) by Germany were 40% higher in volume compared to the same period in 2021, which includes imports from outside the EU[161]. This coincided with a drop in the German production of inorganic chemicals. This situation can largely be attributed to ammonia production curtailments across the EU as described above in the section on fertilisers. A part of this increase in chemical imports is also due to reduction in chlorine production. Euro Chlor — a sector group of Cefic — indicated that chlorine production has decreased significantly in 2022 compared to 2021, with the average capacity utilisation of European plants down to 66% as of August 2022 compared to 80-89% over 2021[162].

In the petrochemical sector (another major chemical subsector), there have been no reports of the production curtailment or shutdowns in the EU as of July 2022[163]. However, market analysts reported that petrochemical producers have been making detailed plans for rationing and considering temporary shutdowns.

Because of European energy costs rising much faster than elsewhere in the world, market analysts indicate that Europe is now the region with the highest costs for producing many chemicals[164], jeopardising the competitive position of European chemical plants and leading to more imports from outside the EU. Cefic observed this trend in the trade of chemicals, with the EU changing from a net exporter of chemicals to a net importer as of March 2022.[165]

[160] cefic (n.d.). Energy consumption.
[161] Wilkes (2022). Germany cranks up chemical imports as energy crisis hikes costs.
[162] Euro Chlor (2022). August 2022 Chlorine production.
[163] Richardson (2022). Europe's gas crisis: the implications for global chemicals.
[164] Davis (2022). EPCA '22: Europe highest cost chemicals producing region, shutdowns encourage imports - ICIS.
[165] Based on Cefic's analysis of Eurostat data obtained via bilateral communication.

Iron and steel

Key takeaways:

- Steel production has dropped between 7-10% across the EU between May 2021 and May 2022; decline in steel production has been driven by a sharp demand reduction for steel products, high energy costs and high raw material prices.
- High energy costs have reduced competitiveness of the European steelmakers, with more steel being imported from outside Europe.
- As of September 2022, at least 18 steel plants have announced measures to reduce production, while others are shutting down some units, temporarily ceasing production and reducing staff working hours.

The current energy crisis prompted widespread steel output cuts as European steelmakers announce planned outages and reduce steel output[166]. Market analysts indicated that between May 2021 and May 2022, steel production dropped by 6.8% in the EU, while production declined by more than 10% in France, Croatia, Germany, Finland, Netherlands and Spain[167].

According to ArcelorMittal, the largest producer of flat steel in Europe[168], the main reasons for the decline in steel production are the sharp slowdown in demand for steel products from key sectors (including the automotive industry), high energy costs and high raw material prices. ArcelorMittal also indicated that the rise in energy costs especially degraded their competitiveness and led to an increase in imports from outside Europe[169]. Market analysts indicated that flat steel prices in Europe have been pushed down in recent months due to low end-user demand and overstocking from earlier panic buying[170,171]. The Russian invasion of Ukraine has led to a shortage of essential raw materials, which are mostly from Russia and Ukraine resulting in a major global supply shock for the steel value chain[172].

Due to the deteriorating market conditions for European steel producers, as of September 2022, at least 18 steel plants across the EU have announced measures to reduce their production as shown Figure 6. The figure shows that factories are shutting down some units or temporarily stopping production all together, as well as reducing working hours of their staff.

166 Burgess (2022). European energy woes unlikely to significantly boost US steel exports.
167 Eurometal (2022). EU decreased steel production by 6.8% y/y in May 2022.
168 ArcelorMittal (n.d.). Who we are.
169 Eurometal (2022). ArcelorMittal shuts down one more BF in Europe.
170 Eurometal (2022). Weak demand, cheaper imports put pressure on European flat steel prices.
171 Novokreshchenova et al. (2022). Six months of war: How has it changed the global steel market?
172 CRU Webinar (2022). War in Ukraine - The impact on commodity markets.

EUROPEAN STEELMAKER SITE CLOSURES 2022 *Latest updates in red*				
Company	**Plant**	**Location**	**Measures taken**	**Products affected**
ArcelorMittal Spain	Sestao	Spain	EAF operations stopped in mid-August, restart postponed.	Flat steel
	Asturias (Gijon)	Spain	BF "A" to be stopped before end-September.	Plate, wire rod
ArcelorMittal France	Dunkirk	France	BF 2 stopped in June; number of rolling operations adjusted; BF 3 and one sinter line to be stopped before end-September; two glavanizing lines closed.	Flat steel
ArcelorMittal Germany	Bremen	Germany	Reduced working schedule since July; plans to shut down one BF before end-September.	Flat steel
	Eisenhüttenstadt	Germany	Stopped one BF in summer, implemented shortened working hours.	Flat steel
	Hamburg	Germany	DRI module to be shut down starting Q4 2022.	Long steel
	Duisburg	Germany	Shortened working hours implemented.	Long steel
ArcelorMittal Poland	Dąbrowa Górnicza	Poland	BF 3 will be stopped before end-September without fixed date for restart; BF 2 to remain operational.	Flat steel, long steel
	Warszawa	Poland	EAF stopped in August 2022 on high costs.	Long steel
Acciaierie d'Italia	Taranto	Italy	Two BFs stopped in August; hot-dipped glavanizing lines stopped.	Flat steel
Arvedi	Cremona	Italy	Output being reduced; hot flow will stop for one week in four; if market fundamentals remain bad, closures will extend to two weeks in four.	Flat steel
Dunaferr	Dunaferr	Hungary	Stopped small BF in August, stopped second BF in mid-September due to lack of coke.	Flat steel
Hebei Iron and Steel Serbia (HBIS Serbia)	Smederevo	Serbia	One BF stopped end-July 2022 with no date for restart.	Flat steel
Liberty Steel	Liberty Ostrava	Czech Republic	Shut down BF 2 on July 26 2022 for a maintenance, no date for restart.	Flat steel
Pittini Group	Osoppo (Ferriere Nord)	Italy	Production stopped in early September until October 2 due to high energy costs.	Long steel
Salzgitter Group	Salzgitter Flachstahl	Germany	BF "C" idled in October 2019; restart planned for June 2022 but postponed to September 2022.	Flat steel
Thyssenkrupp	Thyssenkrupp	Germany	Shortened working hours implemented, no equipment stoppages heard.	Flat steel
US Steel Kosice	US Steel Kosice	Slovakia	Company denies reports that it stopped one BF end-June 2022; confirmed stoppage of one BF on September 4 for 60 days.	Flat steel
Vitkovice Steel	Vitkovice	Czech Republic	Stopped operations in May 2022 on lack of feedstock.	Plate
Source: Fastmarkets				

Figure 164: Overview of production stops in European steelmaking sites as of September 2022

*Source: Fas*tmarkets MB[173]

Paper and cardboard

Key takeaways:

- Energy prices have risen up to eight times higher in 2022 than the previous years' average, resulting in some plants having to temporarily or permanently reduce production.
- To cope with the increase in energy prices, some paper plants have switched from natural gas to using alternative fuels to mitigate the increase in gas prices, while others have passed some of the costs to their consumers.

The paper and cardboard industry has indicated that the current energy crisis has a major impact on the sector. According to CEPI — the European association representing the paper industry — the sector has witnessed energy prices rising up to 8 times more than previous year's average[174]. Some paper plants have been switching from natural gas to alternative fuels as a way to mitigate the costs. For example, the German papermaker Feldmuehle is changing its steam generation from gas to light heating oil, which

[173] Eurometal (2022). Dunaferr effectively halts steelmaking in Hungary with closure of second BF.
[174] Cepi (2022). Options for ensuring security of energy supply and tackling high energy prices.

requires a €2.6 million investment[175]. The Norwegian pulp and paper company Norske Skog installed a new boiler in its Austrian paper mill to reduce its gas consumption[176]. Other plants have been increasing the prices of their products to manage the rising energy costs such as the paper producer Sappi Europe[177] and Europe's leading corrugated packing company Smurfit Kappa[178]. There are also various plants across the EU that have not been able to cope with the sharply increasing energy prices, resulting in temporary production stops or permanent closures. For example, the German cardboard company Delkeskamp announced the closure of its Nortup paper mill, which employs 70 people, in August 2022 due to the increase in energy costs[179]. In September 2022, Sappi Europe announced the temporary production reduction at its Carmignano paper mill in Italy due to the continuing and sharp escalation of energy costs[180].

6.3 Energy costs and their impact at macroeconomic level

This section provides an overview of the overall impact of energy costs on the economy of the EU and its Member States, by calculating the shares of energy costs in the total production costs in each Member State. Measuring the share of energy costs in production can shed light on the impact of energy costs changes on the production costs of industries, and more broadly, on EU economies.

6.3.1 Methodology

The calculations of energy cost shares rely on three variables, based on parameters available from Eurostat:

1) Purchases of energy products as a proxy for *total energy costs*, and
2) the sum of *personnel costs* and *purchases of goods and services* serves as proxy for *production costs*.

Box 6-2: Description of parameters for calculating the share of energy costs in production costs

Expressed as a formula:

$$Energy\ costs\ as\ \%\ of\ total\ production\ costs = \frac{Purchases\ of\ energy\ products}{(Personnel\ costs\ + Purchases\ of\ goods\ and\ services)}$$

Purchases of goods and services, based on Eurostat's definition, 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.

Purchases of energy products (based on the definition of the Commission Implementing Regulation (EU) 2020/1197) the structural business statistics (SBS) 240105 includes only energy products, which

[175] Feldmuehle GmbH (2022). Feldmuehle is switching steam generation, away from Gas.
[176] Norske Skog (2022). High energy prices necessitate temporary downtime at the Bruck paper mil.
[177] Sappi (2022). Sappi Europe announces further price increases for its Speciality Paper Portfolio.
[178] Smurfit Kappa (2022). SKG Full Year 2021 Results .
[179] EUWID (2022). Delkeskamp to close Nortrup paper mill after all.
[180] Sappi (2022). Sappi Europe temporarily reduces capacity at Carmignano Mill.

are purchased to be used as a fuel. Energy products purchased as a raw material or for resale without transformation (such as crude oil) are excluded. Self-consumption of energy is also not captured.

For the majority of data on energy costs, including data from Eurostat, the latest available year is 2019. The results for the indicators with figures are therefore shown from 2010 until 2019. The impacts of COVID-19 and the current energy crisis are therefore not captured in the results based on aggregated statistical data.

Data available from Eurostat only allows the energy cost shares to be calculated for the NACE sectors B, C, D, E and F, which can be grouped under industry and construction. Industry is here defined as the combination of Sections B (*Mining and quarrying*), C (*Manufacturing*), D (*Electricity, gas, steam and air conditioning supply*) and E (*Water supply, sewerage, waste management and remediation activities*), while sector F encompasses *Construction*.[181]

6.3.2 Results

Key takeaways:

- The average share of energy in production costs of EU27 industry sectors decreased by 35.3%, from 2.3% in 2010 to 1.7% in 2016, followed by a period of stagnation up to 2019.
- Luxembourg has the highest share, which ranges from 7% to 11% and Ireland the lowest share of around 0.5% since 2015.

Figure 7 shows the evolution of the share of energy costs in production costs for the above-mentioned sectors[182]. While the available values in the figure vary significantly across the Member States, overall, most Member States show a decreasing trend over time. The countries with the most consistent and sharp decrease in the share of energy costs include Estonia (from 6.2% to 4.3%), Ireland (from 2.4% to 0.6%), Hungary (3.6% to 2.2%), Finland (from 3.2% to 2.3%) and Romania (from 4.9% to 3.4%, although with a slight increase in between 2018 and 2019). Some less marked decreases are observed in Netherlands (from 1.6% to 1.3%).

A few Member States also had a decreasing trend in the early years, but this trend has reversed in the recent years. Most notably is Czechia, which experienced a steady decrease between 2011 and 2015 (from 12.5 to 8%), followed by a period of stagnation and then a sharp increase in 2018 (to 11.4%), with an ongoing increasing trend in the following year. Czechia also shows relative higher energy costs shares compared to other Member States. This is explained by their high energy cost shares in NACE Sector D (Electricity, gas and air conditioning supply) and the relative smaller size of their other industry and construction sectors compared to other Member States. The available data further shows that Greece has experienced a sharp decrease in energy cost shares between 2013 and 2014; followed a steady increase, reaching 5.5% in 2019.

[181] Energy cost shares could not be calculated for the services sectors (NACE sectors G to N) because Eurostat does not provide any data on the purchases of energy products for these sectors. According to Commission Implementing Regulation 2020/1197, EU Member States are only required to collect and share data on purchases of energy products for NACE sectors B, C, D, E and F. For this reason, only qualitative insights of energy costs of the services sector are provided at the end of this chapter. Moreover, the limitations inherent to the chosen approach and data sources are listed as specific annotations attached to the data presented in the figures.

[182] To allow an equal comparison between countries and years, values are only shown if sufficient data was available for the sector. This has significantly reduced the values that can be shown in the figure, primarily due to the lack of data on Purchases of energy products in the NACE sectors D and E.

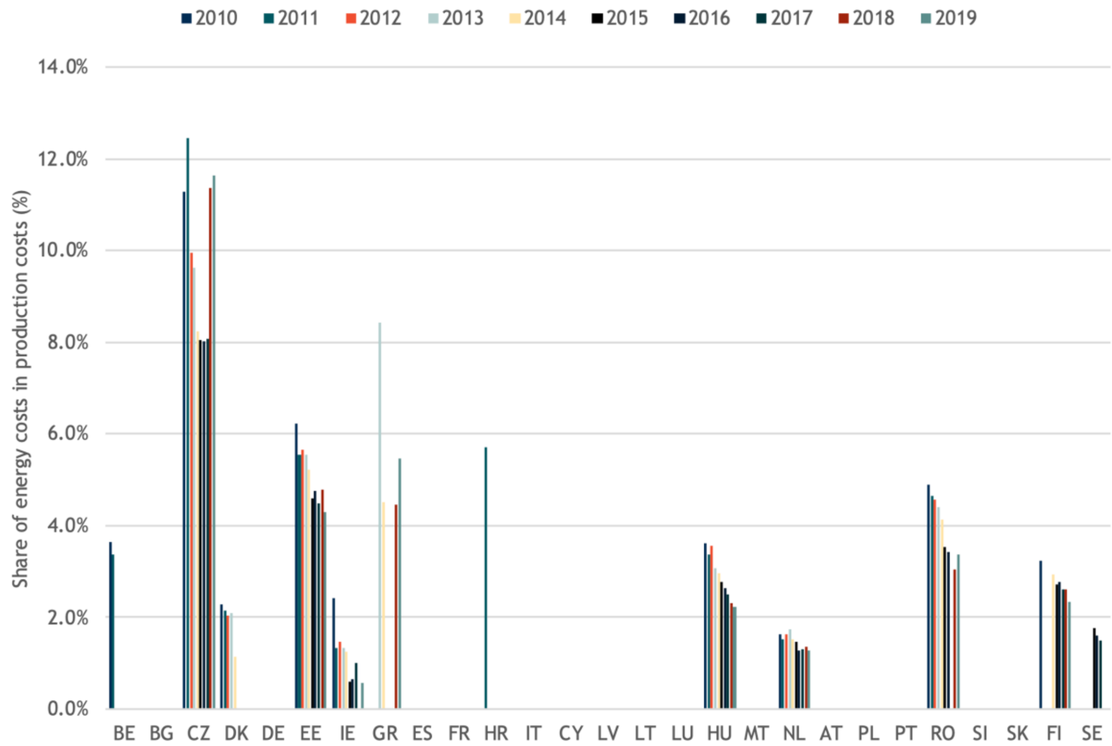


Figure 165: Evolution of energy costs shares in production costs, industry and construction

Note : Data gaps and unavailability of information constitutes the greatest limitation in this graph. To ensure consistency and comparability across countries and years, values are only shown if sufficient data was available for the entire industry and construction sector for a specific year and Member States in Eurostat, resulting in a large number of data gaps. Particularly, data on purchases of energy products lacks for a significant share of the Member States in the NACE sectors D and E. This resulted in some MS not being included at all (BG, DE, ES, FR, IT, CY, LV, LT, MT, AT, PL, PT, SI, SK. Because of the substantial lack of data, a EU27 average of the energy cost shares has also not been calculated.

Data is also analysed separately for NACE sector C *Manufacturing* where most of the relevant industry sectors are included (as shown in Figure 8). The overall trends are in line with the trend for the entire industry and construction sector: the EU average energy cost shares have decreased from 2.3% in 2010 to 1.7% in 2016, followed by a period of stagnation. This trend is consistent when looking at most Member States individually. Significantly higher shares of energy costs for manufacturing, compared to all sectors, are observed for Cyprus (reaching 6.7% in 2012), Latvia (showing a decreasing trend from 8.8 to 7.8% over the time period) and Luxemburg, with the highest figure available of 10.8% in 2011, decreasing to 7.9% in 2019. On the other hand, the lowest figures are observed in Ireland, stagnating around 0.5% from 2015 onwards, and in Italy, though with a slight increase in 2019.

The main difference in values for the manufacturing sector compared to the entire industry and construction sector are visible for Czechia, Estonia and partly Greece. These Member states show significantly lower shares of energy costs when looking at manufacturing only. The main reason is that these countries have relatively higher shares of energy costs in particularly NACE sector D[183].

[183] Electricity, gas, steam and air conditioning supply

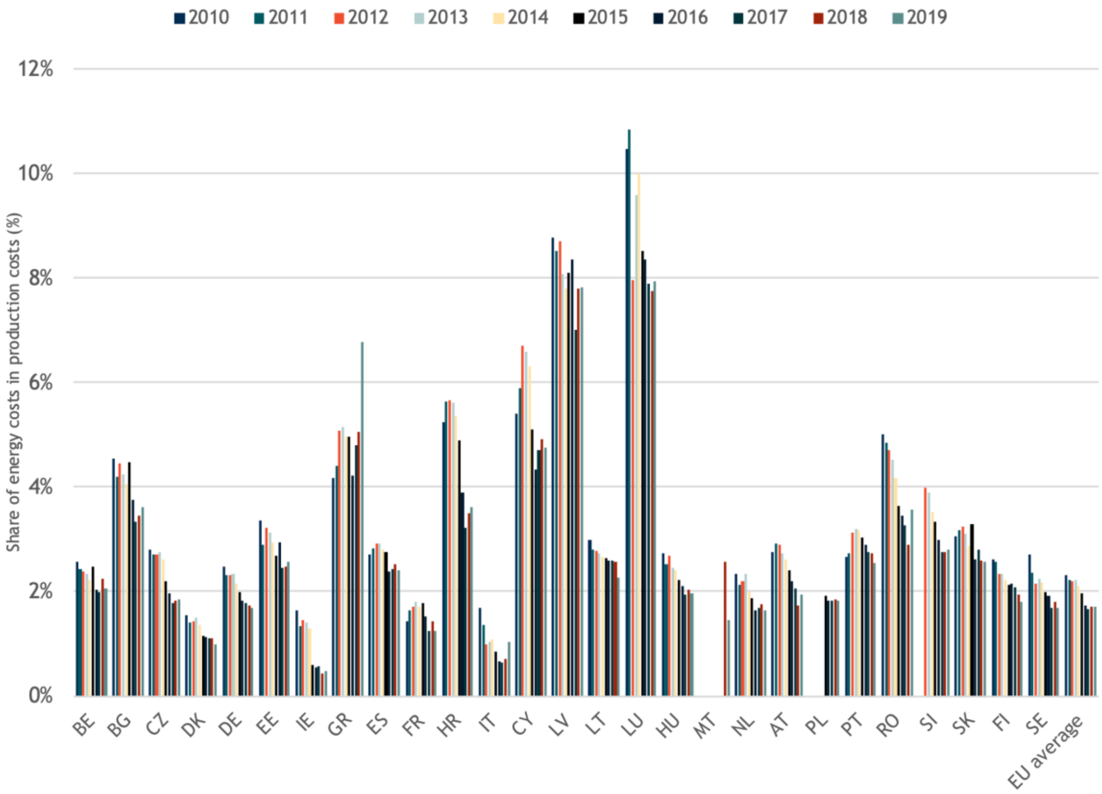


Figure 166: Evolution of energy costs shares in production costs for manufacturing

Note: The energy costs shares for Malta, Poland and Slovenia could not be calculated for several years primarily due to the lack of data on the Purchases of energy costs in Eurostat.

As mentioned above, energy cost shares could not be calculated for the **service sectors** due to the absence of relevant data. In 2020, Eurostat reported that out of the total energy demand of the EU, 9.1% went to the service sector, therefore representing a significant share of all EU energy demand[184]. Eurostat statistics also shows that final energy consumption by services has decreased over the years, by 3.9% between 2007 and 2020. This might indicate a decreasing trend in energy costs shares, similar to the industry and construction sectors, in the services sector although many other factors need to be considered before such conclusion can be drawn, such as energy prices and production costs other than energy cost.

[184] Based on Eurostat (2022). Energy statistics - an overview.

6.4 Energy costs for industry

In this section, results of the analysis on energy cost shares across sectors is presented, followed by the share of gross operating surpluses (GOSs) with respect to the total operational production costs.

6.4.1 Methodology

Energy costs are analysed with respect to total operational production costs. A top-down approach using aggregated statistical data is combined with a bottom-up approach collecting plant data with questionnaires to provide a comprehensive idea of the importance of energy prices and costs for the EU industries. The aggregated statistical data is useful for understanding long-term trends, although it fails to capture the diversity of the subsectors contained in it, with different products and production processes. Plant-level data better captures the characteristics of their subsectors even if it is difficult to obtain, especially a sufficiently representative sample that properly replicates the structure and general characteristics of a subsector.

The analysis of energy costs focuses on manufacturing sectors but also includes relevant sectors from agriculture, extractive industries and services. Table 5 provides an overview of the manufacturing sectors (NACE code C) covered in the analysis and Table 6 provides an overview of the other relevant sectors. **In total, 43 sectors were analysed with aggregated statistical data[185]. The current report focused on the EU energy intensive industry sectors with the highest energy costs shares and levels of international competitiveness pressure.** Table 5 also shows which subsectors were analysed with plant-level data in Section 6.2: the sectors *Aluminium, Ferro-alloys,* and *Zinc* provided data for a representative plant level analysis; while the *Ceramics, Fertiliser,* and *Hollow/container glass* provided data for a limited analysis, but insufficient to be representative of their sectors. The sectors *Basic chemicals*, *Cement*, *Copper*, *Flat glass*, *Iron and steel*, *Mineral wool*, *Paper* and *Refineries* were also contacted but did not provide any data.

Table 12: Coverage of sectors in the manufacturing sector

Sectors analysed with aggregated statistical data		Sectors analysed with plant level data	
NACE code	**Sector description**	**NACE code**	**Sector description**
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	*C2015*	*Manufacture of **fertilisers** and nitrogen compounds**
C206	Manufacture of man-made fibres		
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations		
C222	Manufacture of plastics products		

[185] These sectors are in line with those analysed in the 2020 and 2018 editions of the report, which were selected based on the importance of energy costs, their energy intensities, levels of trade exposure and economic relevance.

Sectors analysed with aggregated statistical data		Sectors analysed with plant level data	
C231	Manufacture of glass and glass products	*C2313*	*Manufacture of hollow glass*
C232	Manufacture of refractory products	*C232, C233, C234*	*Manufacture of Ceramics*
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	C2410	Manufacture of basic iron and steel and of **ferro-alloys***
C244	Manufacture of basic precious and other non-ferrous metals	C2442	Aluminium production
		C2443	Lead, **Zinc** and tin production*
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		

**The sectors analysed are a subsector of the NACE code mentioned. This is fertilisers for C2015, ferroalloys for C2410, and Zinc for C2443.*

Note: For the sectors listed in italics, i.e. hollow glass (container glass), fertilisers and Ceramics, only 3-4 plants responded to the questionnaire and only a limited analysis could be conducted. Results for Ceramics have even been grouped across several NACE 3-digit codes to be able to show some results while maintaining data confidentiality. The sectors Cement, Copper, Flat glass, Iron and steel, Mineral wool, Paper, and Refineries were also contacted but unable to provide data primarily due to circumstances related to the current energy crisis. Shaded sectors are the most energy-intensive ones.

Table 13: Coverage of non-manufacturing sectors

NACE code	Sector
A	Agriculture, forestry and fishing
B	Mining and quarrying
B06	Extraction of crude petroleum and natural gas
B07	Mining of metal ores
B08	Other mining and quarrying
D35	Electricity, gas, steam and air conditioning supply
E38	Waste collection, treatment and disposal activities; materials recovery
F	Construction
G	Wholesale and retail trade
H49	Land transport and transport via pipelines
H51	Air transport
I	Accommodation and food service activities
J	Information and communication

The main data source for the top-down analysis of the energy costs was Eurostat; other databases from international institutions and national statistics, as well as data from industry associations or paid sources have been used to complement it.

Box 6-3 Overview of the data sources used for the analysis with aggregated statistical data

The following data from Eurostat and other international institutions have been extracted for the analysis:[186]

- **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 products for EU countries, Norway, Switzerland, Iceland, Turkey;
- **Eurostat Energy Balances** provides data on Energy Consumption per fuel types in the sector of Agriculture, forestry and fishing, Construction, Mining and quarrying, Land transport and transport via pipelines and 2 manufacturing sectors (Manufacture of basic precious and other non-ferrous metals, Manufacture of machinery and equipment n.e.c.) for EU countries, Norway and Turkey;
- **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 SDBS database** provides data on Number of Companies, Value Added, Gross Operating Surplus, Total Purchases of Goods and Services, Personnel Costs for several EU and non-EU G20 countries.

The data from Eurostat and other international institutions have been complemented with data from the following national databases:[187]

- The **US Bureau of Economic Analysis (BEA)** provides data on Turnover, Value added and Personnel Costs for the United States;
- The **National Institute of Statistics and Geography (INEGI)** provides data on Number of companies, Personnel costs, Production value, Purchases of energy products, Purchases of goods and services and value added for Mexico;
- The **Portal Site of Official Statistics of Japan (METI)** provides data on Number of companies, Production value, Purchases of goods and services and Value added;
- Other sources, such as the **UK Department for Business, Energy and Industrial Strategy (BEIS), Statistics Netherlands (CBS Statline)**, the **Federal Statistical Office of Germany (DESTATIS)**, the **US Energy Information Administration (EIA)**, the **National Bureau of Statistics of China (NBS)**, **Energy information system – Mexico (SENER), Statistics Canada (STATCAN)**, **the Statistical Office of Slovenia (SiStat), The Statistical Database STATcube of Statistics Austria, Statistics Finland, Statistics Estonia** and **Statistics Norway** provide data on Energy Consumption per fuel types.

Data from publicly available sources have been further complemented with the following sources:

- 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;

[186] Energy units have been converted to tonnes of oil equivalent (toe) using conversion coefficients from the Eurostat Energy Statistics Manual and calorific values from Commission Regulation No 601/2012.
[187] Where necessary, monetary values have been converted to Euros with the exchange rates of the European Central Bank

- **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.

In addition, we used the following assumptions:

- Where **energy costs** (purchases of energy) data are unavailable, but energy consumption and price data are available, energy costs (purchases of energy) are calculated as energy consumption multiplied by prices.
- EU **electricity and gas prices** for each sector are estimated based on the prices per type of consumer and an estimation of the average electricity and gas consumption for a typical consumer. The estimation of the average electricity and gas consumption 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. Based on the resulting average consumption, the sector is allocated to one of the consumption bands from Eurostat and the corresponding electricity and gas price. This is in line with the methodology from the previous iteration of this study. For coal prices, only prices including taxes have been updated. Updated coal prices excluding taxes were not available.
- **Energy consumption** is calculated by dividing the energy costs with energy prices per fuel type. Where the energy cost per energy carrier type is not available, the historical average energy mix is used to determine the weighted average energy price to estimate the total energy consumption.

6.4.2 Energy cost shares

The share of energy costs in the total production cost serves as an indicator of the impact that energy costs can have on the competitiveness of a sector. As explained in Section 6.3, energy cost shares are calculated by dividing the purchases of energy by total production costs.

It is therefore important to keep in mind that **results may be an underestimation of the impact of energy costs**, especially in industrial segments where there is a significant amount of consumption of self-produced energy and use of waste products for energy. This is particularly the case for energy-intensive industries such as chemicals, non-ferrous metals, paper, refineries and steel sectors. In addition, the aggregated data only shows the sectoral average; with highly energy-intensive primary producers are grouped together with producers of low energy-intensive secondary products. The analysis of plant-level data in Section 6.2 and previous editions of this study should therefore be seen as complementary to this analysis with aggregated statistical data for a more detailed insight in the impact of energy costs in highly energy-intensive industrial segments.

Results

Key takeaways:

- Between 2010-2019, energy costs for the selected manufacturing sectors typically constituted between 1-10% of total production costs; although for several sectors the costs exceeded 10% (e.g. *Cement, lime and plaster* in all years, and for *Pulp and paper* and *Clay building materials* for some years).

- Between 2010-2019, energy cost shares fell in almost every manufacturing sector, including energy intensive industries such as *Iron and Steel*, *Cement*, *Lime and Plaster*, and *Clay Building Materials*.
- The largest percentage point decline in cost share can be observed in the *Cement, Limes and plaster* sector, in which costs fell from close to 19% in 2010 to 13.6% in 2019. For some sectors, such as *Man-made fibres* and *Refractory products*, there was a temporary increase in the energy costs share in 2016.
- Of the non-manufacturing sectors studied, 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* (39%), *Air transport* (27%), *Electricity, gas and steam* (20%), *Mining of metal ores* (18%), and *Other mining* (8%).
- Energy cost shares declined for the majority of non-manufacturing sectors studied, except *Mining*, *Electricity, gas and steam generation*, and *Air transport*.

Table 7 summarises energy cost shares over time for all the sectors of the study. The table presents the changes over the period 2010-2019, 2010-2017, 2017-2019, as well as the average rate, and the maximum and minimum levels reached, to show the variability of cost shares over years.

The results from Table 7 are depicted in Figure 9 for **manufacturing sectors** in the EU, which illustrates energy costs as a share of total production costs for the subsectors in NACE code C *Manufacturing* from 2010 to 2019. The figure shows that:

- Energy costs typically constituted between **1-10% of total (operational) production costs**, although for several sectors, the costs exceeded 10% (e.g. *Cement*, *Lime and plaster*, as well as *Pulp and paper* and *Clay building materials* in some years);
- Energy costs for **several energy intensive sectors exceeded 7% of their total production costs** in at least one year. This applies to sectors including *Pulp and Paper*, *Refineries*,[188] *Man-made fibres*, *Glass*, *Clay building materials*, *Cement*, *Lime and plaster*, and *Iron and steel*. This indicates that these sectors are most sensitive to energy prices, and cost changes and differentials;
- Energy costs typically constitute **less than 3% of production costs among less energy intensive sectors**, and are therefore a relatively minor cost component for most businesses in these sectors. Sectors such as *Fruit and vegetables*, *Plastics products*, *Beverages*, *Pharmaceutical products*, and *Fabricated metal products* have energy cost shares between 1 and 3%. In several manufacturing sectors—*Computer and electronics*, *Machinery and equipment*, *Motor Vehicles*, *Other Transport Equipment*, *Repair of machinery*—energy costs do not exceed 1% of production costs;
- During this period**, energy cost shares fell in almost every manufacturing sector**, including energy intensive industries. The largest percentage point decline in cost share can be observed in *Cement, limes and plaster*, in which costs fell from 18.9% share in 2010 to 13.6% share in 2019. In some sectors, such as *Man-made fibres* and *Refractory products*, there was a temporary increase in the energy costs share in 2016.

[188] In contrast to the other manufacturing sectors with much better data availability, the value for Refineries is based on the average across four EU27 countries only. A large increase energy cost share in Greece in 2019 therefore leads to a large increase in the presented EU27 average value.

- In several manufacturing sectors, the energy cost shares **started to rise from 2017 onwards** after a continuous decline between 2010 and 2017. This is visible for the sectors such as *Grain products*, *Articles of paper*, *Man-made fibres*, *Clay building materials*, *Porcelain and Ceramics*, *Cement*, *Lime and plaster*, and *Stone*.
- For a few manufacturing sectors the **energy cost shares increased between 2010 and 2019**. The highest increase was observed in the sector of *Refineries*, where the energy costs share increased from 2.5% in 2010 to 7.9% in 2019[189]. In two sectors, Porcelain and Ceramics and *Stone*, the share of energy costs increased by less than 1%.

The results of this analysis for **non-manufacturing sectors** are depicted in Figure 10. **Energy cost shares are particularly high in five non-manufacturing sectors, at levels comparable to or even higher than the cost shares of energy intensive manufacturing sectors. These sectors include *Land transport* (39%), *Air transport* (27%), *Electricity*, *gas and steam* (20%), *Mining of metal ores* (18%), and *Other mining* (8%).** Fuel costs are clearly important drivers of production costs in the transport and energy generation sectors, and mining is an inherently energy intensive activity. Notably, energy cost shares decreased in *Land transport* (-10%) and *Mining of metal ores* (-5%), but increased in *Air transport* (+2%) and *Electricity, gas and steam* (+2%).

[189] However, until 2018, the share of energy costs ranged between 2% and 4.3%. The significant jump in 2019 can be caused by the small data sample, as data were available for only four EU27 countries and the average value was driven by a large increase in energy costs in Greece.

Table 14: Energy costs as shares of total production costs for all sectors studied, averaged across the EU27

Manufacturing sectors (NACE C)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average	Max. level	Absolute change 2010-2019	Absolute change 2010-2017	Absolute change 2017-2019	Relative change 2010-2019
C103 - Fruit and vegetables	2.8%	2.7%	2.9%	2.8%	2.9%	2.5%	2.5%	2.3%	2.3%	2.3%	2.6%	2.9%	-0.5%	-0.5%	-0.0%	-18.3%
C106 - Grain products	4.1%	3.9%	3.9%	3.9%	4.0%	3.6%	3.1%	2.6%	2.9%	2.7%	3.5%	4.1%	-1.4%	-1.6%	+0.2%	-34.1%
C132 - Textiles	3.4%	2.5%	2.6%	2.3%	2.2%	2.0%	2.1%	2.2%	1.9%	1.9%	2.3%	3.4%	-1.6%	-1.3%	-0.3%	-45.7%
C161 - Sawmills	3.2%	3.8%	3.4%	3.3%	3.2%	3.0%	3.0%	2.9%	2.9%	2.9%	3.2%	3.8%	-0.4%	-0.3%	-0.0%	-11.5%
C171 - Pulp and paper	11.1%	11.1%	10.7%	10.0%	9.3%	8.6%	7.1%	6.8%	6.8%	6.7%	8.8%	11.1%	-4.4%	-4.4%	-0.1%	-39.9%
C172 - Articles of paper	2.9%	2.6%	2.8%	2.9%	2.5%	2.4%	2.1%	2.2%	2.8%	2.5%	2.6%	2.9%	-0.3%	-0.7%	+0.4%	-12.0%
C192 - Refineries	2.5%	2.0%	3.0%	3.3%	3.5%	3.4%	4.3%	3.6%	3.4%	8.1%	3.7%	8.1%	+5.5%	+1.1%	+4.4%	+217.3%
C201 - Basic chemicals	6.3%	6.5%	6.1%	6.3%	5.9%	5.8%	5.4%	4.7%	5.1%	4.5%	5.7%	6.5%	-1.9%	-1.6%	-0.3%	-29.8%
C206 - Man-made fibres	6.5%	6.6%	5.8%	7.9%	6.0%	5.9%	7.3%	5.1%	5.5%	5.0%	6.2%	7.9%	-1.5%	-1.4%	-0.1%	-23.4%
C222 - Plastics products	2.7%	2.7%	2.7%	2.8%	2.7%	2.5%	2.3%	2.2%	2.2%	2.2%	2.5%	2.8%	-0.5%	-0.5%	+0.1%	-16.9%
C231 - Glass	8.3%	8.1%	9.5%	9.5%	8.7%	8.1%	6.9%	6.4%	6.6%	5.9%	7.8%	9.5%	-2.4%	-1.9%	-0.5%	-29.3%
C232 - Refractory products	6.2%	6.0%	6.7%	6.9%	5.6%	5.7%	5.9%	4.9%	3.1%	4.6%	5.6%	6.9%	-1.6%	-1.3%	-0.2%	-25.2%
C233 - Clay building materials	12.2%	11.2%	12.5%	12.6%	11.7%	11.4%	9.9%	8.8%	8.6%	9.0%	10.8%	12.6%	-3.2%	-3.4%	+0.2%	-26.1%
C234 - Porcelain and Ceramics	4.9%	5.3%	5.6%	5.6%	4.9%	4.8%	4.7%	4.3%	4.7%	4.8%	5.0%	5.6%	-0.1%	-0.6%	+0.5%	-2.0%
C235 - Cement, lime and plaster	18.9%	20.1%	17.9%	17.7%	17.5%	16.0%	13.9%	12.8%	13.7%	13.4%	16.2%	20.1%	-5.5%	-6.1%	+0.6%	-29.1%
C237 - Stone	3.2%	3.9%	3.3%	4.8%	3.1%	3.7%	2.9%	3.5%	3.6%	3.7%	3.6%	4.8%	+0.5%	+0.3%	+0.1%	+15.0%
C239 - Abrasive products	4.5%	4.4%	4.7%	4.6%	5.3%	4.9%	4.9%	4.5%	4.2%	4.3%	4.6%	5.3%	-0.2%	+0.0%	-0.2%	-4.6%
C241 - Iron and steel	8.7%	7.2%	7.8%	7.9%	6.8%	7.1%	6.8%	6.2%	5.9%	6.1%	7.1%	8.7%	-2.6%	-2.5%	-0.1%	-29.9%
C244 - Non-ferrous metals	4.0%	3.9%	3.8%	3.9%	3.7%	3.7%	3.0%	3.1%	3.1%	3.0%	3.5%	4.0%	-1.0%	-0.9%	-0.1%	-24.0%
C245 - Casting of metal	6.0%	5.5%	5.6%	5.5%	5.5%	5.2%	5.0%	4.5%	4.3%	4.4%	5.2%	6.0%	-1.6%	-1.5%	-0.1%	-26.4%
C11 - Beverages	1.9%	1.9%	1.9%	1.9%	1.8%	1.8%	1.7%	1.4%	1.6%	1.7%	1.8%	1.9%	-0.2%	-0.5%	+0.3%	-11.6%
C21 - Pharmaceutical products	1.1%	1.1%	1.1%	1.2%	1.1%	1.1%	1.0%	0.9%	0.8%	0.9%	1.0%	1.2%	-0.3%	-0.2%	-0.1%	-24.0%
C25 - Fabricated metal products	2.0%	1.8%	1.9%	2.0%	1.9%	1.8%	1.7%	1.6%	1.6%	1.6%	1.8%	2.0%	-0.5%	-0.4%	-0.0%	-22.4%
C26 - Computer and electronics	0.6%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%	0.5%	0.6%	0.6%	0.6%	0.7%	-0.1%	-0.1%	+0.0%	-8.2%
C27 - Electrical equipment	1.0%	1.0%	1.0%	1.0%	1.1%	0.9%	0.8%	0.7%	0.7%	0.8%	0.9%	1.1%	-0.3%	-0.3%	+0.0%	-25.2%

Manufacturing sectors (NACE C)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average	Max. level	Absolute change 2010-2019	Absolute change 2010-2017	Absolute change 2017-2019	Relative change 2010-2019
C28 - Machinery and equipment	0.9%	0.9%	0.9%	0.9%	0.9%	0.8%	0.8%	0.7%	0.7%	0.7%	0.8%	0.9%	-0.3%	-0.2%	-0.0%	-27.3%
C29 - Motor vehicles	0.8%	0.7%	0.8%	0.8%	0.7%	0.7%	0.6%	0.6%	0.6%	0.6%	0.7%	0.8%	-0.2%	-0.2%	+0.0%	-28.7%
C30 - Other transport equipment	0.8%	0.7%	0.7%	0.7%	0.6%	0.6%	0.4%	0.4%	0.4%	0.4%	0.6%	0.8%	-0.4%	-0.4%	+0.0%	-50.4%
C32 - Other manufacturing	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%	0.9%	0.8%	0.7%	0.7%	0.9%	1.0%	-0.3%	-0.3%	-0.0%	-29.0%
C33 - Repair of machinery	0.8%	0.9%	0.8%	0.8%	0.9%	0.8%	0.7%	0.7%	0.7%	0.7%	0.8%	0.9%	-0.1%	-0.0%	-0.0%	-10.3%
Non-manufacturing sectors																
B - Mining and quarrying	2.9%	2.8%	2.8%	2.9%	2.9%	3.0%	3.1%	5.1%	4.2%	4.7%				+2.2%		
B06 - Oil and gas	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.7%	0.5%	0.7%				+0.7%		
B07 - Mining of metal ores	19.8%	20.7%	20.1%	19.7%	17.8%	18.4%	16.8%	17.1%	17.4%	15.3%				-2.7%		
B08 - Other mining	7.7%	8.5%	8.7%	8.9%	8.1%	8.1%	7.3%	8.2%	8.3%	7.6%				+0.5%		
D35 - Electricity, gas and steam	20.4%	22.2%	18.7%	17.5%	17.0%	17.0%	18.3%	18.7%	22.3%	22.6%				-1.7%		
E38 - Waste management	1.6%	1.6%	1.8%	2.0%	2.1%	1.8%	1.5%	1.5%	1.5%	1.6%				-0.1%		
F - Construction	1.2%	1.3%	1.2%	1.2%	1.2%	1.1%	1.1%	1.0%	1.0%	1.0%				-0.2%		
G - Wholesale and retail trade	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%				-0.0%		
H49 - Land transport	43.8%	42.0%	39.5%	40.1%	41.0%	40.2%	38.9%	37.6%	35.2%	34.1%				-6.1%		
H51 - Air transport	27.2%	26.9%	25.3%	24.6%	24.4%	24.9%	27.4%	29.6%	30.5%	29.2%				+2.5%		
I - Accommodation and restaurants	3.5%	3.4%	3.3%	3.1%	2.7%	2.5%	2.1%	2.2%	2.1%	2.1%				-1.3%		
J – Information and communication	0.3%	0.4%	0.5%	0.5%	0.5%	0.4%	0.3%	0.4%	0.4%	0.4%				+0.1%		

Note: Energy cost shares in total production costs are calculated as the average across EU27 countries for which data is available for all years between 2010 and 2019 to ensure comparability between years for each sector. Values may therefore deviate from the previous editions of this study if 2018 and/or 2019 data is not available for an EU27 country and therefore not included in the EU27 average value for that sector anymore. Data is available for at least half of the EU27 countries for all relevant sectors except Refineries (C192), Waste management (E38) and the service sectors (G, I and J), which is based on data and estimations for less than five EU27 countries. Agriculture (A) is not included in the table due to a lack of data.

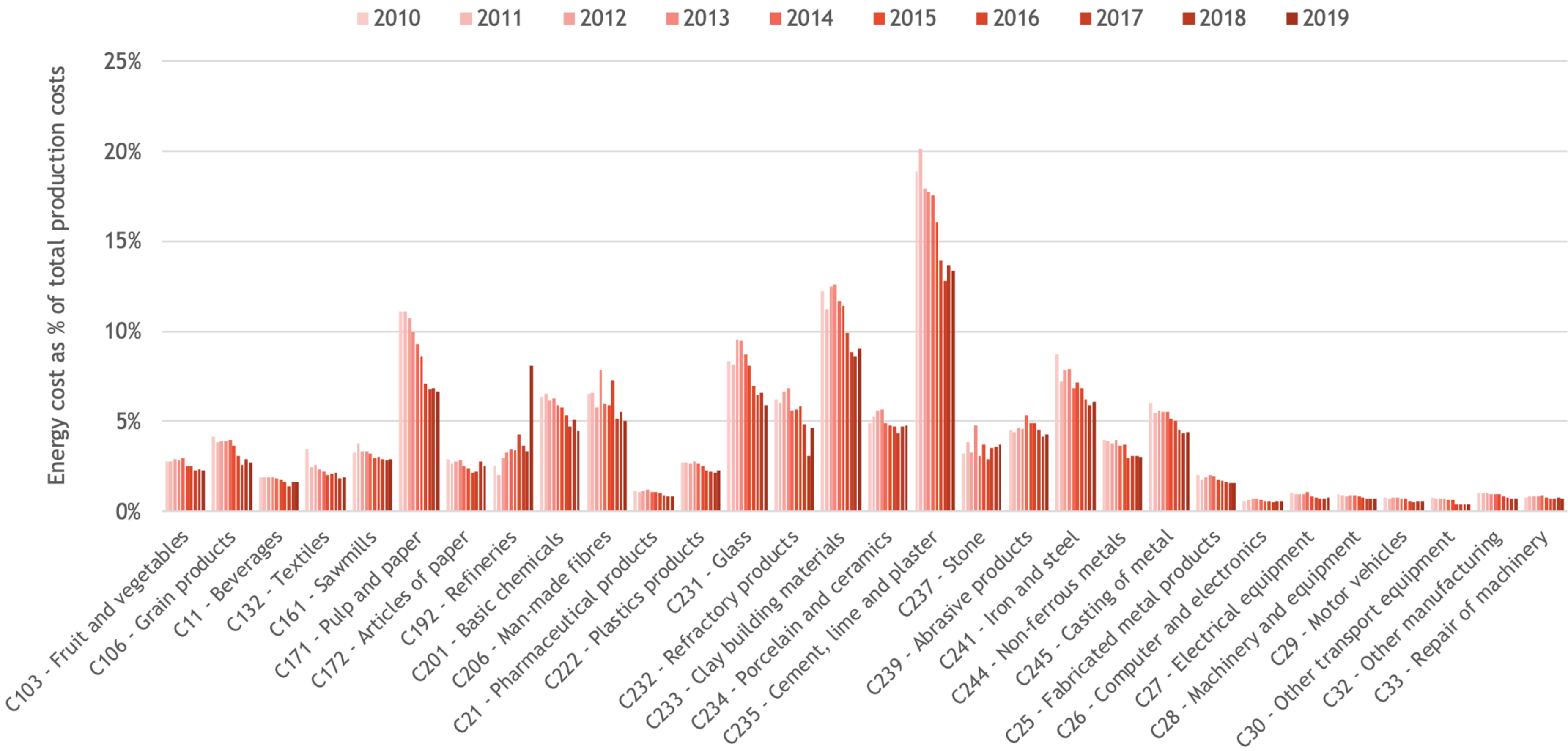


Figure 167: Average energy costs (as shares of production costs) for manufacturing sectors, averaged across the EU27

Source: Own calculations based on data from Eurostat SBS

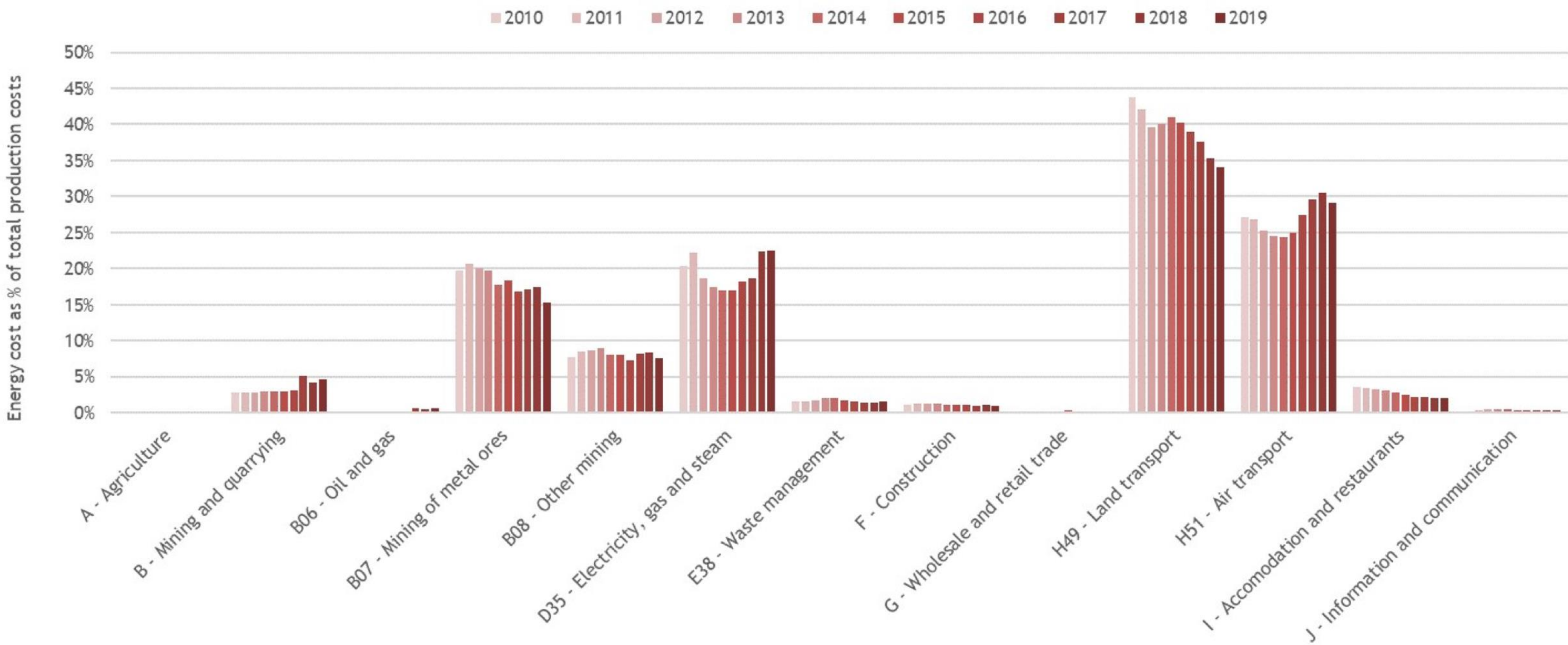


Figure 168: Average energy costs (as shares of production costs) for non-manufacturing sectors, averaged across the EU27

Source: Own calculations based on data from Eurostat SBS and estimations based on national statistics

Energy costs and energy consumption mix in manufacturing sectors

Energy costs are determined by energy prices and quantities of energy consumed for the production of products. In the short term, variations in energy prices are a strong driver for changes in energy costs in a sector. On the other hand, energy consumption tends to be more stable as it depends on more factors than just energy prices, including consumption patterns, competitive position, the economic situation and energy efficiency. **The energy consumption mix of a sector therefore serves as a good indicator on how price changes of each energy product could affect the energy costs of a sector.**

Figure 11 presents the average mix in type of energy carrier for each manufacturing sector in this study. This figure shows the relevance of different energy carriers per sector, given their proportional contribution to total energy consumption, on average. The figure shows that:

- **Electricity and natural gas are the most consumed energy products for most manufacturing sectors.** This means that the fluctuations in the prices of these energy carriers have a bigger influence on total energy costs than others;
- **Natural gas consumption drives energy costs in particular for the sectors where gas consumption ranges from 50% to more than 80% of total energy consumption**; including *Fruit and vegetables*, *Grain products*, *Beverages*, *Glass*, *Refractory Products*, *Clay Building Materials*, and *Porcelain and Ceramics*;
- **Electricity consumption is particularly dominant in the sectors *Textiles*, *Plastics products*, *Stone*, *Non-ferrous metals*, *Computers and electronics*, *Electrical equipment*, *Motor vehicles* and *Other manufacturing***, where electricity consumption represents at least 50% of total energy consumption;
- **Coal still plays a major role in the manufacturing of *Cement, Lime and plaster*, *Abrasive products*, *Iron and steel*, and *Casting of metals*.** In the case of the *Iron and steel* sector, coal is also used 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*.** In the *Refineries* and *Basic chemicals* sector, oil is largely used as a feedstock in the manufacturing of products, with waste and by-products being used for energy;
- **"Other" energy carriers, particularly biomass, contribute significantly to energy consumption for select secto**rs including *Sawmills* (where it comprises 86% of the energy consumed), *Pulp and paper* (with 45%), *Machinery and equipment* (44%) and *Stone* (with 37%).

It is important to note that the mix of energy carriers can vary significantly between subsectors within each sector. For example, the natural gas consumption in *Basic chemicals* does not exceed 50% of the total energy consumption on average. However, the fertiliser sector, which is a subsector of basic chemicals, uses natural gas as its main fuel as well as feedstock for the production of ammonia. Price changes of natural gas would therefore have a large impact on the fertiliser sector. For a few energy-intensive sectors for which data could be collected at plant level, this is further unpacked in Section 6.2.

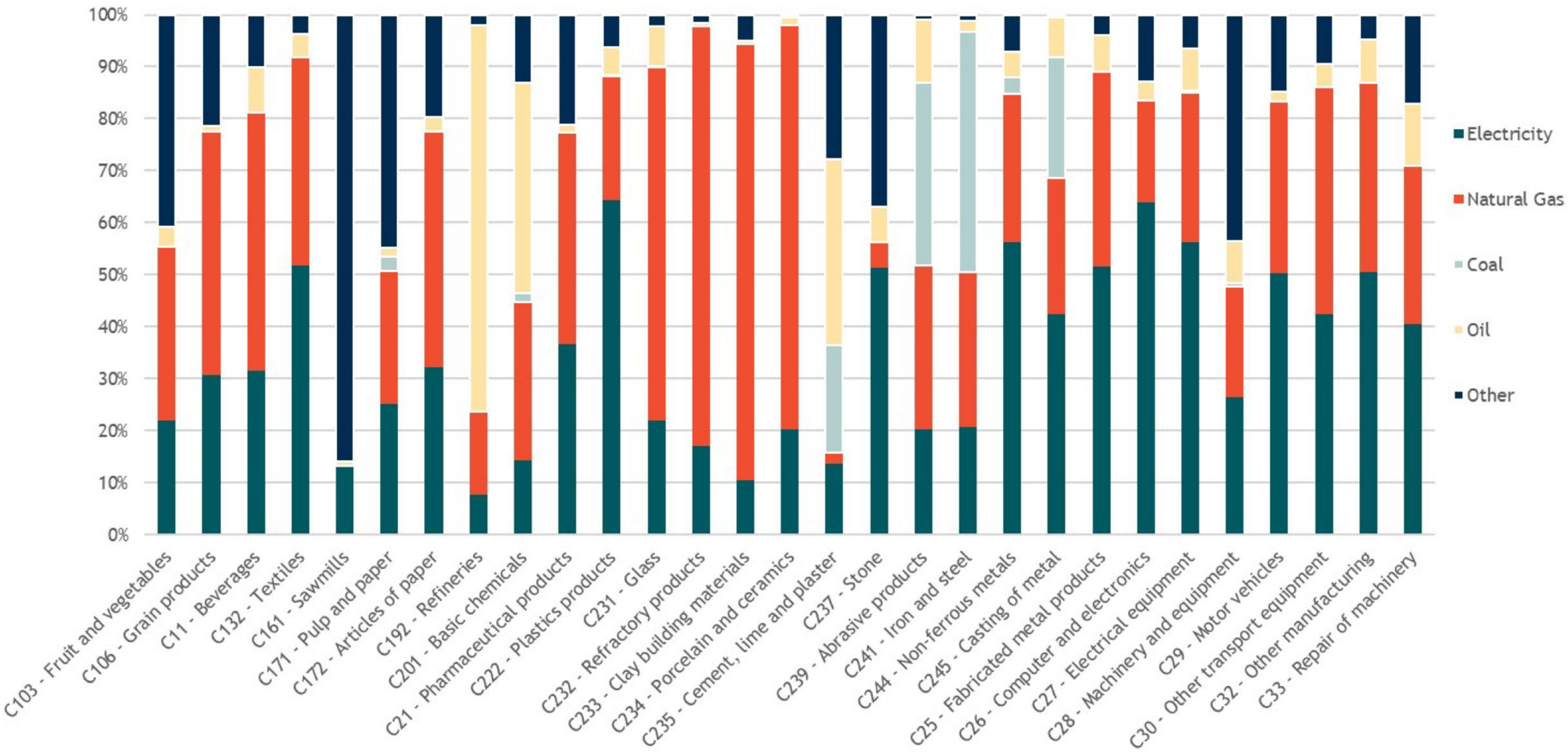


Figure 169: Breakdown of consumption per energy carrier for manufacturing sectors, averages across available EU27 countries, 2010-2019

Source: Own calculations based on data from Eurostat energy statistics and estimations based on national statistics

Note: “other” mainly covers biomass and heat consumption

Dynamics of the energy costs shares in total production costs

Changes in the shares of energy costs in production costs are the result of relative changes in energy costs and production costs. For instance, energy costs shares fall if energy costs decrease more than production costs over the same period. Energy costs shares also drop if energy costs increase less than total production costs.

Table 8 shows the change of each of these two variables for each sector. The absolute values shown are not for the EU27 as a whole (as this data is unavailable), but only the sum of the EU27 countries for which energy and production cost data are available per sector. These sectors have been grouped in Table 9 based on the observed changes in energy and production in absolute terms (i.e. in million euros) between 2010 and 2019. Note that energy and production costs vary on an annual basis, which is not captured in the two tables as it only compares 2019 with 2010. These annual variations for the energy and production costs combined can be observed in Table 7.

The two tables show that **the drop in energy cost shares in production costs observed in most sectors is strongly driven by the increase in production costs.** For about half of the sectors (16 out of 33) with decreasing energy cost shares between 2010 and 2019, this is driven by the production costs increasing more than the energy costs. In four sectors, the decrease in energy cost shares is caused by energy costs dropping more than production costs. The decrease in energy cost shares in the remaining 13 sectors is the result of an increase in production costs accompanied by a decrease in energy costs, which by definition leads to a drop in energy cost shares.

The tables further show that of the **six of the nine sectors that experience a rise in energy cost shares is caused by a stronger rise in energy costs compared to production costs.** These six sectors are *Refineries*, *Electricity, gas and steam*, *Waste management*, *Wholesale and retail trade*, *Air transport* and *Information and communication*. For two sectors (*Stone* and *Mining and quarrying*), the energy costs fell less than the production costs. **The remaining sector (*Oil and gas*) shows an increase in energy costs combined with a decrease in production costs.**

Table 15: Drivers of energy costs shares in total production costs, manufacturing and non-manufacturing sectors, averages across available EU27 countries, 2010-2019

Manufacturing sectors	Changes in total values across the EU27 2010-2019				Change in energy cost share 2010-2019 (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 vs. total production costs (% point)	Relative Δ energy costs vs. total production costs (%)
C103 - Fruit and vegetables	*+130*	+10.6%	*+15713*	+35.5%	-0.5%	-18.3%
C106 - Grain products	*-38*	-3.4%	*+12668*	+46.5%	-1.4%	-34.1%
C132 - Textiles	*-209*	-48.1%	*-551*	-4.4%	-1.6%	-45.7%
C161 - Sawmills	*+108*	+12.3%	*+7262*	+26.8%	-0.4%	-11.5%
C171 - Pulp and paper	*-2510*	-34.7%	*+5656*	+8.7%	-4.4%	-39.9%
C172 - Articles of paper	*+201*	+9.9%	*+17475*	+24.8%	-0.3%	-12.0%
C192 - Refineries	*+1430*	+253.6%	*+2536*	+11.5%	+5.5%	+217.3%
C201 - Basic chemicals	*-2874*	-18.0%	*+42432*	+16.8%	-1.9%	-29.8%
C206 - Man-made fibres	*-102*	-25.8%	*-188*	-3.1%	-1.5%	-23.4%
C222 - Plastics products	*+172*	+4.1%	*+39454*	+25.2%	-0.5%	-16.9%
C231 - Glass	*-146*	-5.1%	*+11653*	+34.1%	-2.4%	-29.3%
C232 - Refractory products	*-67*	-26.1%	*-53*	-1.3%	-1.6%	-25.2%
C233 - Clay building materials	*-219*	-12.7%	*+2539*	+18.0%	-3.2%	-26.1%
C234 - Porcelain and Ceramics	*+12*	+3.5%	*+382*	+5.7%	-0.1%	-2.0%
C235 - Cement, lime and plaster	*-808*	-28.3%	*+187*	+1.2%	-5.5%	-29.1%
C237 - Stone	*-3*	-0.8%	*-1797*	-13.7%	+0.5%	+15.0%
C239 - Abrasive products	*-10*	-1.2%	*+666*	+3.6%	-0.2%	-4.6%
C241 - Iron and steel	*-2440*	-23.4%	*+11065*	+9.2%	-2.6%	-29.9%
C244 - Non-ferrous metals	*+310*	+10.2%	*+34359*	+44.9%	-1.0%	-24.0%
C245 - Casting of metal	*-389*	-21.6%	*+1948*	+6.5%	-1.6%	-26.4%
C11 - Beverages	*+288*	+17.1%	*+29039*	+32.4%	-0.2%	-11.6%
C21 - Pharmaceutical products	*+66*	+5.1%	*+44428*	+38.3%	-0.3%	-24.0%
C25 - Fabricated metal products	*-237*	-3.3%	*+85624*	+24.6%	-0.5%	-22.4%
C26 - Computer and electronics	*+55*	+4.0%	*+29371*	+13.3%	-0.1%	-8.2%

Manufacturing sectors	Changes in total values across the EU27 2010-2019				Change in energy cost share 2010-2019 (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 vs. total production costs (% point)**	**Relative Δ energy costs vs. total production costs (%)**
C27 - Electrical equipment	*-160*	-6.9%	*+56491*	+24.5%	-0.3%	-25.2%
C28 - Machinery and equipment	*+310*	+7.2%	*+216884*	+47.5%	-0.3%	-27.3%
C29 - Motor vehicles	*+834*	+16.9%	*+399994*	+63.9%	-0.2%	-28.7%
C30 - Other transport equipment	*+5*	+0.6%	*+121752*	+102.8%	-0.4%	-50.4%
C32 - Other manufacturing	*+20*	+2.7%	*+32967*	+44.7%	-0.3%	-29.0%
C33 - Repair of machinery	*+65*	+7.3%	*+22430*	+19.6%	-0.1%	-10.3%
Non-manufacturing sectors						
B - Mining and quarrying	*-505*	-15.5%	-54972	-48.6%	+1.8%	+64.3%
B06 - Oil and gas	*+62*	+144.3%	-50259	-77.1%	+0.6%	+965.9%
B07 - Mining of metal ores	*-9*	-11.5%	+54	+14.4%	-4.5%	-22.6%
B08 - Other mining	*-121*	-9.9%	-1329	-8.4%	-0.1%	-1.7%
D35 - Electricity, gas and steam	*+7183*	+24.8%	+18263	+12.9%	+2.2%	+10.5%
E38 - Waste management	*+36*	+18.8%	+2125	+18.3%	+0.0%	+0.4%
F - Construction	*+1155*	+8.8%	+267167	+24.3%	-0.1%	-12.5%
G - Wholesale and retail trade	*+15*	+6.0%	+1474	+1.3%	+0.0%	+4.6%
H49 - Land transport	*+5927*	+3.6%	+123318	+32.9%	-9.7%	-22.1%
H51 - Air transport	*+5735*	+26.2%	+14062	+17.4%	+2.0%	+7.5%
I - Accommodation and restaurants	*-36*	-8.2%	+6691	+54.0%	-1.4%	-40.4%
J - Information and communication	+95	+116.6%	+11948	+39.8%	+0.1%	+55.0%

Note: Agriculture (A) is not included in the table due to a lack of data. The absolute Δ energy costs as a share of total production costs (% point) shows the change in the energy cost shares between 2010 and 2019 as presented in Table 7. The relative Δ energy costs as a share of total production costs (%) is the percentage change in the energy cost share as presented in Table 7 in 2019 compared to 2010.

Table 16: Categorisation of sectors according to changes in energy and production costs, 2010-2019

	Reduced energy costs (2010-2019)	Increased energy costs (2010-2019)
Reduced production costs (2010-2019)	• C132 - Textiles • C206 - Man-made fibres • C232 - Refractory products • ***C237 - Stone*** • ***B - Mining and quarrying*** • B08 - Other mining	• ***B06 - Oil and gas***
Increased production costs (2010-2019)	• C106 - Grain products • C171 - Pulp and paper • C201 - Basic chemicals • C231 - Glass • C233 - Clay building materials • C235 - Cement, lime and plaster • C239 - Abrasive products • C241 - Iron and steel • C245 - Casting of metal • C25 - Fabricated metal products • C27 - Electrical equipment • B07 - Mining of metal ores • I - Accommodation and restaurants	• C103 - Fruit and vegetables • C161 - Sawmills • C172 - Articles of paper • ***C192 - Refineries*** • C222 - Plastics products • C234 - Porcelain and Ceramics • C244 - Non-ferrous metals • C11 - Beverages • C21 - Pharmaceutical products • C26 - Computer and electronics • C28 - Machinery and equipment • C29 - Motor vehicles • C30 - Other transport equipment • C32 - Other manufacturing • C33 - Repair of machinery • ***D35 - Electricity, gas and steam*** • ***E38 - Waste management*** • F - Construction • ***G - Wholesale and retail trade*** • H49 - Land transport • ***H51 - Air transport*** • ***J - Information and communication***

*Note: sectors in **bold and italic** show an increase in the share of energy costs in production costs between 2010 and 2019. The other sectors show a decrease in energy cost shares. In combination with the quadrant that they are a part of, this provides an indication of the drivers for the change in energy costs. For example, in the Refineries sector, the energy cost rose more than production costs, resulting in an increase in the share of energy costs in production costs. For the Cement, lime and plaster sector, the decrease in energy costs was more than the decrease in production costs, resulting in an overall decrease of the share of energy costs in production costs.*

6.4.3 Gross Operating Surpluses shares

The profit margins that can be achieved drive the competitiveness of industries. In the short term, profit margins determine the flexibility companies have in their pricing strategy and their competitive position. In the long term, achievable profit margins are fundamental in attracting investment.

Statistics for profit margins are not publicly available. Therefore, **data on Gross Operating Surplus (GOS), which can be found in Eurostat, is used as a proxy for profit.**[190] The GOS of the sectors in this study are analysed with respect to total operational production costs, using the following formula:

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

Results

Key takeaways:

- Most EU sectors studied maintained an average gross operation surplus (GOS) share between 5-15%, similar as observed in the previous editions of this study.
- The *Pharmaceuticals* and *Cement* sectors maintained the highest GOSs as shares of production costs, on average 22% and 23% respectively. 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 over 2010–2019. Notably, the GOS share of the *Iron and steel* sector was even close to 0% in 2011-2012.
- In the recent years, increasing numbers of sectors show a decrease in their GOS. Since 2017, the GOS declined for most of the sectors (23), while in the period of 2010-2017 only 10 sectors recorded a fall in their GOS. The largest decline in the GOS between 2017 and 2019 can be found in the *Iron and steel* sector (-90%), followed by *Man-made fibres* (-29%) and *Basic chemicals* (-22%).
- The non-manufacturing sectors studied maintain their GOS on par with their manufacturing counterparts, on average between 5-20%. The only exceptions are *Oil and gas* (up to 140%) and *Mining of metal ores* sectors (up to 90%), which maintained much higher GOSs than manufacturing sectors on average.

Figure 12 presents the average GOS as a share of total production costs across EU27 countries for which data for all years between 2010 and 2019 is available. The analysis indicates that:

- **Most EU sectors maintained an average GOS share between 5-15%,** similar as observed in the previous editions of this study;
- The ***Pharmaceuticals* and *Cement* sectors maintained the highest GOSs** as shares of production costs, on average 22% and 23% respectively;
- 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 over 2010-2019. Notably, the GOS share of the *Iron and steel* sector was even close to 0% in 2011-2012;
- Between 2010-2019, the GOS increased in 13 sectors, especially in *Clay building materials* (47%); *Textiles* (40%) and *Casting of metal* (34%);
- On the other hand, the GOS decreased significantly during the same period in *Man-made fibres* (-59%) and *Iron and steel* (-80%); in both cases, this trend can be explained by the decrease in the absolute values of the GOS;
- **In the recent years, the numbers of sectors that show a decrease in their GOS have increased.** Since 2017, the GOS declined for most of the sectors (23), while in the period of 2010-2017 only 10 sectors recorded a fall in their GOS. **The largest decline in the GOS between**

[190] The key difference is that the GOS does not take costs other than production costs, such as depreciation of capital, into account.

2017 and 2019 can be found in *Iron and steel* (-90%), followed by *Man-made fibres* (-29%) and *Basic chemicals* (-22%).

Figure 13 shows the GOS trends across non-manufacturing sectors, averaged across EU27 countries with available data between 2010 and 2019. **The *Oil and gas* and *Mining of metal ores* sectors maintained much higher GOSs than manufacturing sectors on average.** The GOS of the *Mining* sectors do show a decreasing trend until 2017 when the GOS start to rise again. This is the exact opposite trend that the energy-intensive sectors downstream of the *Oil and gas* and *Mining* sectors exhibit, which include *Refineries*, *Basic Chemicals*, *Glass*, *Iron and steel*, and *Non-ferrous metals*. Other non-manufacturing sectors maintain a GOS on par with their manufacturing counterparts, on average between 5-20%.

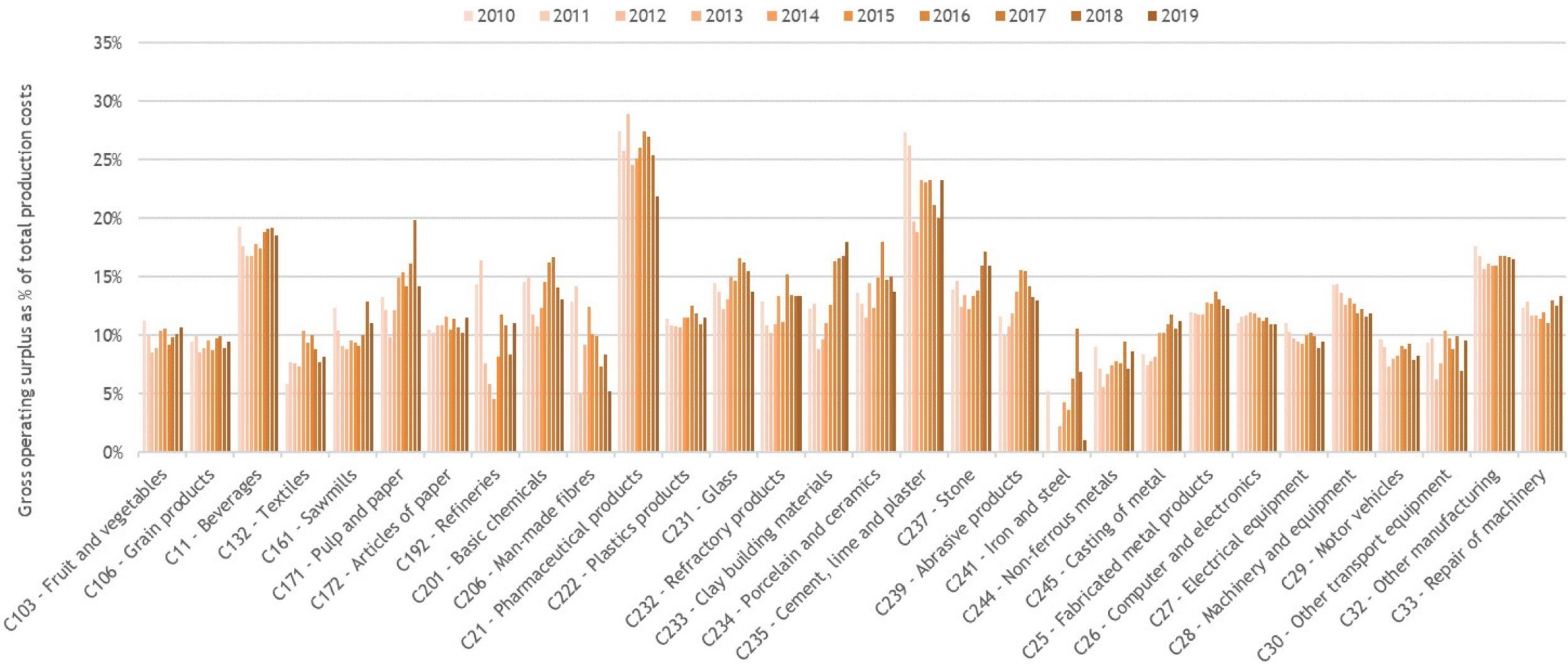


Figure 170: Gross operating surpluses as a percentage of total production costs for EU manufacturing sectors, averaged across EU27 countries with available data for 2010-2019

Source: Own calculations based on Eurostat SBS

Note: GOS shares in total production costs are calculated as the average across EU27 countries for which data is available for all years between 2010 and 2019 to ensure comparability between years for each sector. Values may therefore deviate from the previous editions of this study if 2018 and/or 2019 data is not available for an EU27 country and therefore not included in the EU27 average value for that sector anymore.

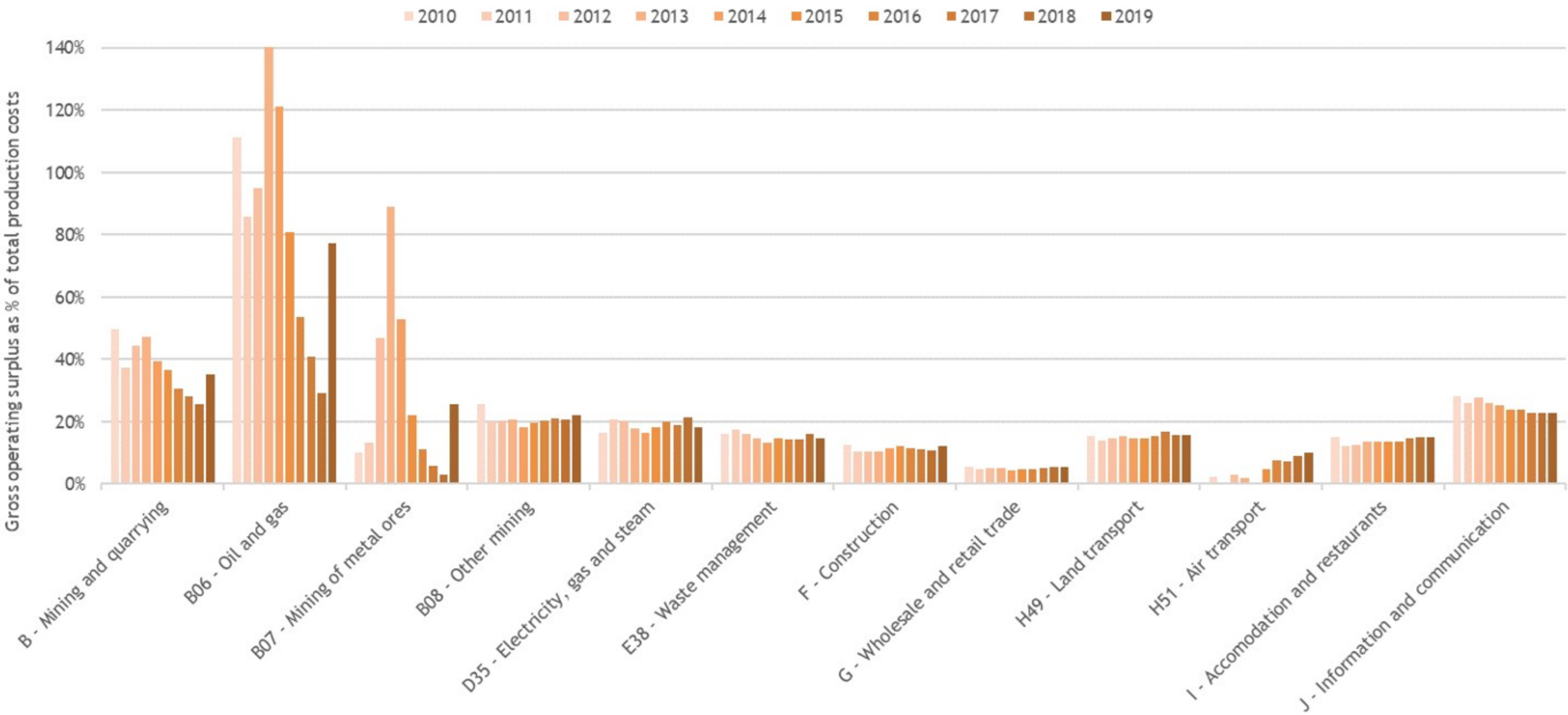


Figure 171: Gross operating surpluses as a percentage of total production costs for EU non-manufacturing sectors, averaged across EU27 countries with available data for 2010-2019

Source: Own calculations based on Eurostat SBS.

Note: Agriculture (A) is not included in the graph due to a lack of data.

In the EU27, the average GOS of the manufacturing sectors in this study is approximately in the range of 10-12% per year. However, there are large differences in the GOS as a percentage of production costs between Member States. Figure 14 shows the 2010–2019 average GOS broken down per EU27 country. Cyprus, Bulgaria, Ireland, Malta, Poland, Denmark, Latvia and Hungary have the highest GOSs with over 14%. Romania, Czechia, Slovenia and Lithuania closely follow these. The lowest GOSs are found in Germany and France, both below 10%.

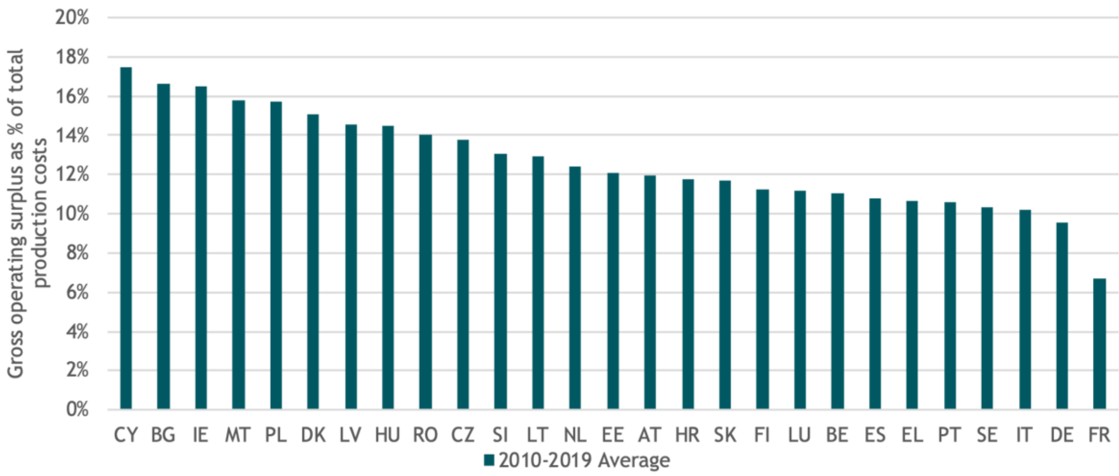


Figure 172: Gross operating surplus as % of total production costs, average across all manufacturing sectors at Member State levels

Source: Own calculations based on Eurostat SBS

6.5 Exploring energy intensities

6.5.1 Methodology

The energy efficiency of production is another key indicator of the impact changes in energy prices and costs can have on sectors. This is generally expressed as the energy consumption divided by the volume of production. However, production volume data is recorded in different units, which does not allow for a direct comparison between sectors and comparable production volume data is not easily available. In this study (and its previous iterations), the energy intensity of a sector expressed as a share of value added at factor costs (Gross Value Added — GVA) is therefore used as a proxy, i.e.:

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

The energy intensity is not a direct measure of the physical energy efficiency of production, since the value added is subject to price effects and other factors. **Changes in product prices due to a change in demand or exchange rates, or a change in personnel costs could affect the value added without these changes necessarily being proportional to changes in production volumes.** Nonetheless, it is a commonly used approximation as production volume data is not comparable across sectors.

6.5.2 Results

Key takeaways:

- Energy intensity (energy consumption/GVA[191]) varies considerably across the sectors studied, with the sectors *Refineries*, *Iron and steel*, *Pulp and paper*, *Cement*, *Lime and plaster*, and *Basic chemicals* among the most energy intensive sectors.
- Of the most energy-intensive sectors studied, *Iron and steel*, *Pulp and paper*, *Cement*, *Lime and plaster* all show decreasing trend in energy intensity over the years. For *Basic chemicals*, the energy-intensity has been relatively stable. The energy intensity of *Refineries* is highly volatile with an increasing trend in the recent years.
- The energy intensities of the sectors *Refineries*, *Clay building materials* and *Iron and steel* are most volatile. They experienced relative large changes in energy intensity between 2014-2016 as their value added (at factor cost) periodically rose and fell.
- In non-manufacturing, energy intensity decreased in *Land transport*, but remained relatively stable in *Air transport* and *Electricity-gas*. Amongst those with lower energy intensity, the results are mixed.

Figure 15 presents the energy intensities of industrial manufacturing sectors in the EU. The figure shows that:

- The energy intensity varies considerably across sectors:
    - ***Refineries*, the *Iron and steel* sector, the *Pulp and paper* sector and the *Cement*, *lime and plaster* sector are the most energy intensive sectors.** They typically require more than 2 toe[192] of energy consumption per thousand Euros of GVA;
    - These are followed by the *Basic chemicals* sectors, which require around 1 toe of energy consumption per thousand Euros of GVA.
    - Out of the 30 manufacturing sectors in this study, 12 have an energy intensity of <0.1 toe of energy consumption per thousand Euros GVA.
- The energy intensities of the *Refineries*, *Clay building materials* and *Iron and steel* are most volatile. They experienced relatively large changes in energy intensity over the years as their value added (at factor cost) periodically rose and fell while the variation in energy consumption relatively limited;
- **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, particularly in 2014 with the sector in some countries having a negative GVA. In other sectors, value added was linked to decreased economic activity levels following the 2014 crisis in the EU.

Figure 16 presents the energy intensities of non-manufacturing sectors in the EU. **The highest intensities are consistently observed in *Air transport*, *Electricity*, *gas and steam*, and *Land transport***, reaching levels similar to the most energy-intensive manufacturing sectors with an energy intensity around 1 to 2 toe of energy consumption per thousand Euros GVA. The energy intensity of *Air transport* and *Electricity, gas and steam* are relatively stable for most years, whereas the energy intensity in *Land transport* has been constantly decreasing. The other sectors show a much lower energy intensity of <0.2 toe of energy consumption per thousand Euros GVA with a mixed trend.

[191] Gross Value Added

[192] Toe = tons of oil equivalent. According to the international conventions, one ton of oil equivalent amounts for example in 1 616 kg of coal, 1 069 m^3 of gas or 954 kg of gasoline. For electricity, 1 toe is worth 11.6 MWh.

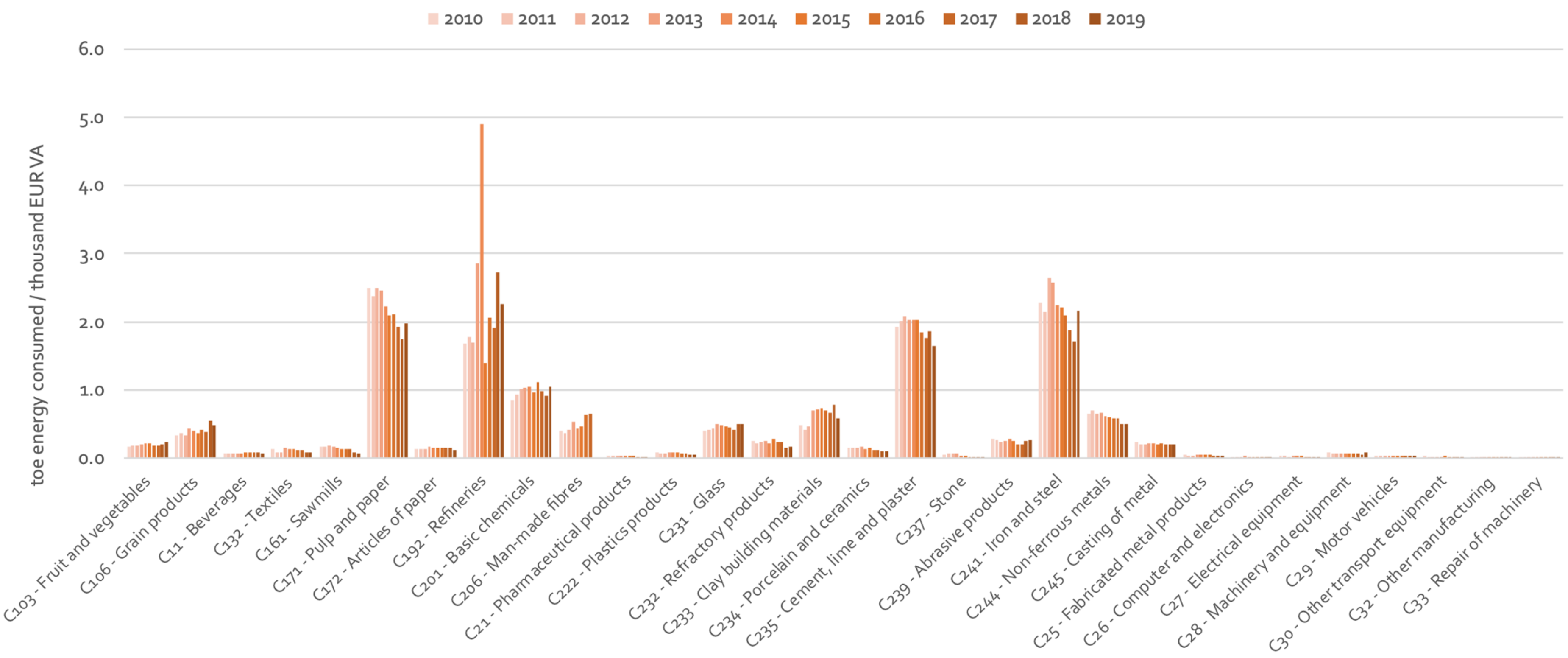


Figure 173: Energy intensities of manufacturing sectors, 2010-2019, averages over limited number of EU Member States with available data

Source: Own calculations based on Eurostat SBS and national sources

Note: the energy intensity for the sector C206 Man-made fibres could not be estimated for 2018 and 2019 due to a lack of data. Values deviate from the previous editions of this study due to improvements to the underlying statistical data and a correction to the data where values in the same graph in the previous edition of the study were shown for the wrong year.

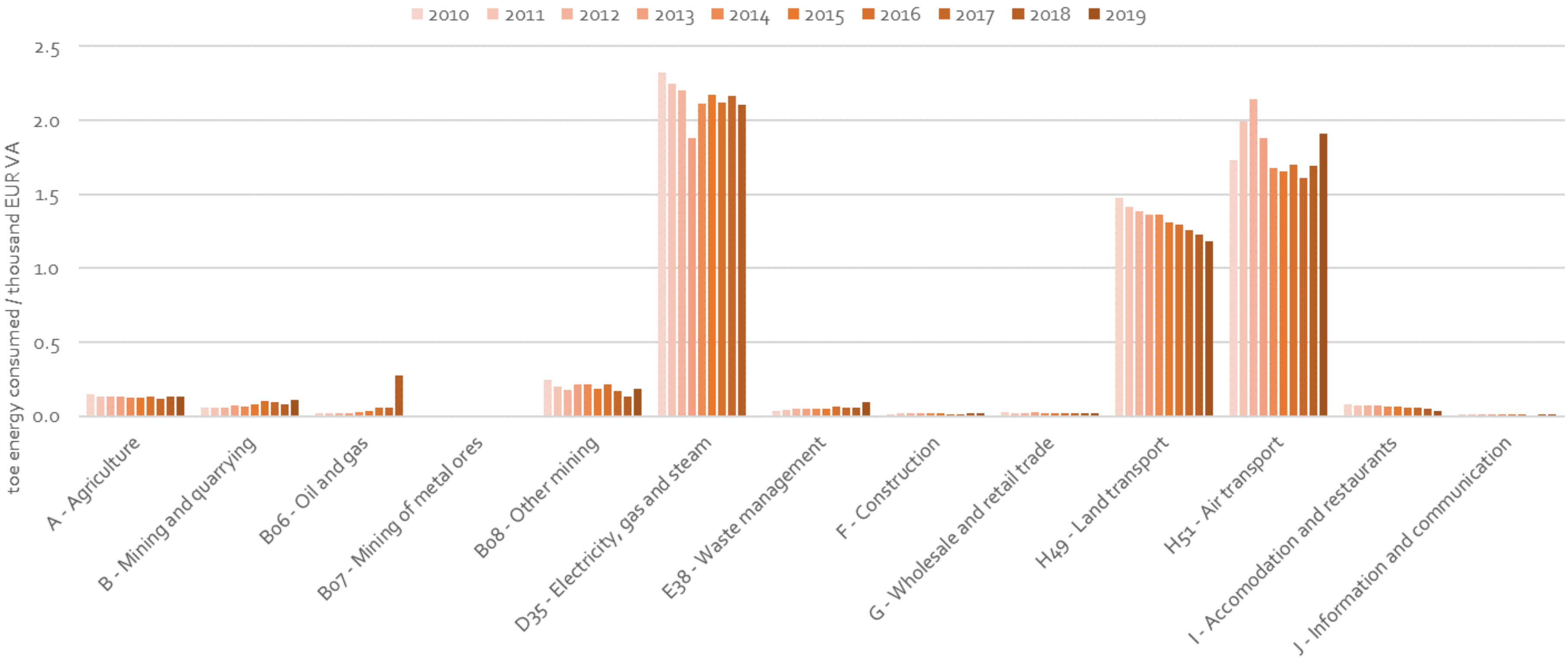


Figure 174: Energy intensities of non-manufacturing sectors, 2010-2019, averages over limited number of EU Member States with available data

Source: Own calculations based on Eurostat SBS, national sources

Note: the energy intensity for the sector Mining of metal ores could not be estimated due to a lack of data.

6.6 Energy costs drivers

This section analyses the drivers of energy cost changes in the EU27 and selected G20 countries via a decomposition analysis (LMDI approach). Furthermore, the section discusses how energy costs shape industrial production costs and how domestic demand, exports and imports shape trends in industrial output.

Key takeaways:

- Total industrial energy purchases in EU27 dropped by 1% between 2015 and 2019. The main driver was the improvement in energy intensity (-17%) in the industries considered. While industrial output rose (12%) energy prices dropped (-1%). The total net effect of these changes on energy costs was a reduction of 1%. The residual (unexplained) component of energy cost evolution amounts to 4%.
- **Energy costs** vary across Member States and rise for various reasons, the most common being the rise in output. **The level of energy costs** improves for most energy-intensive sectors while non-energy intensive manufacturing sectors face higher energy costs in 2015-2019.
- **Energy intensity decreases in almost all countries** and is the main driver of overall energy cost reduction. Sectors facing rising energy prices are incentivized to increase the electrification of their final energy demand and to achieve greater energy efficiency.
- The energy intensity of the examined countries improves, but not to an extent that would counterbalance the effect of rising energy prices and related industrial output.
- The different impact of the price effect across industries is attributed to the (different) structure of the fuel mix, the changes in the fuel mix and/or the differentiated energy price policies implemented by each Member State for the different sectors. Moreover, the EU27 average energy price depends on how much each Member State contributes to total EU production.
- The residual effect is found to be linked with different trends in energy cost evolution in different sectors: the highest reduction of energy costs was found in a non-energy intensive sector (*Refractory products*); and the doubling of energy costs in an energy-intensive sector (Refineries).
- **Specifically in Greece, the residual effect plays a dominant role.** Greece faces the highest energy cost increase in the EU27, together with Ireland and Portugal. This is indicative of important data discrepancies and/or fuel switching in the specific countries.
- In selected G20 countries, namely Brazil, Canada, China, Russia, Turkey, the United Kingdom, and the United States an **increase in energy costs** is recorded due to changes in price and output, while energy intensity improves slightly.
- 76% of total purchase of energy products for the sectors accessed come from China, which also registered the highest increase in energy costs due to rising energy prices and industrial output growth.
- In the EU27, the contribution of energy costs to total production costs is very small; it is other costs that bring about this increase in energy costs. The only sector where energy costs have significant contribution to total production costs are *Refineries* through the important increase in energy costs in 2015-2019.

- In the EU27, Canada, Japan and the UK, output increases due to a surge in domestic demand while in the US output decreases due to higher imports.
- *Beverages, Pharmaceutical, Computer and electronic equipment* and *Other transport equipment* show the highest increase in total output while the largest decrease in output is recorded in the *Textiles* and in the *Refineries* sectors, driven by a drop in domestic demand (textiles) and in domestic and export demand (refineries).

6.6.1 Methodology

First, we show how changes in energy prices, production, and energy intensity affect energy costs in key industries during the period 2015-2019 in the EU27 and selected G20 countries. We use the Logarithmic Mean Divisia index (LMDI) method to decompose the industrial energy costs and determine the drivers of energy costs. The decomposition of the energy costs concerns:

1. **Output effect:** Shows how changes in production levels affect the purchases of energy products for a given industry.
2. **Energy intensity effect:** Shows how changes in energy consumed per unit of output affects the purchases of energy products for a given industry.
3. **Energy price effect:** Shows how changes in cost per unit of energy affect the purchases of energy products for a given industry.
4. **Residual effect:** Shows the gap between the estimated energy cost of the industry (from the three components above) and the purchases of energy products as per the EUROSTAT SBS database.

In algebraic formulation, these are expressed as:

$$Energy\ Cost_{i,c} = Output(c2015)_{i,c} * \frac{Total\ energy\ consumption_{i,c}}{Output(c2015)_{i,c}} * \ Energy\ Price_{i,c}$$

Or

$$Purchases\ of\ energy\ products_{i,c} = Output(c2015)_{i,c} * \frac{Total\ energy\ consumption_{i,c}}{Output(c2015)_{i,c}} * \ Energy\ Price_{i,c} * Residual_{i,c}$$

With

$$D\left(Purchases\ of\ energy\ products_{i,c}\right) = Output\ effect_{i,c} + Energy\ intensity\ effect_{i,c} + Energy\ price\ effect_{i,c} + Residual\ effect_{i,c}$$

In particular, for energy consumption by sector and energy carrier, various methods were used to fill the data gaps. Table 10 shows data availability before and after filling the gaps. We note that data for Malta was largely not available, especially with regards to the purchase of energy products; thus no assessment for the factors shaping the energy costs in Malta was conducted.

Table 17: Data availability before and after filling techniques

	#	Share
Total data points	810	100%
Data points with no gaps identified	76	9%
Data points assessed after filling techniques	631	78%

6.6.2 *Key assumptions*

The following section discusses the key assumptions taken for each of the four main components used in the decomposition analysis.

Output effect

We converted the industrial production into constant prices so as to proxy the physical output and remove price effects and in this way capture the output effect. To this end, we used the sectoral output deflators by Eurostat ([nama_10_a64]). When these were not available, we used the GDP deflator growth rate [nama_10_gdp]. For countries that EUROSTAT does not cover, the GDP deflator from the World Bank ({NY.GDP.DEFL. ZS}) was used. The sectoral output deflators from EUROSTAT were available in NACE 2-digit level. In NACE 3-digit, the corresponding deflator of the aggregate sector (NACE-2 digit) was used.

Energy intensity effect

To calculate energy intensity we divided total energy consumption (by industry) by its production in constant 2015 prices. When the energy intensity of a Member State (and for all years) was not available, we used the EU27 average energy intensity. We estimated the average EU27 intensity using the energy intensities of the EU27 countries for which data was available. For non-EU27 countries, we did not use any filling technique, except for the UK, where we used the same methodology as in the EU27. To fill in data that was missing for total energy consumption, we estimated energy intensities, where possible.

Table 18 Sectors and countries used for the calculation of the EU27 average energy intensity

Code	Description	Countries	Number of Member States
C106	*Grain products*	AT, BE, DE, DK, FR, IT, PT, SE	8
C132	Textiles	AT, BE, DE, FR, IT, PT, SE	7
C161	*Sawmills*	AT, BE, DE, DK, FR, IT, NL, PT, SE	9
C171	*Pulp and paper*	AT, BE, CZ, DE, DK, ES, FI, FR, IT, NL, PL, PT, SE, SK	14
C201	Basic chemicals	AT, BE, DE, DK, FR, IT, PT, SE	8
C206	Man-made fibres	AT, BE, DE, FR, IT, NL, PT, SE	8
C232	*Refractory products*	AT, DE, FR, IT, PT, SE	6
C233	*Clay building materials*	AT, BE, DE, DK, FR, IT, PT, SE	8
C234	*Porcelain and ceramics*	AT, DE, DK, FR, IT, NL, PT, SE	8
C235	*Cement, lime and plaster*	AT, BE, CY, DE, EL, ES, FR, HR, IT, PL, PT, SE	12
C237	*Stone*	AT, BE, DE, DK, FR, IT, NL, PT, SE	9
C241	*Iron and steel*	AT, BE, BG, CZ, DE, EL, ES, FI, FR, HU, IE, IT, PL, PT, RO, SE, SI	17
C244	*Non-ferrous metals*	AT, BE, BG, CZ, DE, DK, EE, EL, ES, FI, FR, HU, IE, IT, NL, PL, PT, RO, SE, SI, SK	21

Code	Description	Countries	Number of Member States
C192	*Refineries*	BE, EL, HU, PL, PT	5
C231	*Glass*	AT, BE, DE, DK, FR, HR, IT, PL, PT, SE	10
C103	*Fruit and vegetables*	AT, BE, DE, DK, FR, IT, PT, SE	8
C11	*Beverages*	AT, BE, DE, DK, FI, FR, IT, NL, PT, SE, SI	11
C172	*Articles of paper*	AT, BE, DE, DK, FR, IT, NL, PT, SE	9
C21	*Pharmaceutical products*	AT, DE, DK, FI, FR, IT, PT, SI	8
C222	*Plastics products*	AT, BE, DE, DK, FR, IT, NL, PT, SE	9
C239	*Abrasive products*	AT, BE, DE, DK, FR, IT, NL, PT, SE	9
C245	*Casting of metal*	AT, BE, DE, DK, FR, IT, NL, PT, SE	9
C25	*Fabricated metal products*	AT, BE, DE, DK, FI, FR, IT, NL, PT, SE, SI	11
C26	*Computer and electronics*	AT, BE, DE, DK, FI, FR, IT, NL, PT, SE, SI	11
C27	*Electrical equipment*	AT, BE, DE, DK, FI, FR, IT, NL, PT, SE, SI	11
C28	*Machinery and equipment*	AT, BE, BG, CY, DE, DK, EE, EL, ES, FI, FR, HR, HU, IE, IT, LT, NL, PL, PT, RO, SE, SI	22
C29	*Motor vehicles*	AT, BE, DE, DK, FI, FR, IT, NL, PT, SE, SI	11
C30	*Other transport equipment*	AT, BE, DE, DK, FI, FR, IT, NL, PT, SE	10
C32	*Other manufacturing*	AT, BE, DE, DK, FI, FR, IT, PT, SE, SI	10
C33	*Repair of machinery*	AT, BE, DE, DK, FI, FR, IT, PT, SE, SI	10

Energy price effect

The average energy price for each sector within a given country was estimated based on the fuel mix and the price of fuels. For the latter we considered coal, light sulphur fuel oil, gas, and electricity. For missing data on fuel mix shares, we used data from the previous or following year. When data was missing between years, we carried out a linear extrapolation of the fuel mix evolution. In case the fuel mix of a sector was missing in all years, we used the EU27 fuel mix of the corresponding sector. In the analysis, we used energy carrier prices including taxes and levies. For missing data points, the EU27 growth rate of the respective sectors was used. For the non-EU countries where prices including taxes and levies were not available, prices excluding taxes and levies were used.

Residual effect

The methodology for filling the data gaps uses a number of assumptions, which creates inconsistencies between the estimated and the actual energy costs. The data that serves as point of comparison against the estimated energy costs is EUROSTAT SBS data “purchases of energy products” ([sbs_na_ind_r2]). The residual effect is estimated as the difference between the estimated energy costs and the SBS data.

In more detail, the residual effect captures:

1. Inconsistencies between the SBS database and other databases used for the estimation of energy costs. (If no data was missing, this will be the only effect in the residual component);
2. Missing data, which leads to filling gap techniques, most notably the use of the EU27 averages;
3. Consideration of limited energy carriers for the energy price calculation, which also limits the ability to fully capture the fuel switching effect (e.g., towards bioenergy or other renewables).

6.6.3 Results

The following section first presents the result of the decomposition analysis of identified sectors at the EU27 and Member State level and the sector level. Analysis on G20 countries have also been carried out, but due to limited data availability, only few sectors have been included in the aggregate total industry sector. This is followed by the analysis on each of the four main components used in the decomposition analysis, in order to understand their impact on energy costs within EU27.

Thereafter, the impact of energy costs on total production cost of the industries within EU27 is also presented.

Decomposition analysis of identified sectors

EU27 and Member State results

Figure 17 shows how the output, price, energy intensity and residual effect have changed the energy costs in a total of selected manufacturing sectors in the EU27 between 2015 and 2019. The total EU industrial energy purchases was reduced by 1% in 2019 from 2015 levels, despite the rise in industrial production. The energy efficiency effect is the key driver of energy cost reduction, while prices contribute only marginally. The residual effect, namely the unexplained drivers, plays an important, although not dominant role.

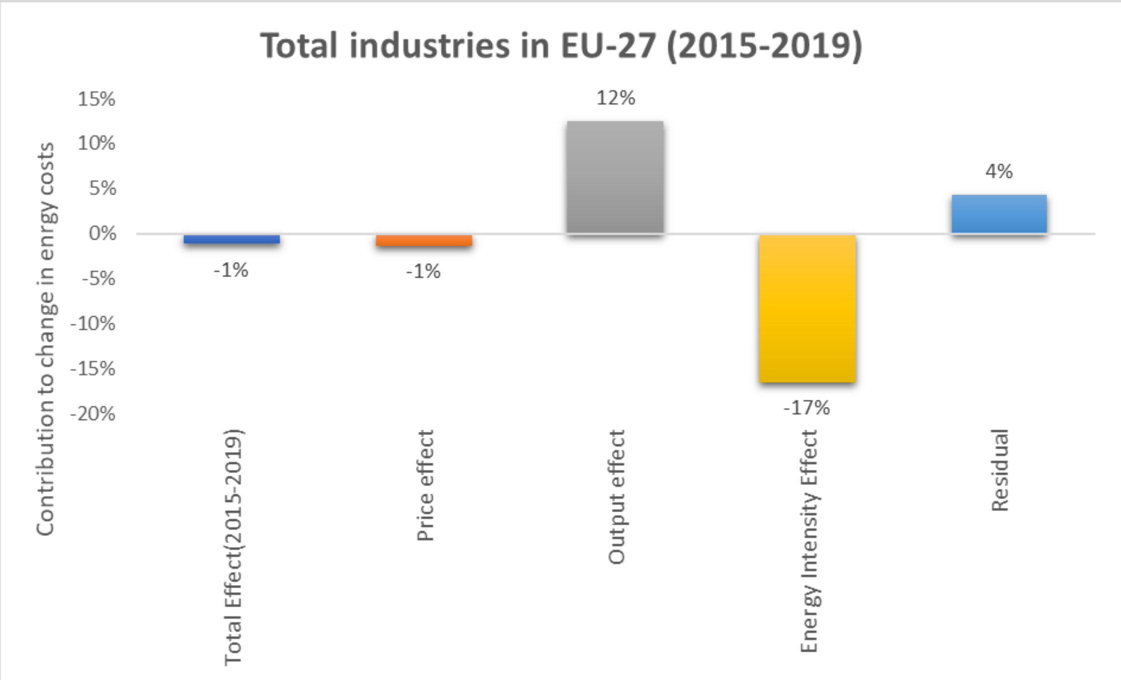


Figure 175: Decomposition of the Total industry (sum of selected manufacturing sectors) energy costs in EU27 between 2015-2019

Table 12 presents the decomposition analysis in the aggregate industrial sector for each Member State. There is strong divergence in the **energy cost evolution** across Member States: energy costs decreased in several countries such as Croatia, Denmark, Italy and Luxemburg, while increased in others, like Greece, Cyprus, Romania and Lithuania. **Energy intensity decreases across countries** and is the main driver of overall energy cost reduction in most EU27 countries. Exceptions are Finland and Italy, where the key driver of energy cost reduction are falling energy prices, as well as Croatia, Luxemburg and Slovakia, where the key driver is the residual effect.

Energy costs are rising for various reasons in the different EU27 Member States. The most common reason is the output effect, which has increased between 2015-2019 for the sectors examined. In Bulgaria, the price effect is the key driver, while in Cyprus and Slovenia the price and output effect are equally important.

In Greece, the residual effect plays a dominant role. Greece faces the highest energy cost increase in the EU27, together with Ireland and Portugal, which is not explained by neither the price nor the output or energy efficiency effects. This is indicative of important data discrepancies and/or fuel switching in the specific countries.

Table 19: Decomposition of the energy costs for Total industries (those available) by EU27 MS

	Price effect	Output effect	Energy intensity effect	Residual effect	Total effect (2015-2019)
EU27	-1%	12%	-17%	4%	-1%
AT	-2%	14%	-4%	-5%	3%
BE	-4%	7%	-18%	2%	-13%
BG	18%	11%	-14%	-12%	4%
CY	52%	53%	-23%	-43%	40%
CZ	9%	19%	-10%	-11%	7%
DE	4%	10%	-23%	8%	-1%
DK	-12%	11%	-14%	-6%	-21%
EE	9%	13%	-10%	-5%	7%
EL	25%	20%	-28%	69%	87%
ES	0%	14%	-12%	3%	4%
FI	-20%	3%	1%	3%	-13%
FR	1%	18%	-21%	-17%	-18%
HR	3%	10%	-5%	-34%	-26%
HU	9%	11%	-20%	-1%	-2%
IE	-13%	14%	-23%	36%	14%
IT	-21%	11%	-14%	6%	-19%
LT	4%	22%	-20%	18%	23%
LU	28%	8%	-14%	-40%	-18%
LV	-1%	25%	-13%	6%	18%
NL	8%	6%	-4%	-10%	0%
PL	17%	19%	-6%	-13%	17%
PT	-24%	16%	-17%	26%	1%
RO	20%	23%	-15%	7%	35%
SE	4%	13%	-12%	-5%	0%
SI	20%	19%	-11%	-18%	10%
SK	5%	13%	-3%	-23%	-8%

Sector level results

Table 13 presents the decomposition analysis for the assessed industrial sectors in the order of sectoral energy intensity. From the table, it is observed that:

- The **top five energy intensity sectors register a reduction in energy costs**, i.e. in *Manufacture of cement*, *Pulp and paper*, *Iron and steel*, *Plastics* and *Clay building materials sectors*. This is driven by **the price effect** (*Metals, Cement*) and **energy efficiency improvements** (*Manufacture of Basic chemicals, Fertilizers, Plastics* sector). In non-energy intensive sectors, while energy intensity improves for most of them, the price and output effects push energy costs up.
- The different impact of the price effect across industries is attributed to the structure of the fuel mix, the changes in the fuel mix and/or the differentiated energy price policies by sector implemented by each Member State, especially since the analysis considers the energy prices after taxes and subsidies.
- **Changes in the fuel mix affect the energy costs**: the *Stone* sector mainly uses electricity whose price increases over the 2015-2019 period, while the *Glass and glass products* sector primarily consumes natural gas whose price falls. The share of coal increased in the fuel mix of the *Basic iron and steel* sector, which brings down the average energy price, since coal was cheaper than gas, electricity, and light fuel oil during this period.
- Overall, the **level of energy costs improves for most energy-intensive sectors** while **non-energy intensive manufacturing sectors face higher energy costs** in the 2015-2019 period.
- The residual effect is found to be linked to different trends in energy cost evolution for different sectors.
    - The *Manufacturing of refractory products*, a non-energy intensive sector, faces the highest reduction in energy costs, attributed to the (unexplained) residual effect. This is attributed mainly to the results of Austria and Germany, the two countries with the largest sectoral share in the EU27.
    - Energy costs double in *Refined petroleum products*, an energy-intensive sector. Likewise, this cannot be attributed to price, output or energy efficiency effects. Rather, it is the residual effect that is driving this surge in energy costs, with a large number of missing data (for example the EU27 average is only assessed with data for AT, PT, EL, EE) or data inconsistencies.
    - At the Member State level, the highest residual for this sector is recorded in Greece, which produces 48% of the Refinery products among the four producing Member States where data was available. This high residual is the outcome of the filling gap technique we applied, where we: i) kept the 2015 fuel mix stable to 2019 and ii) assumed that the energy intensity of the sector grows in line with the average EU27 energy intensity.

Table 20: Decomposition analysis in energy costs in EU27 by sector (2015-2019)

NACE Code	NACE Label	Price effect	Output effect	Energy intensity effect	Residual effect	Total effect (2015-2019)	Energy Intensity (toe/ mn.€)
C235	Manufacture of cement, lime and plaster	-7%	1%	-6%	4%	-8%	591.5
C171	Manufacture of pulp, paper and paperboard	-16%	-5%	6%	-4%	-19%	528.3
C241	Manufacture of basic iron and steel and of ferro-alloys	-29%	5%	-12%	35%	0%	311.0
C201	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	5%	6%	-18%	-5%	-12%	161.0
C233	Manufacture of clay building materials	-15%	15%	-6%	2%	-4%	153.7
C231	Manufacture of glass and glass products	-8%	21%	-11%	-7%	-5%	121.1

NACE Code	NACE Label	Price effect	Output effect	Energy intensity effect	Residual effect	Total effect (2015-2019)	Energy Intensity (toe/ mn.€)
C206	Manufacture of man-made fibres	-6%	-9%	-1%	6%	-9%	107.2
C192	Manufacture of refined petroleum products	24%	19%	-19%	177%	200%	106.4
C244	Manufacture of basic precious and other non-ferrous metals	-34%	5%	0%	30%	1%	78.5
C239	Manufacture of abrasive products and non-metallic mineral products n.e.c.	0%	-3%	-8%	1%	-9%	69.1
C232	Manufacture of refractory products	0%	-9%	4%	-19%	-24%	66.1
C245	*Casting of metals*	6%	-5%	1%	-13%	-11%	58.8
C234	Manufacture of other porcelain and ceramic products	9%	-2%	5%	-8%	4%	56.6
C161	Sawmilling and planing of wood	23%	6%	-1%	-23%	4%	54.4
C106	Manufacture of grain mill products, starches and starch products	2%	5%	-13%	-4%	-11%	47.3
C172	Manufacture of articles of paper and paperboard	0%	12%	4%	6%	22%	31.6
C103	Processing and preserving of *Fruit and vegetables*	48%	9%	-9%	-46%	2%	31.3
C222	Manufacture of plastics products	19%	12%	-7%	-19%	4%	18.3
C132	Weaving of textiles	6%	-2%	-5%	-7%	-7%	18.2
C28	Manufacture of machinery and equipment n.e.c.	3%	15%	-30%	15%	3%	15.9
C11	Manufacture of *Beverages*	11%	13%	-4%	-12%	9%	13.9
C237	Cutting, shaping and finishing of stone	57%	10%	3%	-59%	11%	12.4
C25	Manufacture of fabricated metal products, except machinery and equipment	30%	11%	-13%	-24%	4%	11.0
C29	Manufacture of motor vehicles, trailers and semi-trailers	4%	13%	12%	-30%	0%	8.1
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	30%	25%	-62%	10%	3%	5.6
C27	Manufacture of electrical equipment	26%	10%	-27%	-7%	2%	5.5
C32	*Other manufacturing*	29%	16%	-17%	-27%	1%	5.4
C26	Manufacture of computer, electronic and optical products	32%	11%	-30%	-9%	4%	4.1
C30	Manufacture of other transport equipment	11%	38%	-23%	-33%	-6%	4.0
C33	Repair and installation of machinery and equipment	47%	4%	-21%	-27%	3%	3.3
T	**Total**	**-1%**	**12%**	**-17%**	**4%**	**-1%**	**42.4**

Energy intensity effect

The energy intensity effect shows the effect of changes in energy consumed per unit of output into changes in purchases of energy products for a given industry.

Energy intensity improves in all sectors except the following sectors: *Manufacture of pulp and paper*, *Refractory*, and *Ceramic products*, *Casting of metals* and *Manufacture of motor vehicles*. **Energy intensity improvements are most notable for sectors that face higher energy price increases in the 2015-2019 period.** These are indeed the sectors that achieve a higher electrification of their final energy demand, thus moving to more efficient uses of energy. The results shown in Figure 18 are calculated using the change in energy intensity weighted with 2015 production for both for the years 2015 and 2019 (no weights option) and the change in energy intensity weighted with actual production of the respective years (with weight option). Changes in the location of production within the EU27 have only a marginal impact on the energy intensity effect by sector.

Figure 176: The change in energy intensity for EU27 with and without weight options against actual production

Energy price effect

The **energy price effect s**hows the effect of changes in cost per unit of energy into changes in purchases of energy products for a given industry. The average energy price effect depends on the change in the fuel mix and the fuel prices in each sector. Fuel prices incorporate differentiated taxes, subsidies and levies. **In 2015-2019, the price of coal increased but remained significantly lower than the rest of the energy carriers assessed.** In the same period, the price of gas decreased while that of fuel oil increased. The price of electricity evolves differently across sectors in the Member States. In addition, sectoral prices differ because some sectors face higher electricity prices while others lower electricity prices **due to dedicated policies for taxes and levies** (electricity prices are after taxes and levies).

On a sectoral level, the **price effect is positive for non-energy intensive manufacturing industries and negative for energy intensive ones**. The upward trend in the energy costs facing energy intensive sectors is not only the outcome of change in energy carrier prices, but also in the fuel mix. **Electrification of final energy demand is growing with the share of natural gas declining.** This fuel shift is significant in the sectors that register the highest price effect (i.e., *Processing of fruits and vegetables*, *Repair and installation of machinery*). Sectors that experience a decreasing price effect are consuming less electricity, as for example the *Manufacture of basic precious and other non-ferrous metals*. However, the main driver in this specific sector is the decline in electricity prices in the 2015-2019 period, which is close to -7% for the average EU27.

Finally, the EU27 average energy price depends on how much each Member State contributes to total EU production. To capture this, we calculated the average energy price changes weighted with 2015 production both for the years 2015 and 2019 (no weights option) and the average energy price growth weighted with the actual production of the respective years (with weight option). Figure 19 shows that, in fact, changes in the contribution of each Member State to the total EU production levels have little impact on the average energy prices.

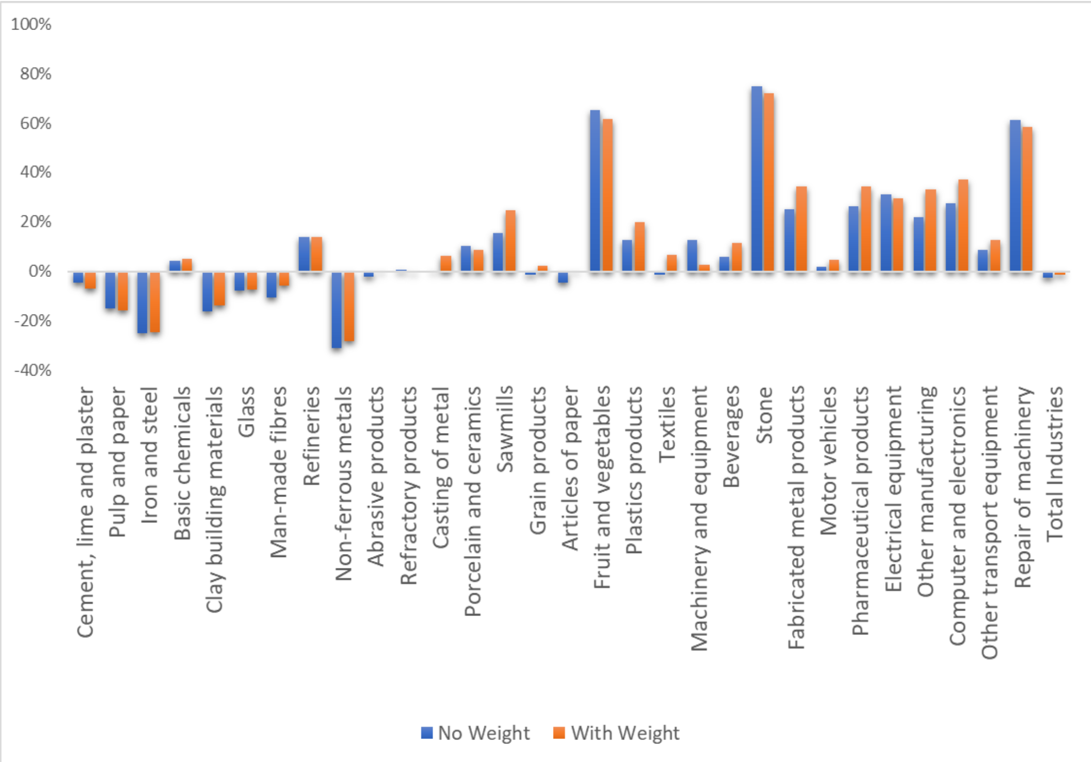


Figure 177: The change in energy price for EU27 with and without weight options against actual production

Residual effect

The **residual effect** captures the difference between the estimated energy costs and the data collected from EUROSTAT SBS database. To better understand the residual term, we undertook an econometric estimation with panel data across sectors and Member States to determine the level of contribution of each component/coefficient to the estimated residual.

Equation:

$$\begin{aligned}&\boldsymbol{Purchase\ of\ energy\ products}\\&\quad = \boldsymbol{C_0} + \boldsymbol{C_1} * \boldsymbol{Energy\ Intensity} + \boldsymbol{C_2} * \boldsymbol{Energy\ Price} + \boldsymbol{C_3} * \boldsymbol{Production} + \boldsymbol{Residual}\end{aligned}$$

The coefficients of the analysis can be interpreted as follows:

- $\boldsymbol{C_1}$: the % change of the purchase of the energy products driven from 1% change in energy intensity (ceteris paribus)
- $\boldsymbol{C_2}$: the % change of the purchase of the energy products driven from 1% change in energy price (ceteris paribus)

- C_3: the % change of the purchase of the energy products driven from 1% change in production (ceteris paribus)

All variables are expressed in natural logarithms.

Based on the difference between the estimated energy costs and the purchase of energy products we expect that the coefficients of the regression will be <1. Full consistency between the estimated energy costs and the purchase of energy products from SBS would mean that all coefficients = 1.

Overall, the estimated coefficient of the regression shows that 54% of the energy intensity, 34% of the energy price, and 77% of the production are depicted in the purchase of energy products from SBS statistics (Table 14). For example, a 100% increase in the energy intensity (ceteris paribus) leads to a 54% increase in the purchase of energy products, so there is a 46% that remains unexplained. As expected, the production is the coefficient with the highest value – there was little need to apply filling techniques - followed by energy intensity and energy price. Energy price accounts for the largest deviation between the estimated energy costs and the purchase of energy products.

Table 21: Results of the regression analysis with panel data across sectors and EU member states

	Estimated Coefficient	95% statistically significant Interval
Energy Intensity	0.54	(0.51, 0.57)
Energy price	0.34	(0.28, 0.39)
Production	0.77	(0.73, 0.80)

G20 countries results

Out of the G20 countries, the analysis focuses on Brazil, Canada, China, Russia, Turkey, the United Kingdom, and the United States. Only few sectors were included in the total industry sector, given the limited data availability. No filling techniques were used for the G20 country analysis, thus only sectors and countries with complete datasets were considered. To this end, only one sector was assessed for Brazil, Turkey and the United States, and two sectors for Russia.

Overall, an **increase in energy costs** is recorded, driven by the price and output effects. The energy intensity of the examined countries improves, but not to an extent that would counterbalance the effect of rising energy prices and related industrial output.

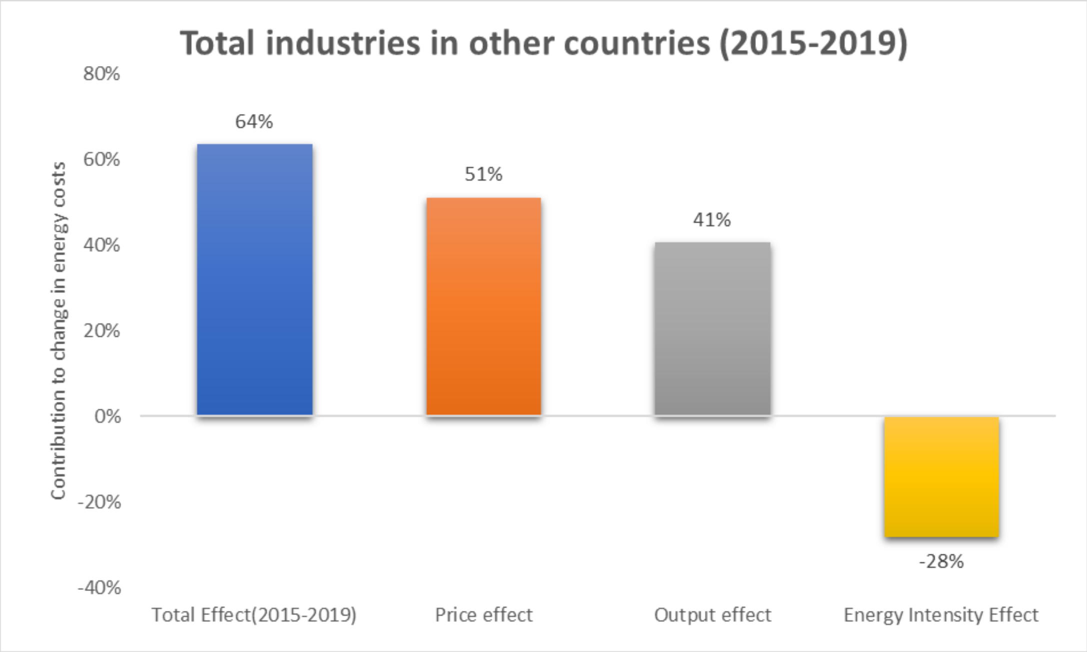


Figure 178: Decomposition analysis of energy costs for G20 countries

As shown in Table 15, trends in China are shaping the results given the country's large contribution to the total assessed energy costs (China comprises 76% of total purchase of energy products for the sectors accessed). Moreover, **China registered the highest increase in energy costs between 2015-2019**, owing to rising energy prices and industrial output growth.

Similarly, in the UK, output increase drives higher energy costs up. In the US, increasing energy intensity result in rising energy costs. Nevertheless, we note that due to the very limited data availability, results for the US (and Brazil) refer only to the *Manufacture of non-metallic minerals* and *Abrasive products*. Finally, **almost all assessed countries register an increase in output except Brazil and Russia** (limited data availability).

Table 22: Decomposition analysis for G20 countries (for those with available data)

Country	Price effect	Output effect	Energy intensity effect	Total effect (2015-2019)
Brazil	-18%	-20%	9%	-29%
Canada	-10%	12%	-4%	-3%
China	55%	43%	-36%	61%
Russia	10%	-6%	-10%	-6%
Turkey	-11%	23%	-33%	-22%
United Kingdom	6%	17%	-13%	10%
United States	-4%	4%	8%	8%

At sector level, all the Chinese industries assessed register an increase in energy purchases due to higher output and prices; in some cases, e.g., in the *Manufacture of electrical equipment* sector, energy costs doubled. In Canada, most assessed sectors register lower energy purchases, except *Plastics* and

Pharmaceuticals, which register important increases due the energy intensity effect and the energy price effect respectively.

In the UK, a few sectors record lower energy costs, due to energy intensity improvements, while the majority faces increased energy costs due to an increase in output coupled in some cases with higher energy prices.

Table 23: Decomposition analysis for G20 countries by sector

Country	NACE code	Price effect	Output effect	Energy intensity effect	Total effect (2015-2019)
Brazil	C239	-18%	-20%	9%	-29%
Canada	C192	-20%	20%	-16%	-15%
	C11	-42%	9%	-10%	-43%
	C21	27%	13%	-6%	34%
	C222	53%	-2%	141%	192%
	C239	-14%	14%	-27%	-26%
	C25	-29%	6%	-4%	-28%
	C26	7%	-4%	-22%	-19%
	C27	-17%	-4%	-4%	-25%
	C28	-30%	13%	-25%	-43%
	C30	-12%	13%	-19%	-17%
	T	-10%	12%	-4%	-3%
China	C206	7%	44%	-16%	35%
	C11	74%	38%	-55%	57%
	C21	66%	56%	-60%	62%
	C239	43%	32%	-48%	27%
	C25	40%	36%	12%	89%
	C26	8%	42%	20%	69%
	C27	93%	55%	-41%	106%
	C28	36%	43%	-15%	64%
	C29	51%	44%	-26%	70%
	T	55%	43%	-36%	61%
Russia	C239	10%	4%	-20%	-5%
	C28	13%	-18%	-1%	-6%
	T	10%	-6%	-10%	-6%
Turkey	C28	-11%	23%	-33%	-22%
United Kingdom	C231	-12%	45%	-7%	26%
	C11	6%	11%	-5%	13%
	C21	-3%	18%	-51%	-36%
	C25	0%	16%	-12%	5%
	C26	15%	26%	-25%	16%
	C27	10%	8%	-34%	-15%
	C28	-9%	8%	-24%	-24%
	C29	18%	10%	7%	35%
	C30	33%	31%	-21%	43%

Country	NACE code	Price effect	Output effect	Energy intensity effect	Total effect (2015-2019)
	C32	20%	16%	-21%	15%
	T	6%	17%	-13%	10%
United States	C239	-4%	4%	8%	8%

6.6.4 Impact of energy costs on total production costs

This section presents the decomposition analysis for:

1. Total production costs of the EU27 industries, split in energy costs and other costs (labour and capital costs and purchases of intermediate products except energy);
2. Output using three main components of domestic demand, exports and/or imports.

Decomposition analysis of total production costs

Methodology

This section focuses on the decomposition analysis of the production costs driven by energy costs and other costs such as purchase of products (except energy), capital and labour costs.

$$Total\ production\ costs = energy\ costs + other\ costs =>$$
$$\Delta(total\ production\ costs) = \Delta(energy\ costs) + \Delta(other\ costs)$$

We used the EUROSTAT SBS to collect “Total purchases of products”, “purchases of energy products”, “personnel costs” and “gross operation surplus” data. Other costs comprise the “personnel costs”, “gross operation surplus” and “Total purchases of products” minus the “purchases of energy products”, while “purchases of energy products” data is used to represent energy costs. Total production costs are the summation of energy costs and other costs. The sector level that has been used for the analysis are presented in Table 17.

Table 24: Sector level of the production cost decomposition analysis in EU-27 (sorted by energy intensity)

NACE code	Description:	Energy intensity (toe/M€)
C17	*Pulp and Paper products*	242
C24	*Basic metals*	199
C20	*Chemical*	192
C23	*Non-metallic minerals*	175
C19	*Refineries*	118
C16	*Wood products*	55
C10	*Food products*	42
C22	*Rubber and plastic products*	21
C13	*Textiles*	20
C28	*Machinery and equipment n.e.c.*	19
C11	*Beverages*	14
C25	*Fabricated metal products*	12
C29	*Motor vehicles*	10
C21	*Pharmaceutical*	7
C27	*Electrical equipment*	7

NACE code	Description:	Energy intensity (toe/M€)
C32	*Other manufacturing*	6
C26	Computer, electronic and optical equipment	6
C30	*Other transport equipment*	5
C33	Repair and installation of machinery and equipment	4
T	Total Industries	42

Results

The total industries results in Figure 21 shows that **the contribution of energy costs to total production costs is very small and the increase is driven from other costs.**

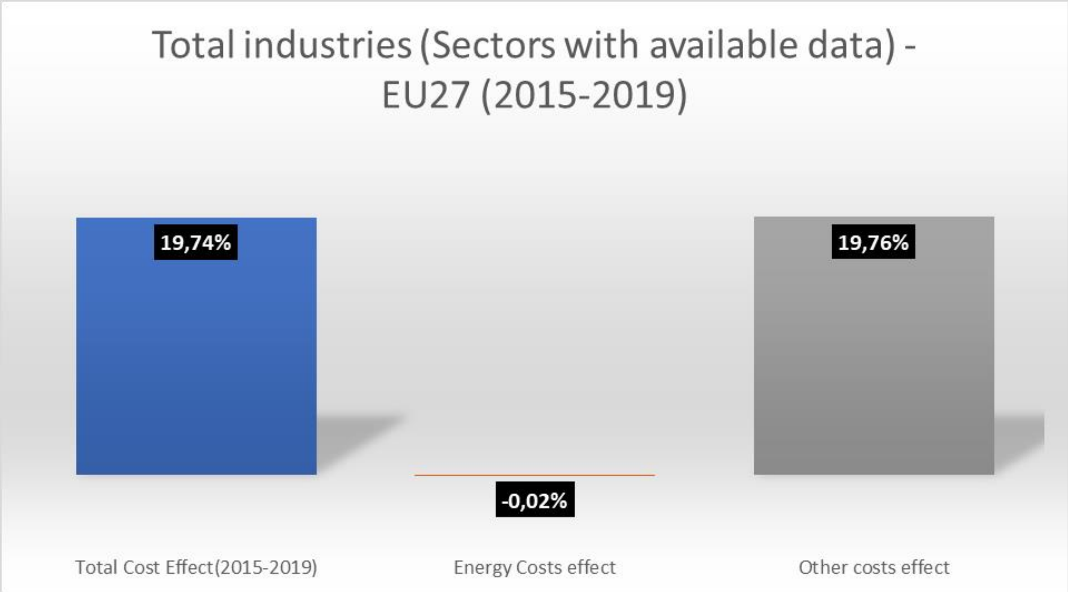


Figure 179: Decomposition of total production costs for total industries in EU-27

Figure 22 and Figure 23 show the share of energy costs in total production costs by industry. Figure 22 shows the shares for the more disaggregated sectors analysed earlier in this section, whereas Figure 23 shows the results in a more aggregated form for the sectors listed in Table 17. The analysis shows that:

- All sectors (except *Refineries*) show a decline in the contribution of energy costs to total production costs in the 2015 to 2019 period.
- The decline in the share of 2019 compared to 2015 is associated primarily with energy intensity improvements and secondly with the decline in energy prices. The *Refineries* sector is an exception due to the doubling of energy costs in the 2015-2019 period.
- It is noteworthy that in energy intensive sectors the decline in the energy cost share is stronger than in non-energy intensive sectors.
- Among energy-intensive sectors, the *Cement, lime, and plaster* sector faces the highest energy costs.

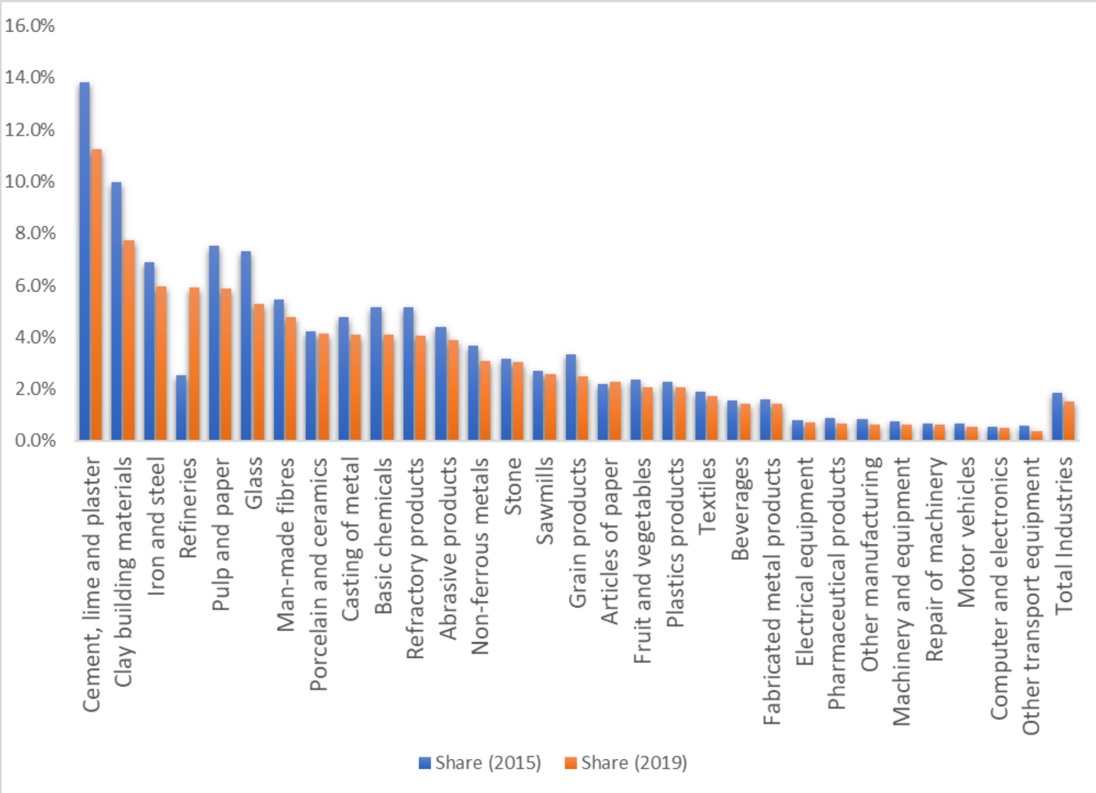


Figure 180: Share of energy costs in total production costs in EU27 by the analysed NACE 2- and 3-digit sector (sorted by share 2019)

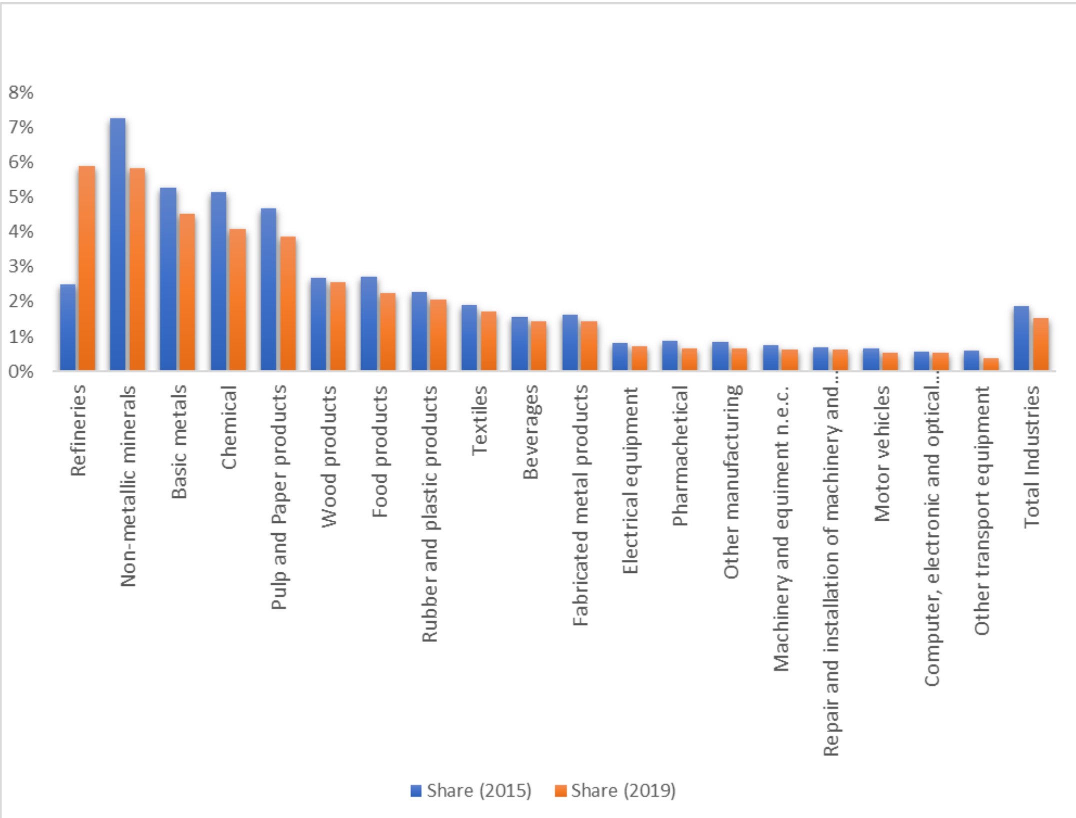


Figure 181: Share of energy costs in total production costs in EU27 by NACE 2-digit sectors (sorted by share 2019)

Table 18 presents the results from decomposition analysis of total production costs in EU27 by sector. For all sectors, the other cost effects dominate the energy costs effect. The only sector that energy costs have significant contribution to total production costs are *Refineries* through the significant increase in energy costs in the 2015-2019 period.

Table 25: Results of the decomposition analysis in total production costs in EU-27 by sector

NACE Code	Description	Total effect	Energy cost effect	Other cost effect
C10	*Food products*	16.9%	-0.11%	17.0%
C11	*Beverages*	19.1%	0.14%	19.0%
C13	*Textiles*	1.9%	-0.14%	2.1%
C16	*Wood products*	9.8%	0.11%	9.7%
C17	*Paper products*	10.7%	-0.40%	11.1%
C19	*Refineries*	27.9%	5.02%	22.8%
C20	*Chemical*	11.4%	-0.59%	12.0%
C21	*Pharmaceutical*	35.8%	0.03%	35.8%
C22	*Rubber and plastic products*	15.1%	0.09%	15.0%
C23	*Non-metallic minerals*	17.6%	-0.40%	18.0%
C24	*Basic metals*	15.6%	-0.06%	15.7%
C25	*Fabricated metal products*	18.3%	0.07%	18.3%
C26	*Computer, electronic and optical equipment*	10.5%	0.02%	10.5%
C27	*Electrical equipment*	18.3%	0.02%	18.3%
C28	*Machinery and equipment n.e.c.*	22.8%	0.02%	22.8%
C29	*Motor vehicles*	19.6%	0.00%	19.6%
C30	*Other transport equipment*	54.8%	-0.04%	54.8%
C32	*Other manufacturing*	30.2%	0.01%	30.2%
C33	*Repair and installation of machinery and equipment*	12.6%	0.02%	12.6%

Decomposition analysis of the output effect

The **output effect** shows the effect of changes in production levels into changes in purchases of energy products for a given industry. We also perform a decomposition analysis for the output effect that drives energy costs and identify whether the increase of output is associated with changes in domestic demand, exports and/or imports by sector.

Methodology

The calculation of domestic demand:

$$Domestic\ demand = output + imports - exports$$

Type for the decomposition analysis:

$$Output = domestic\ demand + exports - imports =>$$
$$\Delta(output) = \Delta(domestic\ demand) + \Delta(exports) - \Delta(imports)$$

The data collected was processed as follows:

1. We converted data from national current prices to € using the exchange rates from the OECD database
2. We used sectoral level deflators (as in the previous section) to deflate prices into constant prices 2015
3. We calculated EU 27 output data based on the data that was available per sector and country, removing any intra EU-trade (for countries where data was available[193]).

Results

Figure 24 presents the results of the decomposition analysis regarding the source of changes in output for the aggregate sectors shown in Table 18. **The EU27, Canada, Japan and the UK register an output increase that is driven by domestic demand while the US registers an output decrease driven by higher imports.**

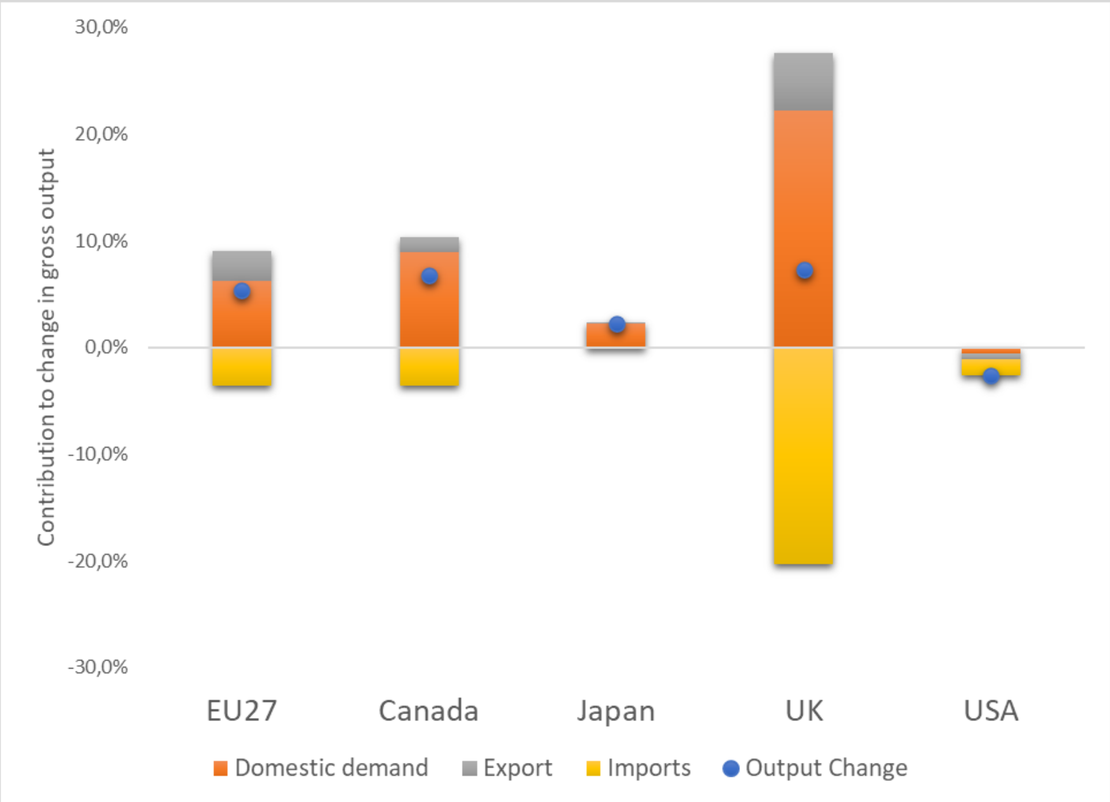


Figure 182: Decomposition analysis of output changes

EU27

Beverages, *Pharmaceutical*, *Computer and electronic equipment* and *Other transport equipment* sectors show the highest increase in total output, according to the available data. Domestic and export demand are driving this increase. The export effect is remarkable in the pharmaceuticals sector. On the contrary, the largest decrease in output is recorded in the *Textiles* and in the *Refineries* sectors, driven by a drop in domestic demand (textiles) and in domestic and export demand (refineries).

193 Austria, Belgium, Czech Republic, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Netherlands, Poland, Portugal, Sweden, Slovenia, Slovak Republic, Canada, Japan, United Kingdom, United States

Table 26: Decomposition analysis results in EU27 for output

NACECode	Description	Domestic Demand Effect	Export Effect	Import effect	Total Output effect (2015-2019)
C10	Food products	-1%	1%	0%	1%
C11	*Beverages*	12%	4%	0%	16%
C13	Textiles	-4%	0%	-1%	-5%
C16	Wood products	-1%	1%	-1%	-1%
C17	Paper products	1%	0%	0%	1%
C19	*Refineries*	-1%	-1%	-1%	-3%
C20	Chemical	-3%	5%	-2%	0%
C21	Pharmaceutical	6%	26%	-14%	18%
C22	Rubber and plastic products	6%	2%	-2%	6%
C23	Non-metallic minerals	7%	0%	-1%	6%
C24	Basic metals	3%	2%	-2%	3%
C25	*Fabricated metal products*	7%	0%	-1%	6%
C26	Computer, electronic and optical equipment	20%	10%	-17%	13%
C27	*Electrical equipment*	4%	4%	-7%	1%
C28	*Machinery and equipment* n.e.c.	9%	2%	-3%	7%
C29	*Motor vehicles*	14%	-1%	-4%	9%
C30	*Other transport equipment*	12%	11%	-8%	15%
C31_32	Furniture and other manufacturing	8%	2%	-5%	5%

G20

In Canada, most sectors assessed show an increase in output. The highest increase is registered in the *Refineries*, *Non-metallic minerals* and *Computer equipment* sectors and is driven primarily by the domestic effect. In Japan, sectors related with the production of motor vehicles (one of the largest contributing sectors in total industrial output), such as *Fabricated metal products*, Machinery equipment and *Motor vehicles*, register output increases that are driven by domestic demand.

The largest drop in output, seen in the *Computer, electronic and optical equipment* and *Textiles* sectors, is caused by changes in domestic demand. Similarly, in the UK changes in sectorial output occur mostly due to changes in domestic demand, with the exception of *Basic metals* and *Electrical equipment*. There, despite higher domestic demand, total output decreases.

In the US, the largest reductions are recorded in the *Beverages*, *Textiles* and Chemicals sectors, driven primarily by domestic demand.

Table 27: Decomposition analysis results in G20 for output

Country	NACE Code	Description	Domestic Demand Effect	Export Effect	Import effect	Total Output effect (2015-2019)
Canada	C10	*Food products*	6%	5%	-1%	11%
	C11	*Beverages*	5%	2%	-1%	6%
	C16	*Wood products*	8%	-1%	1%	7%
	C17	*Paper products*	6%	-5%	0%	1%
	C19	*Refineries*	15%	4%	-4%	15%
	C20	*Chemical*	7%	-5%	-4%	-1%
	C21	*Pharmaceutical*	21%	5%	-23%	3%
	C22	*Rubber and plastic products*	6%	2%	-4%	4%
	C23	*Non-metallic minerals*	11%	2%	2%	15%
	C24	*Basic metals*	0%	1%	2%	3%
	C25	*Fabricated metal products*	7%	3%	0%	11%
	C26	*Computer, electronic and optical equipment*	22%	1%	-10%	12%
	C27	*Electrical equipment*	17%	6%	-14%	9%
	C28	*Machinery and equipment n.e.c.*	9%	8%	-6%	10%
	C29	*Motor vehicles*	11%	-4%	-7%	0%
	C30	*Other transport equipment*	16%	4%	-9%	11%
	C31_32	*Furniture and other manufacturing*	12%	0%	-4%	8%
Japan	C10	*Food products*	3%	0%	0%	3%
	C11	*Beverages*	-3%	1%	0%	-2%
	C13	*Textiles*	-9%	-1%	2%	-8%
	C16	*Wood products*	1%	0%	2%	3%
	C17	*Paper products*	3%	0%	1%	3%
	C19	*Refineries*	0%	1%	3%	4%
	C20	*Chemical*	-2%	3%	-1%	0%
	C21	*Pharmaceutical*	-2%	3%	-1%	-1%
	C22	*Rubber and plastic products*	5%	-1%	0%	4%
	C23	*Non-metallic minerals*	0%	0%	1%	0%
	C24	*Basic metals*	4%	-2%	0%	2%
	C25	*Fabricated metal products*	11%	-1%	0%	11%
	C26	*Computer, electronic and optical equipment*	-8%	-2%	0%	-9%
	C27	*Electrical equipment*	6%	0%	-1%	5%
	C28	*Machinery and equipment n.e.c.*	6%	2%	0%	7%
	C29	*Motor vehicles*	4%	0%	0%	3%
	C30	*Other transport equipment*	0%	0%	-4%	-4%
UK	C10	*Food products*	6%	3%	-5%	4%
	C13	*Textiles*	16%	1%	-6%	12%
	C16	*Wood products*	22%	1%	-11%	12%

Country	NACE Code	Description	Domestic Demand Effect	Export Effect	Import effect	Total Output effect (2015-2019)
	C17	*Paper products*	4%	2%	-2%	5%
	C19	*Refineries*	21%	5%	-9%	17%
	C20	*Chemical*	12%	6%	-15%	3%
	C21	*Pharmaceutical*	31%	-10%	5%	26%
	C22	*Rubber and plastic products*	11%	5%	-11%	5%
	C23	*Non-metallic minerals*	5%	2%	-4%	3%
	C24	*Basic metals*	326%	-48%	-287%	-9%
	C25	*Fabricated metal products*	14%	1%	-9%	6%
	C26	*Computer, electronic and optical equipment*	34%	21%	-39%	16%
	C27	*Electrical equipment*	13%	9%	-26%	-3%
	C28	*Machinery and equipment n.e.c.*	8%	13%	-14%	7%
	C29	*Motor vehicles*	14%	9%	-9%	14%
	C30	*Other transport equipment*	-11%	25%	-10%	4%
	C31_32	*Furniture and other manufacturing*	6%	14%	-18%	2%
US	C10	*Food products*	-3%	0%	-1%	-4%
	C11	*Beverages*	-7%	-1%	-3%	-11%
	C13	*Textiles*	-9%	-3%	0%	-12%
	C16	*Wood products*	3%	-1%	0%	2%
	C17	*Paper products*	-4%	-1%	0%	-5%
	C19	*Refineries*	7%	4%	-1%	9%
	C20	*Chemical*	-11%	0%	1%	-10%
	C21	*Pharmaceutical*	11%	1%	-13%	-2%
	C22	*Rubber and plastic products*	1%	-1%	-3%	-2%
	C23	*Non-metallic minerals*	4%	-1%	-1%	3%
	C24	*Basic metals*	-2%	-2%	2%	-2%
	C25	*Fabricated metal products*	1%	0%	-1%	0%
	C26	*Computer, electronic and optical equipment*	-2%	-2%	3%	-2%
	C27	*Electrical equipment*	8%	-3%	-7%	-3%
	C28	*Machinery and equipment n.e.c.*	4%	-4%	-4%	-3%
	C29	*Motor vehicles*	-1%	0%	0%	-2%
	C30	*Other transport equipment*	-2%	-2%	-1%	-5%
	C31_32	*Furniture and other manufacturing*	-1%	-1%	-3%	-5%

6.7 International comparisons

This section compares indicators that can influence the international competitiveness of EU industry with regards to energy costs in relation to non-EU G20 countries plus Switzerland, Norway and Iceland. This group of countries are the main trading partners of the EU27 as shown in Table 21. According to 2021 figures, the US, China and the UK are the EU27's primary trade partners.

Table 28: EU27 trade in goods by partner (2021)

Partner Extra EU-27	Group	Total Trade Value (bln EUR)	Share (%)
China	G20	696.1	16.2%
US	G20	631.8	14.7%
UK	G20	430.5	10.0%
Switzerland	Non-G20	280.2	6.5%
Russia	G20	251.6	5.9%
Turkey	G20	157.2	3.7%
Norway	Non-G20	131.2	3.1%
Japan	G20	124.6	2.9%
South Korea	G20	107.3	2.5%
India	G20	87.9	2.1%
Brazil	G20	66.8	1.6%
Mexico	G20	61.1	1.4%
Canada	G20	60.7	1.4%
Saudi Arabia	G20	45.8	1.1%
South Africa	G20	44.1	1.0%
Australia	G20	42.3	1.0%
Indonesia	G20	24.7	0.6%
Argentina	G20	16.7	0.4%
Iceland	Non-G20	6.9	0.2%
Other partners	Non-G20	1031.9	23.7%

Source: DG TRADE, 2022.[194]

To understand the underlying reasons for energy costs differentials, the comparison is made for the shares of energy costs in production cost, the GOS as share of production costs and the energy intensity. This is only done for the manufacturing sectors. The risk of losing international competitiveness is considered limited in the non-manufacturing sectors as these sectors do not produce tradeable goods. As the data on energy costs and energy intensity are limited, the findings should be interpreted with caution.

This section also looks at the international differences in the prices of energy products, which are generally the main drivers of the energy costs in the short term and thereby of costs differentials. Hereby lies the focus on retail industrial prices for electricity and gas as these two energy carriers tend to be the most relevant for industrial energy costs.

6.7.1 EU energy costs vs other G20 countries

The comparison of the shares of energy costs in production costs between EU sectors and other G20 countries could give indications of the impact energy costs have on the international competitiveness of EU industries. Specific data on energy cost shares of non-EU G20 partners is scarce and therefore only a limited comparison could be made. Energy cost shares could only be depicted for trade partners where

[194] DG Trade (2022). EU27 trade in goods by partner (2021, excluding intra-EU trade).

data on purchases of energy products, personnel costs and total purchases of goods and services were available. Where possible, gaps in data have been estimated using the methods described in Section 6.4.

Figure 25 shows the energy costs shares of the most energy-intensive manufacturing sectors with available data. Of the non-EU G20 countries, the energy cost shares could only be calculated or estimated for sectors in the United Kingdom, Norway, Turkey, the United States, Mexico, Korea and Japan based on data in one or more years between 2017 and 2019. For the other non-EU G20 countries, generally data was missing for energy consumption or energy prices, or both.

Trends in energy cost shares internationally vary per sector, with the results broadly similar to the previous edition of the study. Notably, across the most energy-intensive subsectors in Figure 25:

- On average, the EU27 has energy cost shares comparable to those of its most important international trade partner;
- Compared to the main trading partners with sufficient data for the most energy-intensive manufacturing sectors, the energy cost share of the EU27 is not the highest in any of the sectors. The EU27 does have a relatively high energy cost share in *Pulp and paper* and *Non-ferrous metals* compared to most other countries shown, and a relative low energy cost share in *Refineries* and *Textiles*.
- Norway has the highest energy cost shares in the *Iron and Steel* and *Non-ferrous metals* sectors in spite of lower electricity prices than the EU's, due to their relatively higher energy consumption;
- Mexico has the highest energy costs shares in several sectors, most notably in the *Pulp and paper* and *Textiles*
- Turkey has the highest energy cost share in the *Refineries* sector, closely followed by Japan;
- Japan has the highest energy cost share in the *Glass* sector;
- The United States has by far the highest energy cost shares in the *Basic chemicals* and *Cement, lime and plaster* sectors;
- Korea has the highest energy costs shares in *Clay building materials* and *Man-made fibres*
- Japan, Turkey and the United States appear to have a (much) high energy cost share in the fossil fuel intensive sectors such as *Refineries*, *Basic chemicals*, *Glass* and *Cement, lime and plaster* compared to the EU27. This would imply that on average, these sectors in the EU27 would be less affected by a change in fossil fuel prices compared to the three trading partners. It is, however, important to note that this observation may not be valid for certain subsectors within the sector. Studies comparing the fuel costs in subsectors of e.g. *Basic chemicals* show that the average fuel costs in the EU27 is much higher than for the same subsector in the United States.[195] This would mean that these subsectors are actually more affected by changes in fossil fuel prices compared to their competitors the main trading countries.

The energy cost shares in the less energy-intensive manufacturing sectors appear to show a similar trend for the EU27 as the most energy-intensive sectors, depicted in Figure 26. The EU27 energy cost shares are around the average of the group of countries shown for most sectors. None of the less energy-intensive manufacturing sectors has the highest or the lowest energy cost shares in relation to the production costs. In contrast, Mexico has the highest energy cost shares in five sectors (*Grain products*, *Sawmills*, *Articles of paper*, *Porcelain and ceramics* and *Stone*). In some sectors (*Grain products*, *Sawmills*, *Porcelain and ceramics*, *Stone*, *Casting of metal*), the energy costs shares for Mexico are between 5% and 10% which is

[195] JRC (2016). Production costs from energy intensive industries in the EU and third countries.

around the EU27 average values for some of the energy-intensive sectors. Japan also has significantly higher energy costs shares in several sectors compared to the EU27, which are *Casting of metal*, *Computer and electronics*, *Fabricated metal products*, *Plastics products*, *Fruit and vegetables*, *Motor vehicles* and *Other manufacturing*.

It is important to note is that the sectors compared are made up of various subsectors, and the impact of energy costs in the production costs on a sector in a country is strongly influenced by the composition of the sector.

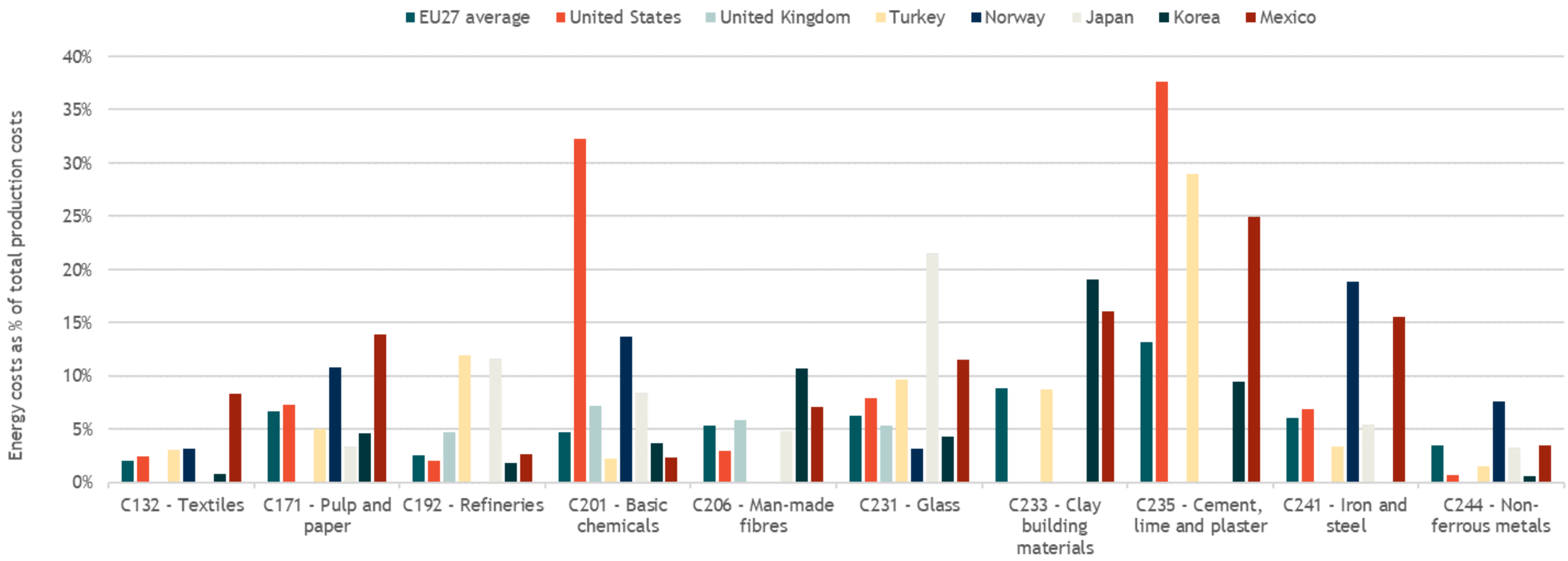


Figure 183: Energy cost shares in production costs of the most energy-intensive manufacturing sectors in the EU27 and main trading partners with available data, 2017-2019 average

Source: Own calculations based on Eurostat SBS, National data sources, IHS database, and OECD SISS database

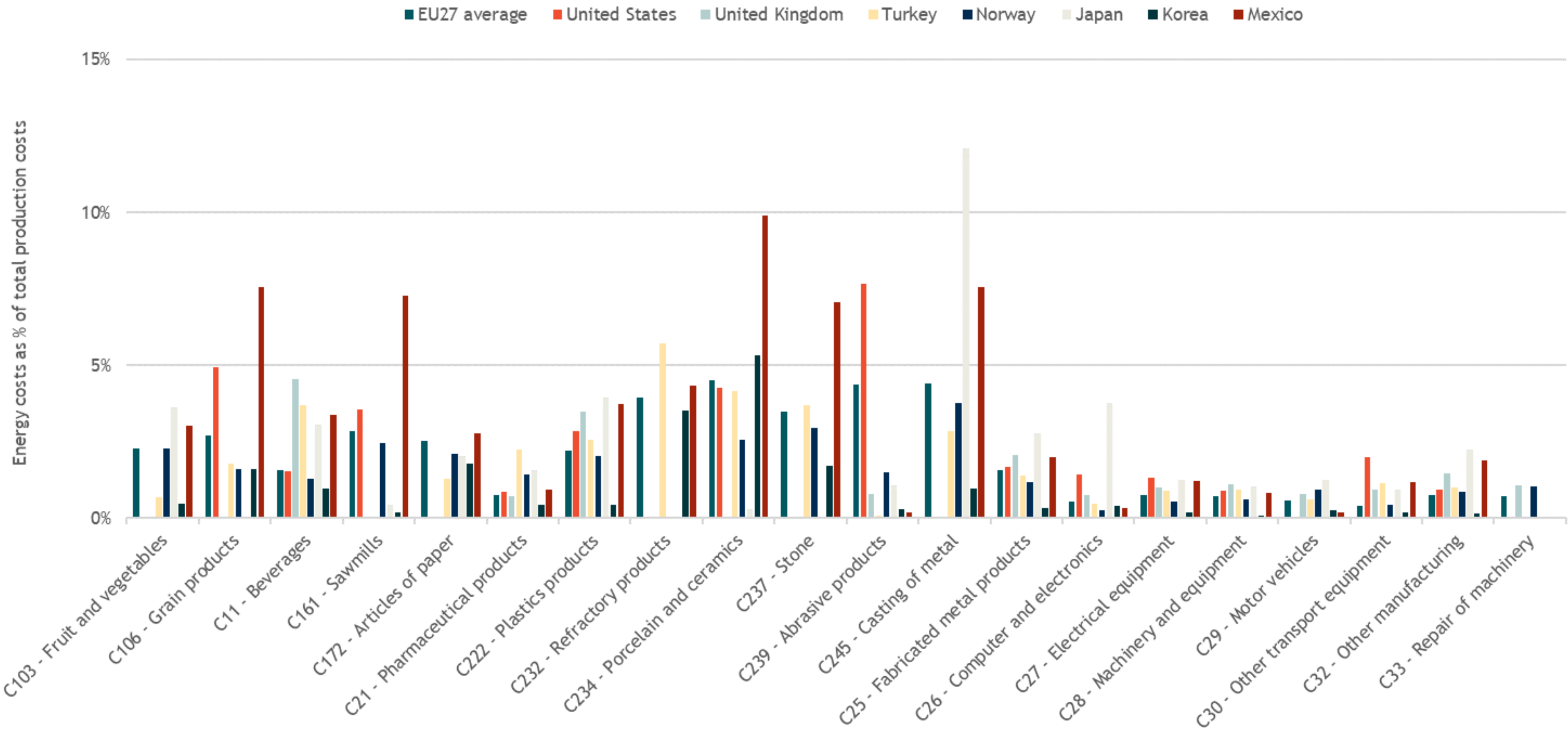


Figure 184: Energy cost shares in production costs of the less energy-intensive manufacturing sectors in the EU27 and main trading partners with available data, 2017-2019 average

Source: Own calculations based on Eurostat SBS, National data sources, IHS database, and OECD SISS database

6.7.2 Gross Operating Surpluses of EU sectors vs other G20

A comparison of the EU27's GOS share in the production costs across the main trading partners gives an indication of the profitability of the sectors and thus the competitive position. Figure 27 provides the GOS share for the EU27 averaged across all manufacturing sectors compared to the average GOS share of the manufacturing sectors of the main trading partners for which data is available.[196,197]

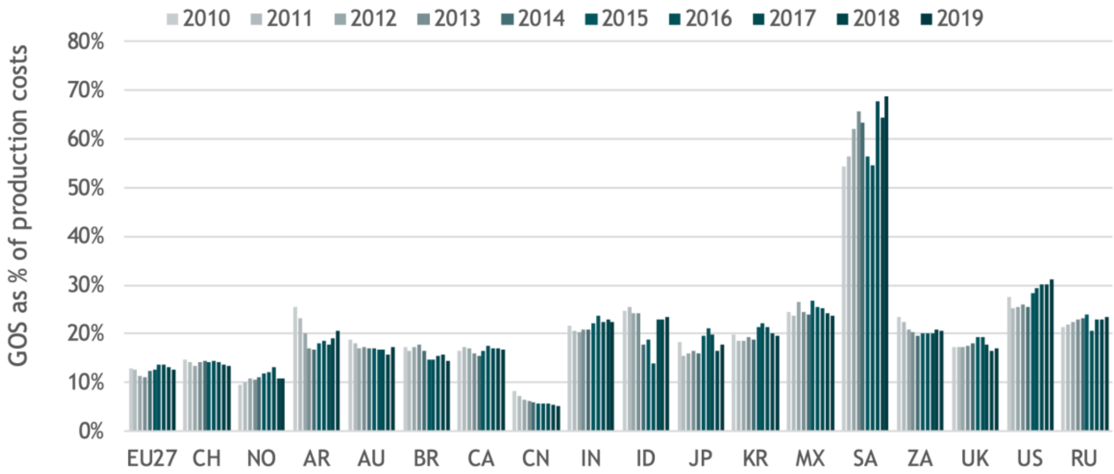


Figure 185: Gross Operating Surplus as a share of production costs, averaged across all available manufacturing sectors

Source: Own calculations based on Eurostat SBS and IHS database.

The results of the analysis show that the EU27 average profitability of between 10% and 15% is similar to that of Switzerland and Norway — both have direct access to the EU single market. This is lower than the EU's main trading partners, which have an average GOS share between 15% and 25%. Saudi Arabia even has an average GOS share between 50% and 70%, which is largely driven by the high profitability of its *Refineries* and *Basic chemicals* sectors. Only China has a lower GOS share for its manufacturing sector between 5% and 10%, driven by the high costs in 'Total purchases of goods and services' across all sectors with available data.

Overall, the average profitability in the EU manufacturing sectors is less volatile than in most of the G20 countries. Australia, Brazil and China have seen a sliding GOS share since 2010 and in the recent years, a same trend can be observed for Japan, Korea, Mexico and the United Kingdom. Only the United States registers a continuously increasing GOS share. India and Saudi Arabia have the most volatile GOS share. For the other countries, the GOS share is remains roughly stable as in the EU27.

6.7.3 Energy intensity of EU sectors vs G20 countries

Energy efficiency affects its international competitiveness of companies and can help provide more insight in drivers of energy cost shares. The more energy efficient a firm is, the lower its relative energy consumption and related costs compared to its competitors. By comparing energy intensities across sectors and countries, this provides an indication of the energy efficiency in these sectors and countries. This does come with the caveats as discussed in Section 6.5 with the energy intensity expressed as share of the GVA. In addition, international data on energy intensity is much more limited, especially for the

[196] In the previous edition of this study, the GOS was calculated as a % of GVA instead of production costs due to the absence of data on personnel costs (production costs = purchases of goods and services + personnel costs) In this study, the personnel costs have been calculated as the difference between the GVA and GOS as Eurostat defines the GOS as the value added minus personnel cost.
[197] Iceland is excluded from the figure due to insufficient data.

recent years. The energy intensity for the international comparison has therefore been calculated as an average over 2010-2019 instead of 2017-2019 as with the other international comparisons. A comparison between the averages of 2010-2019 and 2017-2019 for the sectors and countries for which data is available reveals little difference. Nonetheless, these results should still be taken with caution.

Figure 28 shows the energy intensities for the most energy-intensive manufacturing sectors, averaged over time in the EU27 and main trade partners for which sufficient data is sufficiently available. The energy intensities of these manufacturing sectors varied considerably across countries with similar results as the previous edition of this study:

- In *Pulp and Paper*, the EU27's average energy intensity is more than twice as high as the US, Japan and Korea's due to higher energy consumption on average in EU plants;
- In *Refineries* and *Cement, lime and plaster*, the energy intensity for the EU27 is also higher than all of its international trade partners for which data was available;
- The EU27 has an average energy intensity that is lower than China, Japan and Russia for *Basic Chemicals*. For *Man-made fibres*, the EU27 energy intensity is also lower than China;
- The EU27 has by far the lowest intensity levels of all international counterparts in *Abrasive Products*;
- In *Iron and Steel* and in *Non-ferrous metal*, the EU27 has higher intensity levels than Switzerland but lower levels than Norway due to higher energy consumption levels in Norway, can be partly attributable to the distribution of upstream and downstream manufacturing processes across these countries;
- In *Glass*, the EU27 has lower energy intensity levels than Mexico and the United States, but higher intensity than Norway and Canada.

Figure 29 shows the comparison of energy intensities for the less energy-intensive manufacturing sectors. The figure shows that for many sectors there is no data available for comparison. For the sectors that have data for an international comparison, the EU27 has lower than average intensity levels. This is visible for the sectors *Beverages*, *Sawmills*, *Pharmaceutical products*, *Fabricated metal products*, *Computer and electronics*, *Electrical equipment*, *Machinery and equipment*, and *Motor vehicles*.

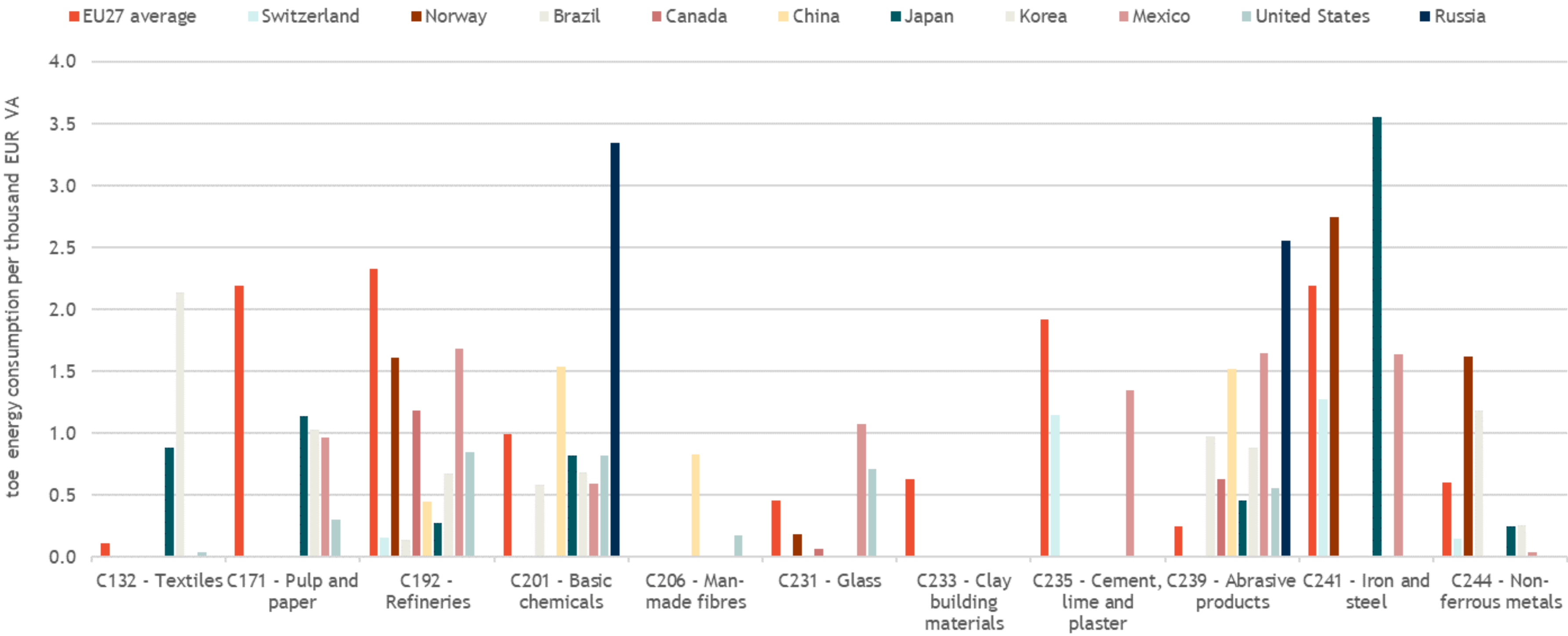


Figure 186: Energy intensities of the most energy-intensive manufacturing sectors in the EU27 and main trading partners with available data, 2010-2019 average

Source: Own calculations based on IHS database and national sources

Note: the energy intensity could not be calculated as an average of 2017-2019 as with the other international comparisons due to a lack of data.

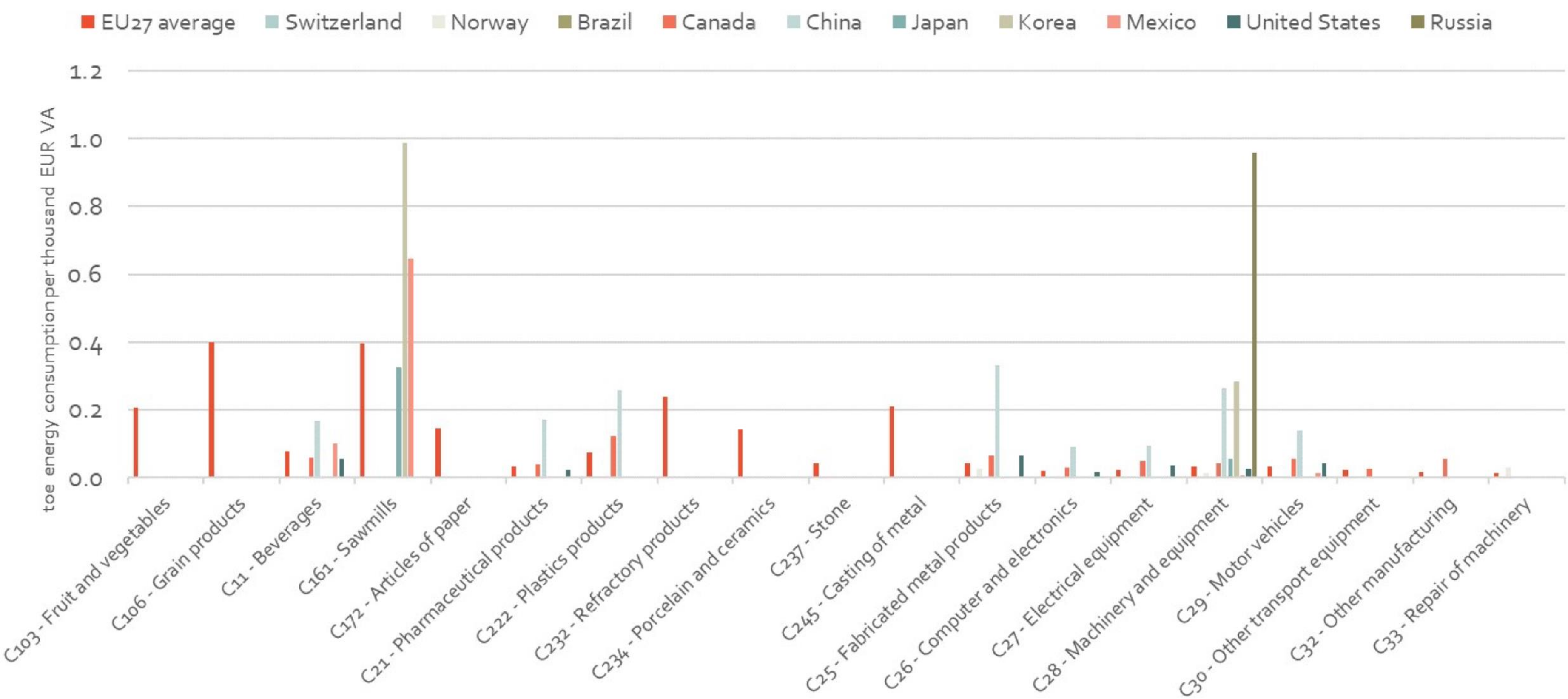


Figure 187: Energy intensities of less energy-intensive manufacturing sectors in the EU27 and main trading partners with available data, 2010-2019 average

Source: Own calculations based on IHS database and national sources

Note: the energy intensity could not be calculated as an average of 2017-2019 as with the other international comparisons due to a lack of data.

6.7.4 Industrial electricity prices: EU vs G20 countries

Please refer to analysis in section 2.2.2.

6.7.5 Industrial gas prices: EU vs G20 countries

Please refer to analysis in section 3.2.2.

6.8 Introduction to PPAs

Key takeaways:

- There are many hedging strategies available to the industry against energy price volatility.
- Successful hedging (that essentially leads to risk reduction) requires transactions where the contracting parties involved have opposite risk profiles.
- Power purchase agreements (PPAs) for electricity from renewable (RES) power plants are emerging as a significant tool for further developing investment in renewables and securing long term price stability for industries.
- The majority of power projects are structured on power purchase agreements.
- EU located industries steadily increased the use of RES-PPAs over the last 7 years: the EU RES PPA market has grown from 0.5GW in 2014 to 24W in 2021.
- In 2021, the PPA market grew by 8.8 GW. The key regions of RES PPA in EU are: i) Iberia (Solar), ii) Germany (Solar and Wind), Belgium and Luxembourg (Wind) and Nordics (Wind).

Hedging is an agreement that sets energy prices to a predetermined level over a time period and secures the industry against the price volatility of energy carriers. It also allows to reduce risk and to develop an accurate future economic outlook. Hedging can be carried out through many instruments involving bilateral contracts (supplier of energy and industry) and/or access to a marketplace. Hedging through a marketplace requires cash collateral and entails certain reporting duties. Successful hedging (that essentially leads to risk reduction) requires transactions where the contracting parties involved have opposite risk profiles.

Although there are many hedging strategies, below we list the most common[198] in the industry and power sectors: i) Hedging Tolling Contracts, ii) Energy forwards, iii) Energy futures: Swaps:, iv) Contract for Differences (CfDs), v) Spreads, vi) Options, vii) Structured power-purchase-agreements. The majority of the power projects are structured on power purchase agreements.

Power purchase agreements (PPAs) for electricity from renewable energy sources (RES) are emerging as a significant tool for further developing investment in renewables. A PPA is a traditional financial instrument to qualify an investment project for efficient fundraising. A PPA is essentially a bilateral contract for economic differences (equivalent to a two-ways option) with a strike price defining remuneration of electricity produced by the RES power plant. The bilateral contract applies for a period usually longer than one year and acts as a guarantee and source of future revenues for the investment project. Such a bilateral contract may also qualify for being directly dispatched in the power system,

[198] As identified by ACER (2015) , MONDAQ (2019) , Halkos (2019) and McKinsey (2022)

having characteristics similar to a nomination of load and power capacity for the system operator to include in the dispatching schedule. It depends on regulatory rules whether a nomination based on a RES PPA is possible and for this purpose, usually, the PPA will have to associate balancing resources, such as storage of electricity and flexibility resources (gas-based power capacities, hydropower, etc.). For example, such an augmented PPA, i.e., "RES PPA plus storage", qualifies for direct dispatching as it operates as a virtual dispatchable power plant.

Depending on location, there are different types of PPAs, such as:

- ‘on-site’ (a producer's RES plant is immediately next to the customer’s plant – a PV system on a factory's roof),
- ‘near site direct wire’ (a RES plant is located nearby the customer and the power is transmitted over a dedicated direct line,
- classic ‘off-site’ (energy produced in a RES plant is transmitted to the customer over transmission/distribution lines of the grid operator).

‘Off-site’ PPAs commonly take various forms such as ‘multi seller’ (several RES producers sell power to one customer based on one contract) or ‘multi buyer’ (opposite to the ‘multi seller’ – one producer sells power based on one contract with several customers). At the same time, there are ‘virtual’ PPAs, i.e., contracts for difference signed between the renewable energy producer and the end consumer. The virtual PPA (also sometimes called a ‘synthetic’ PPA) is not a contract for supply to an end consumer but an agreement guaranteeing a fixed and stable power price in a long-term perspective.

One type of Corporate PPA is a “sleeved” or “physical” PPA. This purchasing contract may be executed if the plant is located on the same grid network as the corporate off-take point or if the electricity is sleeved by the utility from the generation plant to the buyer. The sleeved or physical Corporate PPA is the most commonly used contractual structure in some countries in the early stages of PPA market development. Under this scheme, the corporate buyer simultaneously enters into a PPA with the developer and a back-to-back PPA with its incumbent utility. One characteristic of this type of Corporate PPA is that it requires the utility to physically deliver power to the relevant site, for the corporate buyer that is not permitted to offtake the power directly under local electricity supply rules. Instead, the developer transfers the electricity to the utility, which will sleeve it through the grid to the corporate buyer.

The parties may also agree that physical delivery is not required. This is called taking a “virtual”, “synthetic” or “financial” approach. Virtual PPAs are financial derivatives (such as Contracts for Difference), where generators and off-takers agree to a strike price that will be paid for each unit of energy generated over an agreed period of time. The project sells the power to the open market, and the off-taker purchases power from the open market. If the market price rises above the strike price, then the developer pays the difference to the off taker. Conversely, the off taker compensates the developer in the event that the market price falls below the strike price. Similar financial structures may be created through the use of call options and put options. For instance, put options would give the developer the opportunity to buy the right to sell the generated energy at a certain strike price. If wholesale power prices fall below the strike price, then the developer can exercise its option to sell the electricity at a higher strike price.

A PPA has at least two contractual parties, the seller (i.e., the investor) and the purchaser of electricity, the latter being an electricity supplier to customers, an aggregator of RES or an individual or group of customers. Obviously, there is interest to conclude a PPA primarily if a) the strike price is competitive in comparison to alternative sources of electricity and b) stable enough over time. A PPA acts as a source of electricity and risk management instrument hedging against the variability of electricity prices observed in spot markets. The cost certainty also depends on hedging against cost variability of balancing energy and ancillary services. Renewable energy sources are, by their nature, variable and therefore need significantly higher and more expensive balancing services than other sources of electricity. Therefore, complex PPAs, such as the "RES PPA plus storage", become attractive when they effectively incorporate resources for self-balancing at a reasonable cost.

The RES-PPAs enjoyed a demand-pull recently. They are attractive to large corporate electricity customers who see significant benefits, both economic and related to their brand reputation and sustainability, in switching to renewable energy. The RES-PPAs exhibited a spectacular development in recent years driven by large corporations' demand and drove a new record for clean energy purchased by corporations worldwide. It is noteworthy that the international RE100 initiative, involving more than 280 multinationals, with the common aim of transforming their consumption into 100% RES, already records 315 TWh of green energy per year.

A well-structured RES-PPA is beneficial to both parties: it ensures a steady stream of income for suppliers and provides price security that simplifies business planning for the buyer. Putting PPAs in place during the development phase helps investors mitigate risks and predict long-term income streams for new projects, making the project more attractive to investors and maximizing the chances for securing funding.

The market for RES-PPAs is still at an early stage of development in Europe and is often opaque. It can be difficult for participants to tell whether the prices and terms they are being offered are as good as possible. The rapid pace of change in energy markets and policy can make planning a PPA strategy difficult, with a variety of sometimes-unfamiliar risks to account for. At the same time, the RES investors face challenges during the current transition from security under support schemes to a more uncertain financial environment, depending on yet uncertain revenues from PPAs. Such conditions may lead to a market coordination failure unless public intervention helps participants mitigating short-term risks and uncertainties.

A key question from a regulatory perspective is whether pure market forces are sufficient to drive the expansion of RES-PPAs, hence RES investment, at a fast pace as required for the energy transition. Would it be enough to put regulatory-driven enabling conditions in place, such as facilitation measures, non-market barrier removals and arrangements for risk-hedging and protection of small players? On the other hand, would it be necessary to include direct support measures, of financial and economic nature, at least in the early stages to push development effectively?

To enlighten the issue, we need first to identify current barriers impeding development of RES-PPAs towards a mature free market. The barriers are differently depending on market and non-market factors, and challenges can be categorised as follows:

- Challenges in the new era

- Structure and parameters of contracts
- Platforms and reliability
- Industry
- More ambitious corporate goals
- Storage
- PPA for green gas
- Cross-border PPAs
- Risks associated with the PPA definition

Each of these challenges are explored below.

6.8.1 Challenges in the new era

The support schemes for RES projects are being transformed internationally, with the implementation of competitive procedures and the transition from guaranteed prices to revenues based on market prices. In several countries, the abolition of direct supports is already underway or implemented, reflecting the decline in costs, particularly mature technologies. It is typical that in RES auctions in Portugal, conducted in August 2020, the lowest price in the world so far was 11.14 EUR/MWh for the photovoltaic power station.

The day-ahead markets experience under-pricing of total costs due, among others, to the increase in RES having zero marginal costs. Thus, the wholesale market revenues are not enough for RES investment seeking capital cost recouping. The RES projects may also see revenue eroding in the balancing and ancillary services markets, as they are stochastic[199] and cannot bid for such services. As there is more RES in the system, the lower are the revenue recouping possibilities (cannibalization effect). Under such conditions, only bilateral electricity purchase contracts can allow RES investment projects to achieve financial security and bankability.

In Europe, bilateral contracts are expected to exceed 10 GW in 2021, according to a study by Pexapark, where investments in 2020 exceeded EUR 26 billion. Box 6-4 shows some recent examples of RES-PPAs. In addition, Aurora Energy Research estimates that photovoltaic projects that will not be subject to aid in France, Germany, Italy, Spain, Portugal, and the United Kingdom will produce more than 70 TWh per year by 2030.

Contract prices are significantly heterogeneous between European countries, reflecting in particular the dynamics of wholesale prices, the structure and adjustment of the energy mix, the level of competition and liquidity of the markets, and financial risks. For example, in the 4th quarter of 2020, PPA prices for wind ranged from 30 EUR/MWh in Finland to 91 EUR /MWh in France, for photovoltaics from 31 EUR /MWh in Denmark to 62 EUR /MWh in Austria.

Box 6-4 Recent examples of RES-PPAs

The current dynamics of PPAs in Europe are reflected in a number of transactions completed in recent times, after years of analysis and negotiations. In October 2020, Norwegian Statkraft signed a PPA with the Spanish supply company Fortiaso that its industrial customers could absorb about half of the production from wind farms with a capacity of 93 MW.

[199] I.e. intermittent due to external, unpredictable factors such as weather conditions.

In November 2020, German railway company Deutsche Bahn announced new PPAs for 780 GWh of green energy per year, having set a target of 80% RES energy by 2030, compared with 60% today. In December 2020, the largest PPA in Europe was announced for offshore wind power.

Then, in January 2021, Iberdrola made a PPA for one of the largest photovoltaics under construction in Europe (590 MW) with the French food company Danone. In addition, the English chemical company Johnson Matthey secured 100% green energy for its battery plant in Poland. In February 2021, RWE announced a 10-year contract with a Dutch semiconductor company for an annual production of 257 GWh.

The response of banks on a global scale to meeting their energy needs is also noteworthy. In July 2018, the first contract of this category was announced, between Iberdrola and Spain's Kutxabank, In June 2020, Bank of America signed 10 PPA contracts guaranteeing 340 GWh of green energy per year. An interesting case is the Japanese bank MUFG, which finances, before concluding PPAs with multiple users, the world's largest hybrid seawater project in Chile.

6.8.2 Structure and Parameters of Contracts

The structure of bilateral contracts is constantly evolving to reflect the characteristics of each consumption better and to address the intermittency of RES production more effectively. More generally, contracts now contain a set structure with a number of parameters and conditions, to incorporate the individual risk factors (price, volume, liquidity, balancing, credit, tax and regulatory changes), to be assessed by means of simulations and scenarios, and to distribute the degree of risk, reflecting the acceptable limits of the parties.

The most notable of the current trends are:

- the involvement of electricity suppliers to avoid imbalances and representation in the balancing market (sleeved synthetic PPA);
- the introduction of collar PPAs with ceilings and thresholds at final prices;
- liquidation on the basis of pre-agreed indicators (not necessarily the domestic wholesale market or measured production);
- terms of redefinition in the event of substantial changes, but also tendering procedures for the promotion of the best offer.

The shift from pay structures-as-proved to pay-as-consumed is a new form of bilateral contract (pgPPa), recently appearing in the US between BP and Capital Solutions, also allows for the management of weather-related risk.

At the same time, contracts have evolved to allow the participation of multiple companies (multi-corporate PPA), while maintaining the favourable conditions resulting from a negotiation of large quantities. Storage and renewable gases are two important dimensions, which will also release new prospects for cross-sector integration. While the actual parameters of contracts may vary, their basic content is standardized, with master agreements such as EFET and ISFM.

6.8.3 Platforms and Reliability

In addition to established platforms for corporate PPAs, such as Re-Source and LevelTen, new ones are emerging, with an emphasis on smart technology, to match the desired characteristics on the part of buyers, with the optimal RES portfolio. DNV GL launched a digital PPA platform, Instatrust. Similarly, in England, the new Zeigoplatform has managed to register 300 RES projects directly, totalling 20 GWh, attracting more than 100 developers.

Crowdfunding is an alternative way of raising funds for RES projects, from a large number of stakeholders that can enhance acceptance by local communities. The new European regulation[200] aims to harmonise practices and standards in order to strengthen competition and trust on all sides, and to establish safeguards for investors, inviting local residents to invest between EUR 20 and 2000, providing a gross interest rate of 3% over a five-year period.

More generally, as industry experts point out, a crucial parameter for the future of PPAs is the increase in buyers who can be considered financially solvent by banks.

6.8.4 Industry

As announced in December 2020, after many months of consultation, Spain's energy-intensive industries and exposure to international competition will be compensated, to a degree of up to 85%, for charges they pay (equivalent to ETMEAR and SSF) by the end of 2022. The budget for the measure is estimated at EUR 92 million. At the same time, the EU approved the granting of state guarantees for the conclusion of bilateral contracts with RES in order to remove the financial risk, in particular the risk of bankruptcy of buyers.

More specifically, large industries (with consumption of more than 1 GWh in 2 of the previous 3 years and at least 50% consumption in non-peak hours) will have access to the special fund to be set up. The fund will be able to channel up to EUR 200 million per year to industries that contract bilaterally with RES for at least 10% of their consumption over the next five years.

6.8.5 Storage

The institutional framework for storage differs between European countries, and institutional gaps or insufficient incentives are often found, potentially creating conditions for the development of projects through PPAs.

It is worth noting that in Spain, despite the introduction of an institutional framework, no storage projects have been awarded in recent RES competitions. In particular, as the target for 2.5 GW of batteries has been set by 2030, high expectations had been set for storage participation in the auctions held on 26 January 2021.

However, the restriction on charging batteries exclusively from the RES station and not from the network was considered a catalyst for the failed outcome, especially for photovoltaics, as it excludes charging in low-price evening hours. It also appears that the 25% increase in the reference price for hybrid projects was not considered sufficient, despite the emphasis placed on regulatory changes to involve storage in reserve markets. In addition, the 3 GW of hip auctioned were fully allocated and the mean price levels

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[200] Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity

ranged to 24.47 EUR / MWh for photovoltaics and 25.31 EUR /MWh for wind turbines, with the highest levels of 14 EUR /MWh, for contracts of 12 years.

In Portugal, on the other hand, the auctions held in August 2020 were also very successful in terms of storage. It is noteworthy that 483 MW of the 670 MW awarded involve storage. The example shows that the establishment of power mechanisms, in addition to participation in reserve markets, is critical to the sustainability of hybrid projects.

6.8.6 PPA for Green Gas

In January 2021, the first PPA for renewable gas was announced in Europe. French Wave Energy, with innovative technologies in the sector, and the Spanish waste management company, Ferrovial Servicios, will generate additional funding, helping to prevent the release of 17,000 tonnes of CO_2 per year. The PPA will finance the French company's investment of EUR 7.5 million in the conversion infrastructure and its connection to the natural gas network. It is noted that 10 corresponding plants are already in operation in France, supplying 35 000 households.

6.8.7 Cross-border PPAs

Cross-border PPAs allow the matching of RES projects with consumption in different countries. Corporate consumers can avoid institutional gaps in the countries in which they operate and optimise the desired characteristics of the contract, taking advantage of more favourable climate characteristics but also better levels of market maturity and competition.

At the same time, they allow for a comprehensive approach to the management of individual consumptions and provide flexibility in the event of changes in location or scale of infrastructure. A prime example is Novartis's five 10-year contracts with projects developed in Spain by Enel Green Power, EDP and Accion. The company will implement its climate neutrality target by 2025, limiting annual emissions corresponding to 113 000 passenger cars per year[201].

In conclusion, bilateral contracts are key to the financing and revenue of RES projects, at a time when support schemes are being transformed or abolished. The structure and parameters of contracts are constantly evolving to reflect more effectively the characteristics and preferences of both parties. The integration of storage, industry participation, offshore wind, the cross-border dimension, and renewable gases, give impetus to the further development of PPAs in Europe.

Guarantee mechanisms, such as the one recently adopted in Spain, strengthen the economic solvency of buyers, removed one of the most serious obstacles to the conclusion of contracts. The role of the Recovery Fund can also be a catalyst for reducing other economic risks. On the buyers' side, companies' ambitious environmental commitments, particularly for green energy at the time rather than year level, but also for their entire supply chain, are strengthening demand. At the same time, the active involvement of municipalities and citizens, through innovative programmes at local level, encourages social acceptance, which is crucial for the energy transition.

[201] The company in 2019 generated nearly 900000 tons of CO_2e. The vehicles fleet contributes around 124000 tons of CO_2 to the total emissions.

More generally, the finalization of the institutional framework, liquidity in the futures market and the removal of bureaucratic obstacles are an important basis for the development of PPAs.

6.8.8 Risks associated with PPA definition

There are numerous risks to consider before entering into a Corporate PPA. Key risks include:

1. Market risk: Agreeing to a purchase price for power over a long period of time could be risky if electricity prices are volatile.
2. Price and project revenue risk: It is related to the PPA pricing structures, which may be fixed or flexible.
3. Tenor risk: It relates to the period over which the corporate buyer is obliged to pay for power contracted for under the Corporate PPA. Lenders will expect that Corporate PPAs cover at least the term of the loan being contemplated.
4. Currency or interest rate risk: The risk arises because of the mismatch in the currency of debt obligations and currency of revenue, which exposes the project to the risk of devaluation over time.
5. Credit risk: Since Corporate PPAs are crucial revenue contracts, the creditworthiness of the corporate buyer is also crucial.
6. Scheduling risk: It relates to the deviations between forecasts of expected power production by generators to network operators and the actual outturn production.
7. Basis risk: This is commonly referred to as location risk. Numerous factors relating to location, including: transmission line congestion, wind and solar intermittency and variability, market saturation, and state-based or regional regulations.
8. Balancing risk: Balancing risk relates to the need to provide a continuous supply of power to the corporate buyer. It is the risk of exposure to power system costs that arise when an asset's forecast generation is less than its actual generation.
9. Volume risk: It captures the variability of power generation of a plant over a period of time, which may be a season or a full year. The risk may derive from climatic variations, such as wind that is higher than expected one year or lower solar irradiation levels due to a cloudy summer.
10. Shape or profile risk: Shape or profile risk is connected to volume risk but it captures the fact that hourly generation will be variable depending on wind speed or solar irradiation, irrespective of whether the overall volume over a given period is equal to the estimated volume.
11. Construction risk: For new projects still to be built, development or construction risk is another factor to be taken into consideration.
12. Performance or operating risk: It is the risk that the project does not perform as expected, in terms of the level of mechanical availability, warranted power curve (wind) or performance ratio (solar PV).
13. Change in law or regulatory risk: During construction or operation of the project or during the term of the contract, a change in law or a force majeure event may occur.
14. Force majeure risk: It is the risk that extraneous events may occur, over which neither the developer nor the corporate buyer have control (including acts of God or extreme weather conditions), which may delay completion of the project or have an impact upon the project's power generation capabilities.

6.8.9 Current status of the European corporate RES PPA market

The EU RES PPA market has grown from 0.5GW in 2014 to 24W in 2021. In 2021, the PPA market grew by 8.8 GW. The key regions of RES PPA in EU are: i) Iberia (Solar), ii) Germany (Solar and Wind), Belgium and Luxembourg (Wind) and Nordics (Wind). According to RMW[202], the onshore wind has been the preferred technology for PPA deals in 2021, while the average size and length of PPAs has decreased to 11 years from 14 years in 2018. Figure 30 provides the RES PPA capacity in the EU as if 2021. The EU market grows at an accelerated pace and the EU located industries increasingly use RES-PPAs.

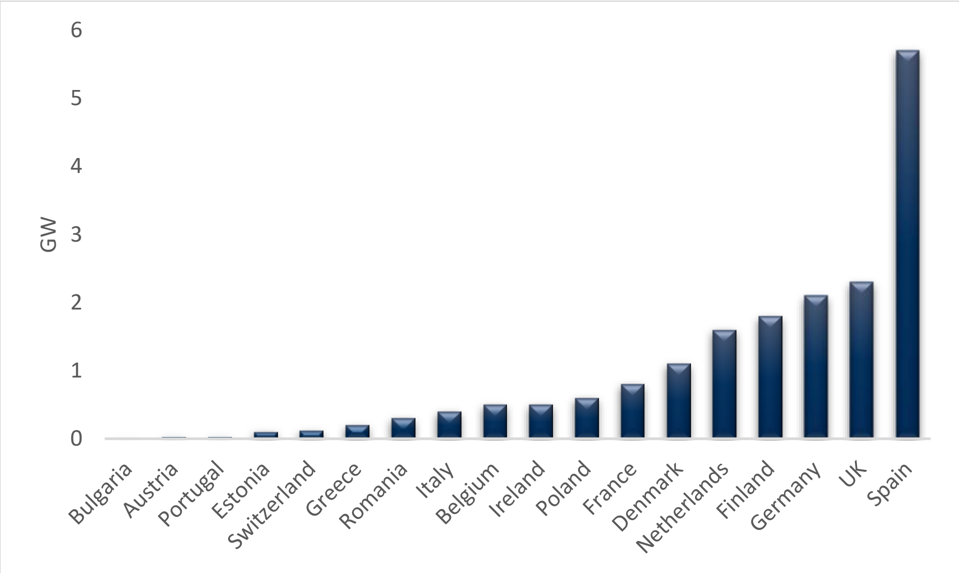

Figure 188: Cumulative Corporate RES PPA capacity by 2021

Source: Based on RMW (2021)[203]

[202] Rebewable Market Watch “Europe Corporate Renewable PPA Market” (2021)
[203] Renewable Market Watch “Europe Corporate Renewable PPA Market” (2021)

7 The EU energy bill

In this chapter, we outline the main drivers of the EU energy import bill and estimate its size in the last few years.

Main findings:

- The EU is highly dependent on energy imports, with an overall dependency rate of around 60% and showing an upward trend since 2013. The import dependency rate is particularly high for oil and petroleum products (97%) and for natural gas (94%), which results in a large annual energy import bill of between EUR 200 and EUR 400 billion. Crude oil is by far the largest component of the import bill, representing 74% of the total in 2019. The share of gas and hard coal was 24% and 2%, respectively, in 2019.
- The fall in oil prices at the beginning the Covid-19 pandemic in 2020 and the parallel drop in consumption (caused by the slowdown in economic activity and transport due to worldwide lockdowns) reduced the energy bill by almost half in 2020, to around EUR 150 billion. The overall import dependency rate fell to 57.7%, 84% for natural gas. It increased slightly by 0.2 percentage point for oil and petroleum products.
- However, in 2021, the energy import bill has more than doubled to EUR 320 billion (2.2% of EU GDP), returning close to the 2014 level, due to the explosion in gas prices and the sharp rise in oil prices. The latest data show that the import bill for the first half of 2022, at around EUR 330 billion, is already higher than the annual bill of 2021.
- In particular, the gas import bill was already 3.5 times higher in 2021 than in 2020 and reached EUR 129 billion (twice the annual average over the period 2014-2019). The trend continued into 2022 and the gas import bill reached over EUR 160 billion for the first half of the year. It corresponds, over the same period, to 9 times the amount for 2020 and 4.6 times that for 2021.

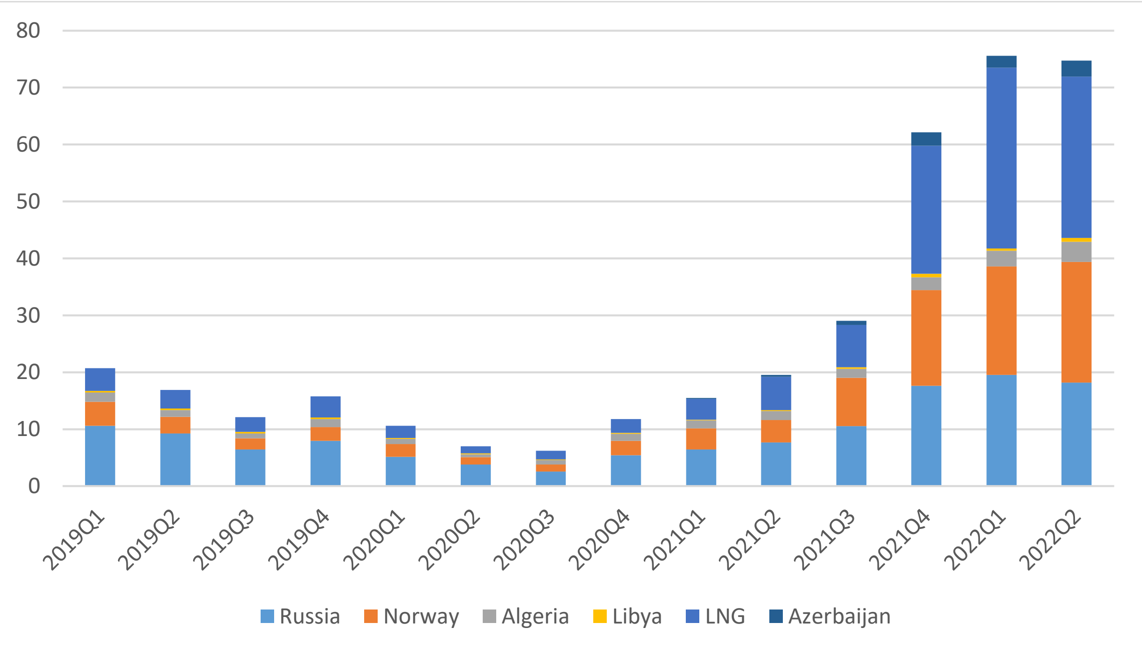

Figure 189: The EU quarterly gas import bill 2019-2022
Source: DG ENER calculation for gas imports (until June 2022) based on ENTSO-G flow data and estimated average import prices, based on information from Eurostat, natural gas and LNG hubs.

7.1 Introduction

The EU is a net importer of energy and highly dependent on other region of the world to meet its energy needs, especially when it comes to fossil fuels. The EU's import dependency[204] increased from 50.7% in 1990 to an unprecedented peak in 2019 at 61.5%, slightly decreasing to 57.7% in 2020 due to Covid-19 measures. In other words, the EU imports more than half of all the energy it consumes. Import dependency is particularly high in case of fossil energy carriers such as oil, gas and coal.

- Between 2013 and 2019, import dependency increased steadily for gas, from 65.6% to 94.1%, because of the confluence of two trends: rising residential and industrial gas consumption and falling domestic production. This dependency dropped to 83.9% in 2020 due to the decrease of gas consumption, particularly in the industry sector.
- Oil import dependency has always been at high levels, and shows a consistently upward trend, particularly since 2017: from 91.8% in 2013 to 97.4% in 2020.
- Import dependency also increased for solid fossil fuels from 39.1% in 2013 to 42.8% in 2019, notably because of the consistently decreasing lignite production in the EU - then dropping to 35.4% in 2020 for the same reasons as for gas. Import dependency reached 66.7% for hard coal in 2019.

While the import dependency of fossil fuels shows a long-term increasing trend, their share in the EU27 energy mix is gradually decreasing. The share of renewables - typically produced within the EU - is growing steadily. However, the increase in the EU energy import dependency shows that renewable energy expansion has not been strong enough to compensate for the reduction in intra-EU fossil fuel production and the increase in EU energy consumption.

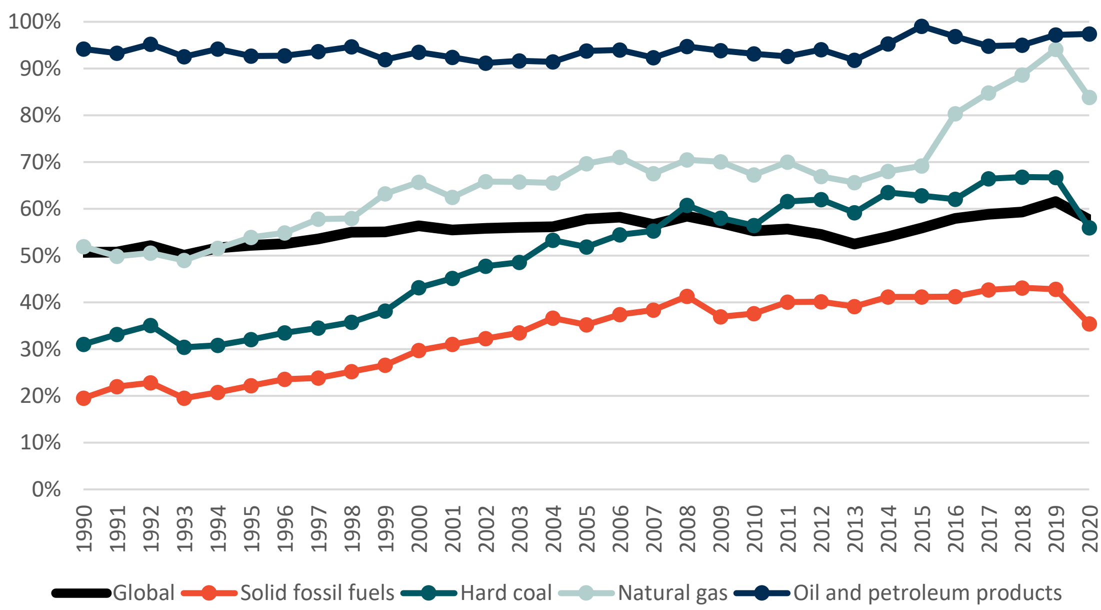

Figure 190: EU import dependency by fuel

Source: Eurostat (nrg_bal_c, nrg_ti_sff, nrg_te_sff, nrg_ti_gas, nrg_te_gas, nrg_ti_oil, nrg_te_oil, nrg_ti_eh, nrg_te_eh)

[204] Import dependency is calculated as net imports divided by gross available energy (instead of net imports divided by gross inland consumption as in the previous report). Nuclear fuel imports are not included in this figure by convention.

As recent events show very clearly, a high import dependency poses significant challenges in terms of energy security, especially in the absence of the diversification of suppliers and supply routes. It also means that in times of high demand and price volatility, the EU faces a substantial energy import bill.

7.2 Methodology

In this analysis, the EU is treated as a whole and only extra-EU imports are considered in the calculation of the EU import bill.

The analysis covers the main fossil fuels: crude oil, natural gas and hard coal[205]. These fuels still account for two thirds of the EU's gross inland energy consumption and the overwhelming majority (around 97% in 2020) of net energy imports[206]. Crude oil alone accounts for more than half of the EU's net energy imports, while gas accounts for a third.

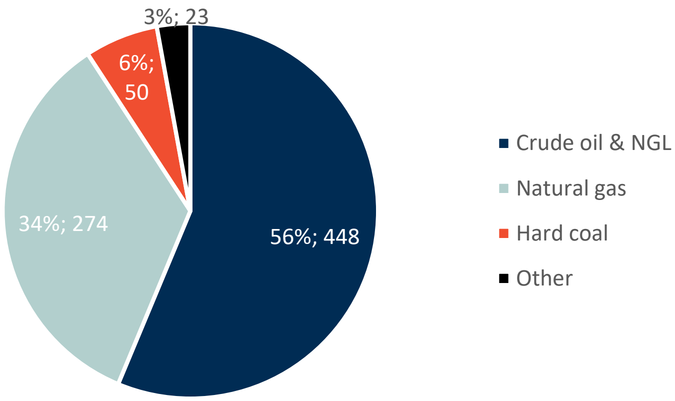

Figure 191: EU net energy imports in 2020 (share in % and amount in Mtoe[207])
Source: Eurostat (nrg_bal_c, nrg_ti_sff, nrg_te_sff, nrg_ti_gas, nrg_te_gas, nrg_ti_oil, nrg_te_oil, nrg_ti_eh, nrg_te_eh)

In addition to crude oil, the EU is also an importer of petroleum products. However, considering the fact that the EU's exports of petroleum products are similar in magnitude to its imports (the EU generally exports motor gasoline and imports middle distillates) and the practical difficulties of finding reliable volume and price data for a multitude of products with different specifications, petroleum products were not included in the calculation of the import bill. Brown coal is typically not traded internationally and imports into the EU are negligible. Therefore, the analysis of solid fossil fuels was restricted to hard coal. The EU exports electricity most of the time, in the range of 2-6 TWh per year between 2014 and 2019, which represents a revenue of around EUR100 million per year. The EU was a net importer of electricity in 2018 and 2020 but the bill did not exceed EUR500 million according to rough estimates. Electricity was therefore not included in the analysis.

In terms of time horizon, the import bill is estimated for the period 2014-2021 and first estimates are given for the first half of 2022.

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[205] Hard coal includes anthracite, coking coal and other bituminous coal. Sub-bituminous coal was included in hard coal in the previous report although it is brown coal according to the Eurostat nomenclature; it has therefore been excluded from the analysis.
[206] Nuclear fuel imports are not included in this figure by convention.
[207] Toe = tons of oil equivalent. According to the international conventions, one ton of "oil equivalent" amounts for example to 1 616 kg of coal, 1 069 m³ of gas or 954 kg of gasoline. For electricity, 1 toe is worth 11.6 MWh.

7.2.1 Calculation of the energy dependency rate

Regarding the energy dependency calculations and the analysis of imported volumes as a driver of the energy bill, the energy data is taken from the Eurostat energy balances (nrg_bal_c) dataset, which is expressed in tonnes of oil equivalent (toe), to ensure comparability between fuels. However, the data taken from this dataset include intra-EU flows, i.e. imports and exports between Member States. Because the EU is treated as a whole in this report, these intra-EU flows must be removed to analyse only imports and exports with non-EU countries. The Eurostat datasets of imports and exports by partner country[208], which are expressed in physical units, are used to calculate the ratio of extra-EU imports to total imports for solid fossil fuels, natural gas, oil products and electricity. This approach is replicated for exports. Then, these ratios are applied on the energy balances figures to obtain harmonised energy data for extra-EU imports and exports (in toe)[209].

7.2.2 Calculation of energy bills

Regarding the calculation of energy bills by fuel, more detailed data is used as described in the following.

Crude oil

In the case of crude oil, Member States report on a monthly basis the volume and average CIF price[210] of imported crude oil[211]. Each month, the collected and aggregated information is published in a Eurostat database (nrg_cb_cosm). This database only includes data on gross extra-EU imports, not on extra-EU exports. The oil bill has thus been calculated without removing extra-EU exports. However, these exports are negligible, so the bill is only slightly overestimated. Data are available until August 2022. Volumes in barrels and prices in USD per barrel are used. For the conversion of US dollars into euros, the monthly arithmetic average of the daily official exchange rates published by the European Central Bank is used[212]. The bill is therefore calculated per month for each country and then summed up to get the annual figure for the EU, which allows price and volume variations to be better taken into account than with annual averages.

- It should be noted that since 2015 Czechia does not report these figures. In 2014, Czechia's imports represented about 1.5% of total EU imports, implying an estimated annual import bill of EUR 2-4 billion.
- For confidentiality reasons, Germany does not report pipeline import volumes and prices since 2018.
- From January 2020 onwards, data for Denmark, Ireland, Greece, Poland and Finland have become confidential; for Sweden in July 2020, and for Slovakia in December 2020.
- Only crude oil volumes are reported for Bulgaria, Lithuania and Hungary from January 2020.
- The calculation methodology is therefore adjusted from 2020 onwards. The monthly oil import volumes reported are multiplied by a coefficient reflecting the share of these reporting countries in the total oil import volume in 2017-2019, in order to estimate the import volumes of the countries no longer reporting data for confidentiality reasons. This estimated monthly import volume for the EU is multiplied by the average monthly import price for the EU (calculated as

[208] Namely nrg_ti_sff, nrg_te_sff, nrg_ti_gas, nrg_te_gas, nrg_ti_oil, nrg_te_oil, nrg_ti_eh, nrg_te_eh.
[209] Because of missing data, the data for renewables and other energy products are not corrected (so they include intra-EU flows). However, as their share is very small (less than 1% of the EU net energy imports), this doesn't affect the global results and the estimations can be considered sufficiently accurate.
[210] The CIF price includes the FOB price (the price actually invoiced at the port of loading), the cost of transport, insurance and certain charges related to transfer operations.
[211] Reporting obligation introduced under Regulation (EC) No 2964/95 of 20 December 1995 introducing registration for crude oil imports and deliveries in the Community. (EC (1995). Council Regulation (EC) No 2964/95 of 20 December 1995 introducing registration for crude oil imports and deliveries in the Community.
[212] European Central Bank (2022). Euro foreign exchange rates.

the average of the monthly prices of the 9 countries still providing this information, weighted by the import volumes of these countries) to obtain the monthly oil import bill for the EU. The conversion between dollars and euros is still done on the monthly bills.

Natural gas

For natural gas, the monthly import volumes of the European Network of Transmission System Operators for Gas (ENTSO-G) transparency platform[213] are used, which are based on the gas flows reported by gas transmission system operators. Gas imports come into the EU from Russia, Norway, Algeria, Libya, Azerbaijan and the UK through several pipelines, while in 2020 LNG imports were coming from 12 supplying countries to 24 terminals in 12 Member States[214]. Volumes are calculated by adding the gas flows at the relevant entry points of the EU gas network. As the re-exports (Balkans, Kaliningrad, etc.) are removed, these volumes can be considered as net imports. Data are available until August 2022.

Gas import prices can vary across Member States depending on the supplier, the supply route, the type of contract (spot or long-term), the pricing method (hub-based or oil-indexed) and the level of competition. Based on available sources, including customs data, national agencies (e.g. BAFA in Germany) and commercial data providers, an estimated monthly average price has been established for each supplier (Russia, Norway, Algeria, Libya, Azerbaijan and LNG) by DG ENER. The gas import price for the UK is estimated by the price for Norway. These prices are nominal. Data are available until June 2022. The annual average prices shown in the table below are averages weighted by the volumes imported each month.

Table 29: Estimated average gas import prices by supplier (EUR/MWh)

Year	Russia	Norway	Algeria	Libya	LNG	Azerbaijan	Average
2014	28.0	20.1	28.3	29.4	25.4		25.5
2015	23.5	19.1	23.4	23.5	20.5		21.9
2016	16.0	14.1	16.0	14.7	15.4		15.4
2017	17.8	17.3	17.9	15.4	18.4		17.6
2018	21.7	23.3	20.6	21.2	23.6		22.2
2019	18.4	14.0	21.9	17.8	14.9		16.7
2020	11.2	8.7	15.4	12.2	8.8		10.2
2021	28.8	38.6	18.0	33.5	47.6	42.1	35.0
2022*	77.8	92.5	36.7	85.0	92.7	94.2	83.9

Source: DG ENER estimations
**Only for the first half of 2022.*

Coal

In the case of coal, the volumes considered are the net extra-EU hard coal imports reported in the annual Eurostat statistics (nrg_ti_sff for imports, nrg_te_sff for exports). The CIF ARA spot price reported by Platts is taken as representative of most coal imports into the EU. An annual average price is calculated as the arithmetic average of the monthly prices.

[213] Entsorg (n.d.). Transparency platform.
[214] Including small-scale terminals in Finland and Sweden.

At the date of writing, data from Eurostat are only available until 2020. Import volumes for 2021 and the first half of 2022 are estimated by applying the variations in extra-EU imports from the nrg_cb_sffm dataset to the 2020 data. The CIF ARA spot price is available for the whole period.

Table 30: Sources of data for the calculation of the bills

Fuel	Volume	Price	Restated
Crude oil	Eurostat (monthly)	Eurostat (monthly)	Yes (from 2020)
Natural gas	ENTSOG (monthly)	DG Energy estimations (monthly)	No
Hard coal	Eurostat (annual)	Platts (monthly)	Yes (from 2021)

7.3 Drivers

The import bill depends essentially on the volume and average price of imports. Like most commodities, energy sources are generally traded in US dollars and therefore the evolution of the USD/EUR exchange rate also influences the import bill if expressed in euros.

7.3.1 Volumes

Import volumes depends on the level of consumption, the evolution of domestic production (a decrease leads to a higher import dependency) and, to a lesser extent, stock changes. Exports can also influence import volumes, as an increase in exports must be balanced by an increase in imports.

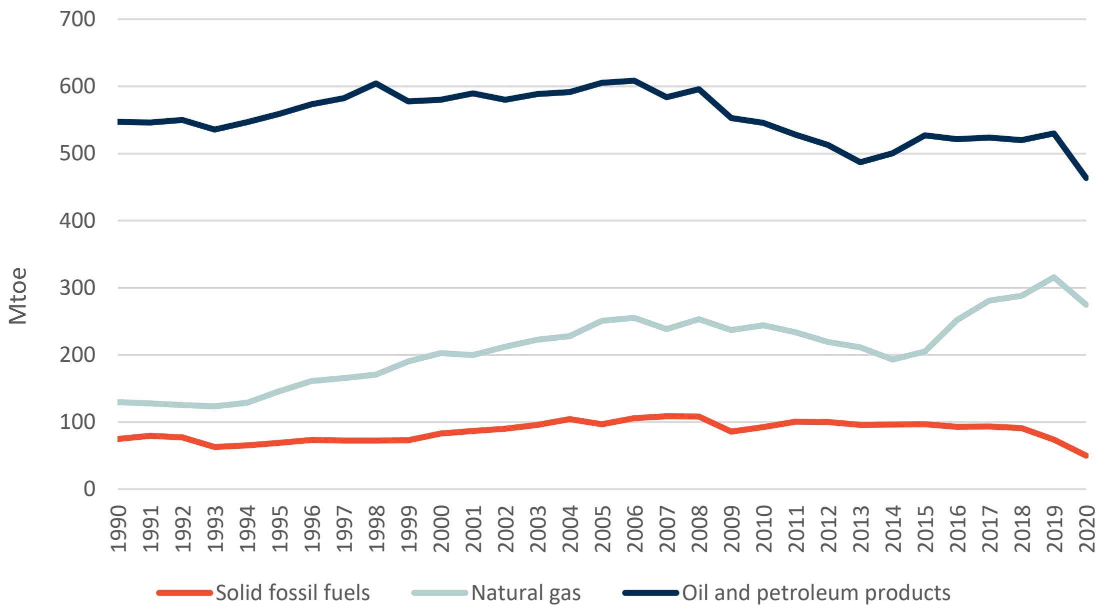

Figure 192: EU net energy imports 1990 - 2020

Source: Eurostat

Total EU fossil fuel imports showed a clear upward trend during the 1990s and most of the 2000s. Since then, the trends for the different fuels are diverging.

- In the case of oil, imports declined from 2008 onwards but rebounded in 2013 as the sharp fall in oil prices triggered an increase in fuel demand. As a result, they rise slightly until 2019. In

2020, oil imports plummeted due to the COVID-19 pandemic, which drastically reduced demand and international trade.

- Gas imports fell between 2010 and 2014 as gas lost ground in the power sector, where it faced increasing competition from renewables and coal. Gas imports rose sharply again after 2014, as increased gas consumption and the ongoing decline in domestic production increased the need for imports, as did the substitution of coal for industrial and power generation needs.
- In case of hard coal, import volumes increased in 2010 and 2011, helped by low prices (cheap shale gas squeezed coal out of the US power sector and made it available for export), coupled with low carbon prices. Imports then stagnated, before starting a marked downward trend from 2018. Indeed, the competitiveness of gas has improved compared to coal and, in addition, many Member States have announced their intention to phase out coal. This trend has reversed in 2021 and 2022 as historically high gas prices led to gas-to-coal switching in the power sector.

7.3.2 Prices

International commodity prices generally decreased between 2014 and 2016 and rose between 2016 and September-October 2018. Prices subsequently decreased until April-May 2020, before rebounding. The surge in gas and coal prices since mid-2021 is unprecedented.

In the short run, changes in the import volumes are usually moderate whereas prices can be rather volatile. For example, the price of oil fell by almost 70% between mid-2014 and early 2016 or between December 2019 and April 2020, while coal prices have more than doubled between the beginning and the end of 2016.

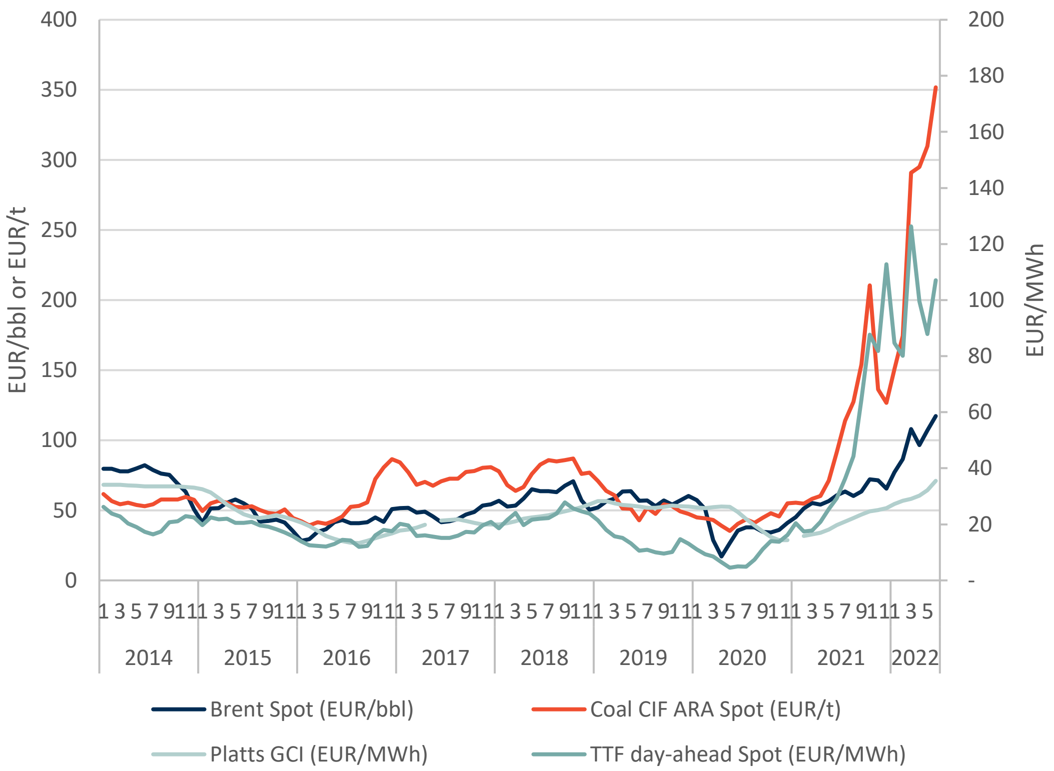

Figure 193: European oil, gas and coal prices over 2014-2022

Source: Platts

GCI is the North-West Europe Gas Contract Indicator, a theoretical index showing what a gas price linked 100% to oil would be.

Price volatility has an impact on the energy expenditure of EU consumers and, at macroeconomic level, the impact can be tracked in economic growth and inflation. According to an analysis carried out in 2015 and 2016, lower oil prices resulted in an additional GDP growth of 0.8% and 0.5%, respectively. Since crude oil prices are rising again, an opposite impact is anticipated.

The **average oil import price** for the EU was close to the Brent spot price until the end of 2019 (deviation ranging from +4.1% to -6.7%, -1.4% on average). A sharp fluctuation occurred between March and May 2020. Since May 2020, the average oil import price for the EU has been below the Brent spot price by an average of 7%.

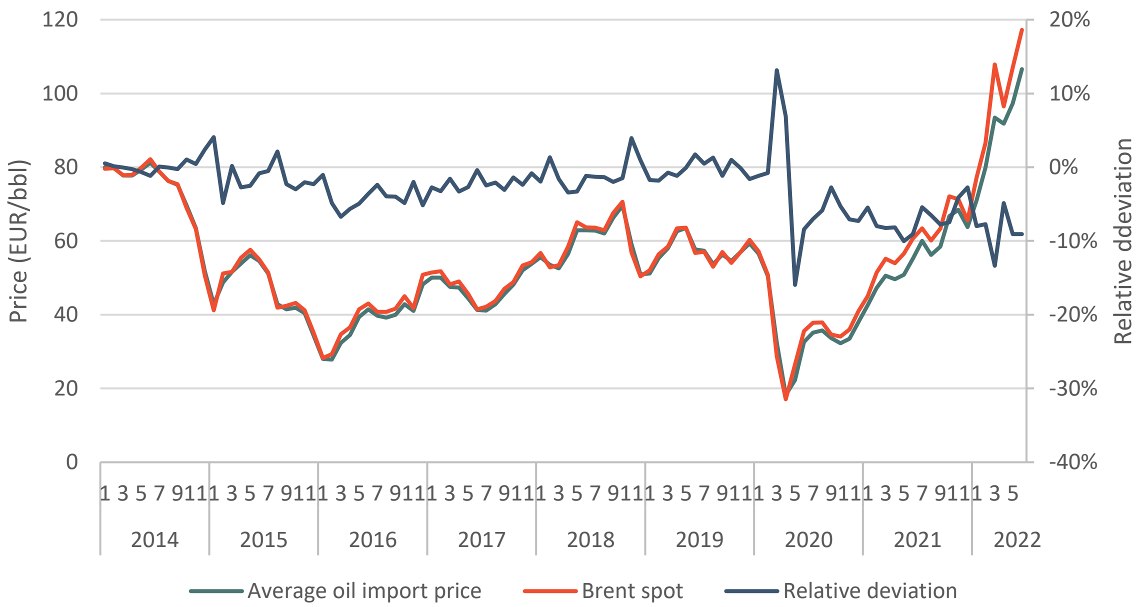

Figure 194: Comparison between average oil import price and Brent spot price

Source: Eurostat (nrg_cb_cosm) for import price, Platts for Brent spot price.

The **average gas import price** for the EU was higher than the TTF day-ahead spot price until around the end of 2016, by 17% on average. In 2017 and 2018, this relative deviation fluctuated, being sometimes positive, sometimes negative. From the beginning of 2019, the import price again became clearly higher than the spot price, reaching +68% in May 2020. Thereafter, the spread collapsed, losing 88 percentage points in four months. The import price has remained below the spot price since then, by 17% on average.

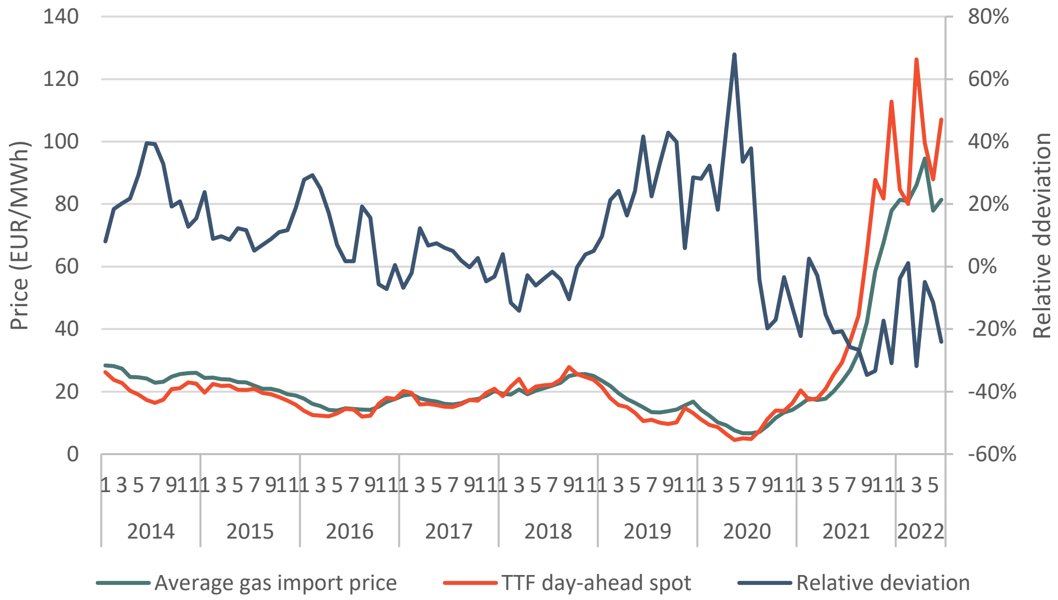

Figure 195: Comparison between average gas import price and TTF day-ahead spot price

Source: DG ENER estimations for import price, Platts for TTF spot price.

7.3.3 Exchange rate

Most energy products are traded in US dollars, even if the share of natural gas contracts signed in euros increased from 38% in 2018 to 64% in 2020[215]. Therefore, fluctuations in the USD/EUR exchange rate can directly affect prices and the import bill when measured in euros.

Historically, there has always been a negative correlation between oil prices and the US dollar. In other words, the price of oil and the value of the US dollar generally move in an opposite direction: a strengthening dollar typically coincides with a decrease in oil prices and vice versa[216]. This means that changes in the oil price, either upwards or downwards, are mitigated by the exchange rate and the volatility of the oil price expressed in euros is lower than the volatility of the price expressed in dollars. Given the correlation between oil, gas and coal prices, this also applies to some extent to coal and gas prices.

In recent years, the USD/EUR exchange rate was fluctuating between 1.25 and 1.05. Then the COVID-19 crisis caused instabilities and a rise in the rate to reach USD 1.23 per EUR by the end of 2020. Since the beginning of 2021, the euro has been weakening and reached an historical low of USD 0.9565 in late September 2022. Since then, the USD/EUR exchange rate recovered to near parity.

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[215] European Commission (n.d.). The international rôle of the euro.
[216] Although recently, with the decline in US oil imports, this relationship has weakened.

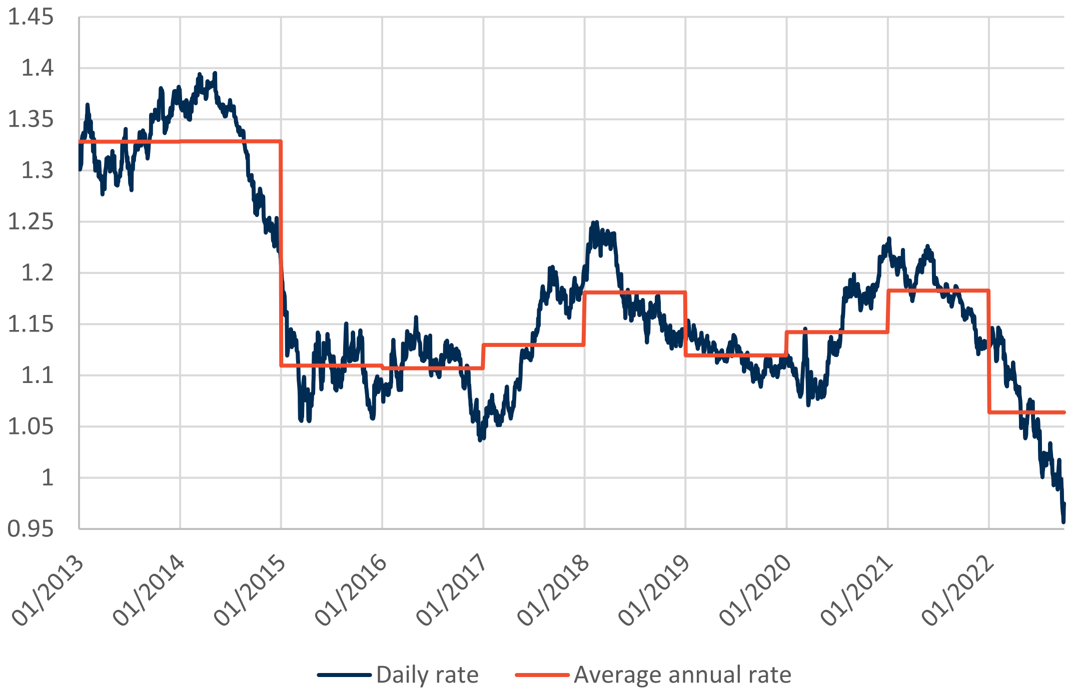

Figure 196: USD/EUR exchange rate

Source: European Central Bank

Therefore, it would be in the best interest of the European Union to develop further the global role of the euro, reflecting the euro area's economic and financial weight[217]. As the EU is a net importer of oil, gas and coal, a broader deployment of the euro in the international trade of these energy products could eliminate the risk of price volatility stemming from the fluctuation of the euro against the US dollar.

7.4 Import bill calculation

7.4.1 Oil

Table 31: EU crude oil import bill in 2014-2022

	Unit	2014	2015	2016	2017	2018	2019	2020	2021	2022 H1*
Imports (extra-EU)	Mbbl	3500	3723	3660	3675	3654	3659	3150	3204	1693
Average CIF price	USD/bbl	99.1	51.8	41.9	53.1	70.3	64.1	40.1	65.9	98.1
Import bill in USD	bn USD	345	192	154	195	257	234	128	212	166
USD/EUR exchange rate	USD/EUR	1.33	1.11	1.11	1.13	1.18	1.12	1.14	1.18	1.09
Import bill in EUR	bn EUR	259	173	139	173	218	209	112	180	153

Sources: Eurostat (nrg_cb_cosm), based on Member State reports under Regulation (EC) No 2964/95, for the volumes and prices; European Central Bank for the exchange rate; own calculations for import bill.
**Only for the first half of 2022.*

[217] European Commission (n.d.). The international role of the euro.

Historically, the EU's oil import bill decreased significantly between 2014-2016 due to falling oil prices, from USD 375 billion to around USD 150 billion in 2016 (~-60% in three years). The weakening of the euro compared to the USD over the same period slightly reduced the impact on the euro bill, which fell from EUR 282 billion in 2013 to EUR 139 billion in 2016, a decrease of 51%.

In 2017-2018, the average price of Brent rose to 71 USD/bbl and, with annual import volumes remaining fairly stable at around 3650 Mbbl per year, the EU's oil import bill was mainly driven by this price increase: around EUR 218 billion in 2018 (+57% compared to 2016). The euro strengthened slightly over this period, which moderated the increase in the oil bill (+57% in EUR vs +68% in USD).

The oil import bill was almost halved in 2020 to EUR 112 billion, as a result of a sharp fall in prices and reduced consumption due to the COVID crisis, before rebounding by 60% in 2021 to EUR 180 billion following the sharp rise in prices and the recovery in consumption. The bill for the first half of 2022 already amounts to 85% of the 2021annual bill; the average import price of oil over the period has increased by 50% compared to 2021 and the 8% fall in the exchange rate exacerbates the phenomenon.

7.4.2 Gas

The EU's gas import bill followed the fluctuations in gas prices. It fell between 2014 and 2016, from EUR 65 billion to EUR 49 billion (-25%), thanks to a significant fall in gas prices, despite a 25% increase in gas import volumes. It then rose sharply in 2017 and 2018, due to a parallel increase in import volumes and rising prices, to reach EUR 80 billion in 2018 (+60% vs 2016). The EU's gas import bill fell by 16% in 2019 and by 45% in 2020 to EUR 36 billion before exploding in 2021, multiplied by 3,5 compared to 2020, to reach EUR 129 billion (which is twice the annual average over the period 2014-2019). The main factor is, again, the price of gas, which the EU is obliged to buy on the spot markets as Russian deliveries under long-term contracts fell.

Table 32: EU gas import bill in 2014-2022

	Unit	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Net imports (extra-EU)	TWh	2548	2810	3173	3579	3586	3966	3555	3689	1924
Estimated average import price	EUR/MWh	25.5	21.9	15.4	17.6	22.2	16.7	10.2	35.0	83.9
Import bill	bn EUR	65.0	61.6	48.8	63.1	79.7	66.4	36.2	129.0	161.3

Sources: ENTSO-G for volumes; DG ENER estimations for prices; own calculations for import bill.
**Only for the first half of 2022.*

The trend continued into 2022 and the gas import bill reached over EUR 160 billion for the first half of the year – exceeding the entire year of 2021. It corresponds, over the first 6 months of each year, to 9 times the amount for 2020 and 4.6 times that for 2021.

7.4.3 Coal

Table 33 - EU hard coal import bill in 2014-2022Q2

	Unit	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Net imports (extra-EU)	Mt	151.0	151.6	145.1	150.2	143.5	115.3	77.5	*95.6*	*52.1*
Coal CIF ARA spot price	EUR/t	56.6	51.2	54.4	75.0	77.6	53.7	43.7	105.0	262.1
Import bill	bn EUR	8.6	7.8	7.9	11.3	11.1	6.2	3.4	*10.0*	*13.7*

Sources: Eurostat (nrg_ti_sff, nrg_te_sff and nrg_cb_sffm) for volumes; Platts for CIF prices; own calculations for import bill.

**Only for the first half of 2022.*

Extra-EU coal import volumes remained almost stable between 2014 and 2017 and the import bill followed the evolution of prices: 9% decrease in 2015 to reach EUR 7.8 billion, stagnation in 2016, 40% rebound in 2017 to EUR 11.3 billion. Imported volumes started to decrease in 2018, leading to a stabilisation of the bill despite an increase in prices. This downward trend was confirmed and accentuated in 2019 and 2020. Coupled with a sharp drop in prices, the bill was divided by more than 3 in two years to represent EUR 3.4 billion in 2020.

According to the estimates of net EU coal imports for 2021[218], the coal import bill is expected to rebound sharply in 2021 to around EUR 10 billion, as volumes have increased again, and prices have more than doubled. In line with the increased demand for coal – as an alternative fuel for natural gas – and unprecedented price increases, the coal import bill for the first half of 2022 is estimated at around EUR 14 billion, 36% higher than the annual coal bill for 2021. The coal import bill for 2022 is anticipated to be 2.5 times higher than in 2021 and exceed EUR 25 billion.

7.4.4 Total

Since crude oil accounts for at least 70% of the EU's estimated total import bill (73% over the period 2014-2019), changes in its price and import volumes correspondingly drive changes in that of the import bill. Gas has a lower impact, on average 24% of the total import bill over this period, and coal - 3%.

In 2013, the total import bill was estimated at around EUR 375 billion, which is more than EUR 1 billion per day. Falling prices allowed the EU to reduce its estimated import bill to EUR 333 billion in 2014, EUR 243 billion in 2015 (-28% yoy) and EUR 196 billion in 2016 (-19% yoy). In 2017, higher energy prices and import volumes of gas resulted in a 27% increase in the import bill to EUR 247 billion. The continuation of this trend led to a further increase of 24% in 2018, reaching EUR 309 billion. In 2019, lower prices reduced the total import bill by 9% to EUR 282 billion.

The fall in prices and reduced consumption due to the COVID pandemic almost halved the import bill in 2020 to EUR 151 billion, but it rebounded sharply in 2021 to EUR 319 billion, mainly due to the surge in gas and oil prices. The total import bill for the first half of 2022 is already higher than the annual bill of 2021, accounting for around EUR 330 billion.

When expressed as a percentage of EU GDP (at current prices), the share of the estimated import bill decreased from 2.8% in 2014 to 1.6% in 2016. It rebounded in 2017 and 2018 to 2.3% of GDP in 2018. It

[218] Source: Enerdata (2022)

decreased to 2% in 2019 and dropped to 1.1% in 2020. The estimated import bill stood at 2.2% of EU GDP in 2021. The share of the estimated import bill in the EU GDP for the first half of 2022 was almost twice as high.

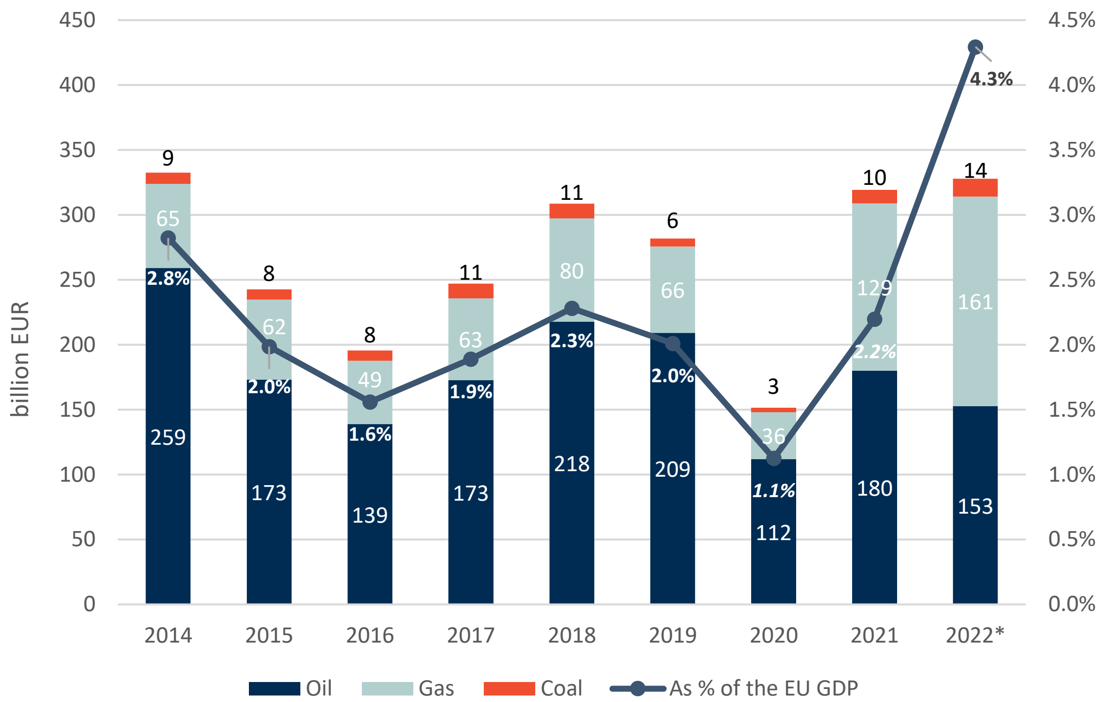

Figure 197: Estimated EU energy import bill
*Source: DG ENER calculation. *Only for the first half of 2022.*

Between 2014 and 2019, the decrease in the total energy import bill is due to the downward trend in energy prices. Two thirds of this effect was offset by the deterioration of the USD/EUR exchange rate (for 52%) and by the increase in imported volumes (for 14%).

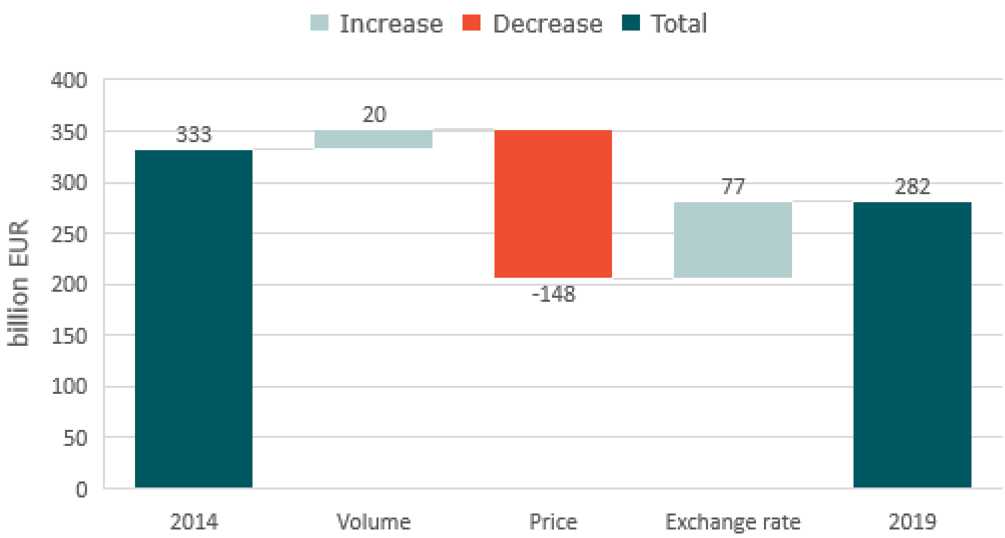

Figure 198: Breakdown of energy bill effects between 2014 and 2019
Source: Own calculations

In 2020, the total energy import bill fell by 45%. This is due to the sharp fall in prices (71%), the drop in imported volumes (linked to the drop in consumption during the pandemic; 26%) and the change in the USD/EUR exchange rate (3%).

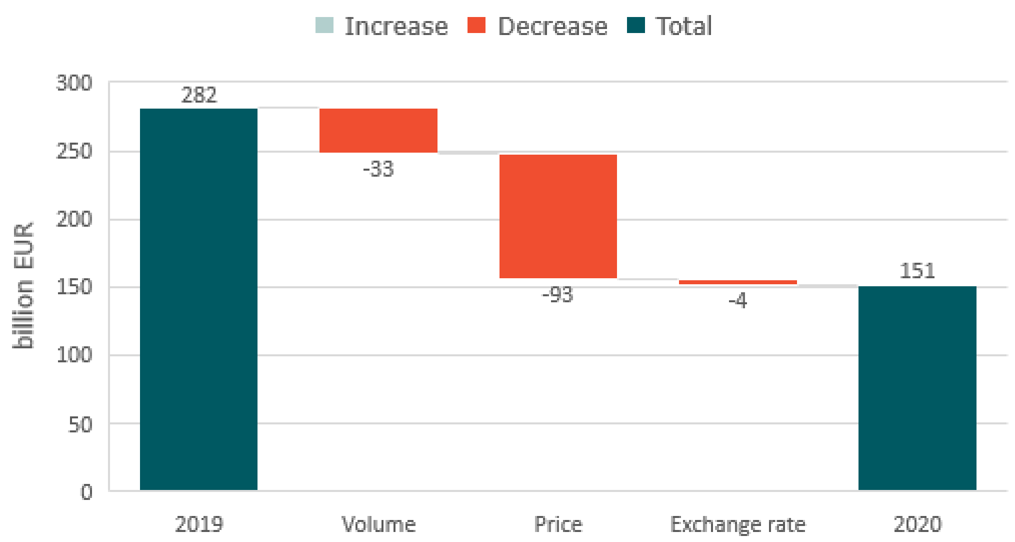

Figure 199: Breakdown of energy bill effects between 2019 and 2020

Source: Own calculations

In 2021, the doubling of the bill is almost entirely due to the explosion in energy prices.

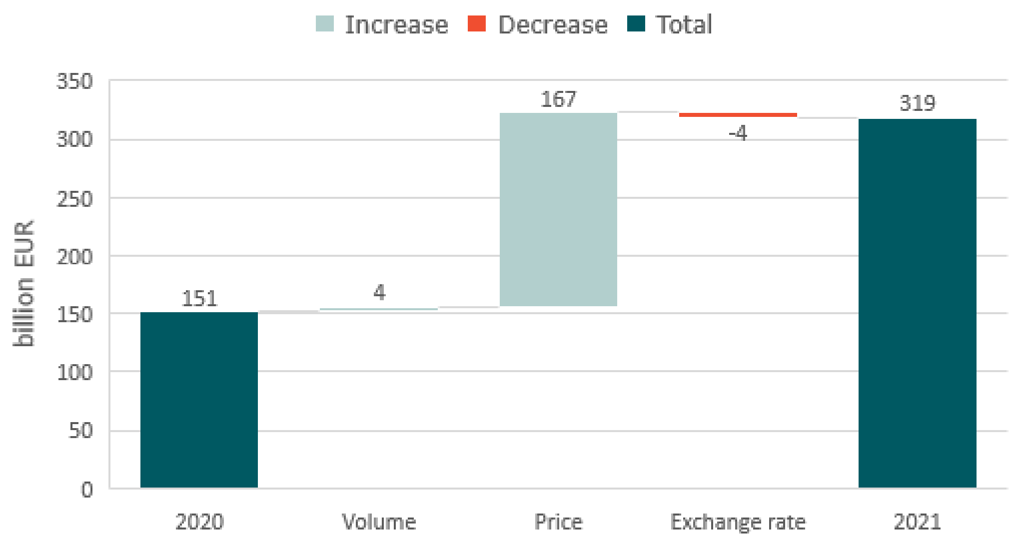

Figure 200: Breakdown of energy bill effects between 2020 and 2021

Source: Own calculations

7.5 Comparison with other estimates of the EU energy import bill

7.5.1 EU imports of energy products - recent developments - Eurostat[219]

Data in this publication is taken from Eurostat's COMEXT database. Its scope is slightly broader than that of our study as lignite, peat and coke are included. When we compare the figures for an equivalent scope (that of this study), we find that our estimates of annual energy import bills are about 4% higher than those of Eurostat since 2018 (which corresponds to EUR 10-17 billion annually), except in 2020 where our estimate is 10% lower (EUR 18 billion) than that of Eurostat. Our estimates tend to underestimate the coal bill compared to Eurostat calculations, and on the contrary to overestimate (by almost 20%) the gas bill. Our estimate of the oil bill is higher than Eurostat's in 2018 (+1.8%) and 2019 (+4%) but lower in 2020 (-10%), 2021 (-6.8%) and for the first half of 2022 (-5.6%).

7.5.2 CREA counter on Russian fossil fuel exports[220]

Since the start of the conflict in Ukraine in February 2022, many attempts were made to estimate the EU's import bill, specifically the payments made to Russia in exchange for natural gas and oil deliveries. One of them is the "counter" published CREA[221]. Such calculations are difficult to compare with those of this study, for many reasons:

- They focus on Russia's exports since the start of the war in Ukraine (24 February 2022).
- Not all detailed results are published.
- Their approach by importing country does not allow to calculate the EU as a sum because only bills of the main importers are published.
- Furthermore, the focus in our study is not on the origin of the imports.

However, the CREA study is interesting to analyse, especially from a methodological point of view. They use ENTSOG data for gas exports by pipeline, and monthly Eurostat data for exports of oil, oil products and coal overland. They track seaborne shipments from Russian ports using data from MarineTraffic.com and Datalastic, derived from ship location (AIS) data. They estimate prices of fossil fuel trades in 2022 by deriving historical monthly average prices for imports from Russia to the EU from Eurostat. They then fit models between these historical prices and average monthly spot prices for the current month and with time lags (Brent crude oil, TTF gas, Newcastle steam coal, Asian LNG, ARA coal).

[219] Eurostat (2022). EU imports of energy products – recent developments.
[220] CREA (2022). Payments to Russia for fossil fuels.
[221] Centre for Research on Energy and Clean Air

8 Role of energy for government revenues, taxes and levies

8.1 Government revenues from the energy sector in the EU-27

Main findings:

- In 2020, energy taxes collected by EU Member States amounted to EUR 232 billion or 1.74% of EU GDP. As a percentage of GDP, energy tax revenue has been rather stable for the period 2010-2019. The Covid-19 pandemic led to an erosion of the energy taxation base (e.g. energy consumption) thus triggering an 11% drop of revenues.
- In EU Member States, the role of energy taxes in government revenues and GDP shows a significant variety: Member States with a lower GDP/capita typically have a higher share of energy taxes in both total tax revenue, and relative to GDP.
- The EU average implicit tax on energy, measured as the energy tax revenue per 1 tonne of oil equivalent of gross inland energy consumption, was EUR 179/toe in 2020. In real terms, this average calculated tax rate increased by 15.3% between 2010 and 2020, peaking at EUR 184/toe in 2019.
- Excise duties constitute the largest part of energy taxes, amounting to around EUR 187 billion in 2020. When adjusted for inflation, excise duty revenues almost constantly increased from EUR 176 billion in 2010 to EUR 216 billion in 2019, which represents a 23% increase. Excise duty revenues dropped by 2.2% in 2019, and by 14.9% in 2020 due to Covid-19 mobility restrictions leading to reduce fuel consumption.
- Oil products derived from crude oil continue to dominate excise duty revenues, with an average share consistently above 80% in EU-27, even though their share decreased over the last decade. In 2020, the share of petroleum products in excise revenues was more than 90% in 19 Member States.
- The total reported energy tax rate has slightly shrunk in the EU-27 from EUR_{2021} 33/MWh in 2015 to EUR_{2021} 31/MWh in 2020, mainly due to the mobility restrictions imposed during the Covid-19 pandemic. The total tax rates in Member States ranged from EUR_{2021} 13/MWh in Hungary to EUR_{2021} 45/MWh in Denmark, with a median of EUR_{2021} 24/MWh, in 2020.
- The total tax rate on electricity for the EU-27 as a whole has almost doubled since 2010 from EUR_{2021} 18/MWh to EUR_{2021} 34/MWh in 2020 because of the growth of renewable charges, which have been a burden shouldered by electricity consumers.

8.2 Energy taxes

Energy taxes are, according to the common definition of the OECD and Eurostat, a subset of environmental taxes[222]. They include taxes on energy production and on the consumption of energy products, used for both transport and stationary purposes; as well as taxes on the stocks of energy and on energy system infrastructure. Eurostat also includes in this category the revenues derived from the auctioning of emissions allowances under the EU ETS[223].

Energy taxes represent a significant source of government revenue in all EU Member States, the total reaching EUR 232 billion in 2020, representing 1.74% of the EU GDP and 4.2% of total tax revenues[224]. While nominal energy tax revenue increased by 15% between 2009 and 2019 (on average by 1.47%/year), it remained relatively stable around 1.9% of EU GDP (and 4.7% of total tax revenues). Energy tax revenues dropped by 10.9% in 2020, mostly due to COVID-19 related mobility restrictions.

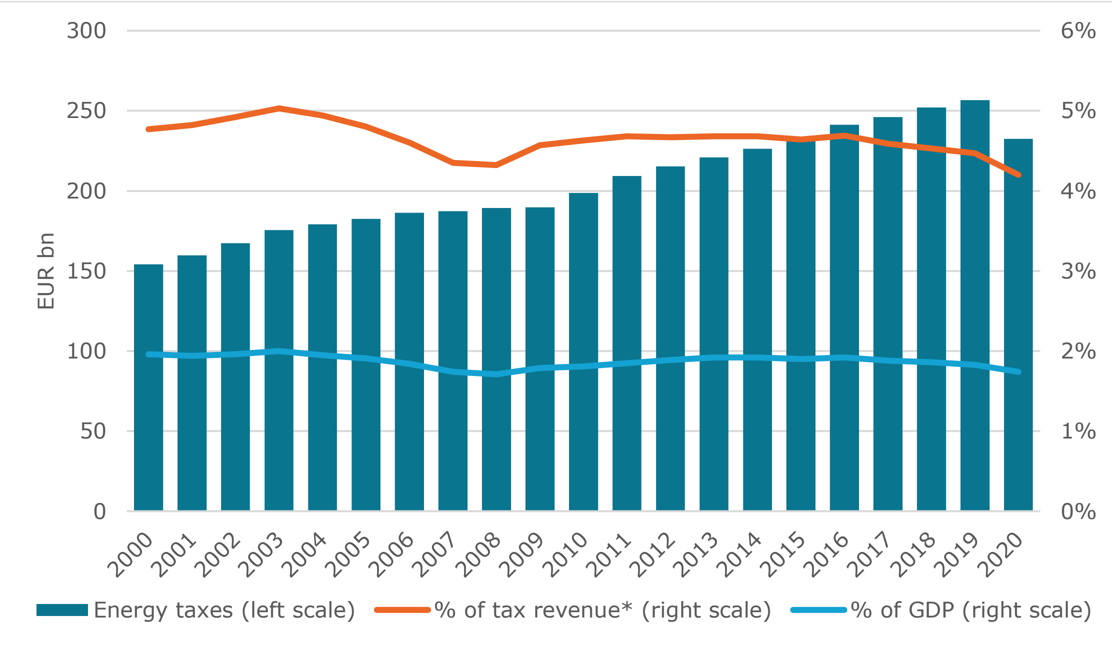

Figure 201: Energy tax revenue in the EU-27

Source: Eurostat (env_ac_tax)
**: Percentage of total revenues from taxes and social contributions (including imputed social contributions)*

The role of energy taxes in government revenues varies a lot between Member States: in 2020, energy taxes in Bulgaria made up 8.7% of total revenues from taxes and social contributions (including imputed social contributions), while this share was only 2.9% in Austria. When compared to GDP, energy tax revenue was the highest in Greece (2.9%) and the lowest in Ireland (0.8%). In general, Member States with a lower GDP/capita tend to have a higher share of energy taxes relative to both total tax revenue and GDP.

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[222] Environmental taxes - A statistical guide - 2013 edition, https://ec.europa.eu/eurostat/fr/web/products-manuals-and-guidelines/-/ks-gq-13-005

[223] It is to be noted that the Eurostat guideline "*recommends that taxes on oil and gas extraction should be excluded from environmental tax statistics*" to facilitate benchmarking across countries and prevent high volatility effect. Similarly, when it comes to "*fees and charges or obligatory contributions to finance renewable energy which are not taxes*", "*this guide recommends being very restrictive about imputing taxes*". The revenues from VAT on the consumption of energy products are also excluded. As a result, revenues from energy taxes reported by Eurostat are yielded quasi-exclusively from taxes on the consumption of energy.

[224] Including social contributions Source : Eurostat, Environmental tax revenues (env_ac_tax), extracted on 17/08/2022

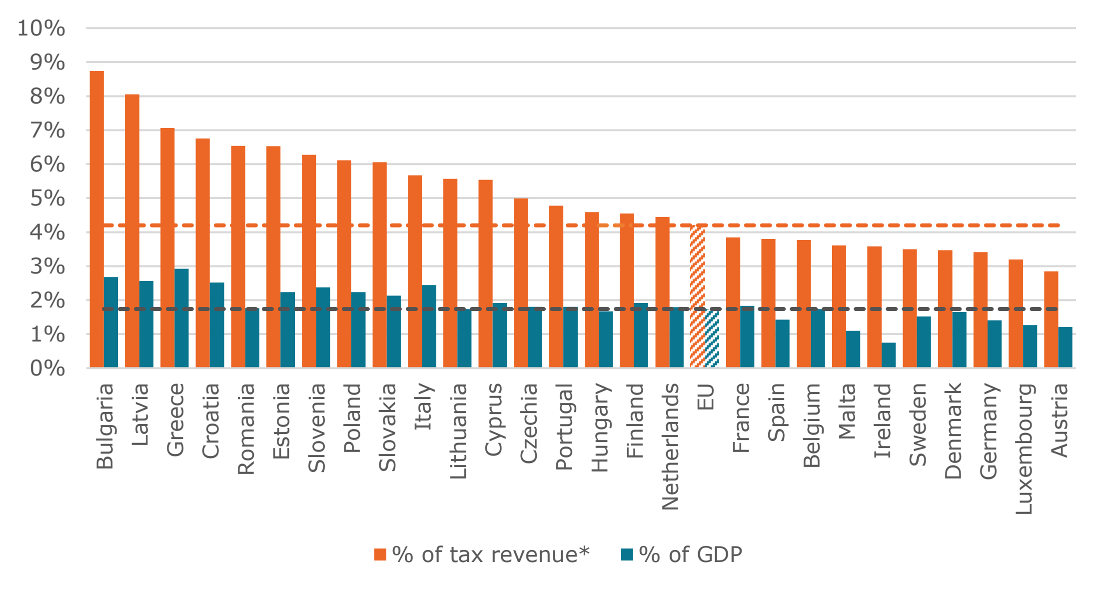

Figure 202: Energy tax revenue as a percentage of tax revenue and of GDP in 2020

Source: Eurostat (data series env_ac_tax)
*: *Percentage of total revenues from taxes and social contributions (including imputed social contributions)*

Eurostat energy tax revenues

The Eurostat energy tax revenue data, based on the National Tax List, is currently the reference dataset in the EU. However, as mentioned by Economisti Associati and Nomisma Energia in their "Study on Energy Taxation Indicators"[225], this dataset suffers serious drawbacks: "*The main advantage of this dataset is that it is fully compatible with the (environmental) national accounting principles (accrual values, territoriality, etc.) so it can be used to make direct comparisons with total taxation, GDP data as well as with the energy balances. It has two main drawbacks. First, only aggregate data per each Member State are available. For instance, there can be Member States reporting a single category for 'excise duties', without differentiating between transport or heating fuels, or electricity. (…). Secondly, and possibly even most importantly from the policymaking perspective in terms of possible quantitative distortions, there are major problems with data comparability, because of the national definition of what a tax, or an energy tax is, as already discussed in the case of RES charges (…). Once compliance with national accounts is ensured, there is no binding criterion Member States must follow for tax reporting. This gives rise to a number of heterogeneous reporting practices that hinder subsequent data comparability. For instance, there are countries: (i) separately reporting excise duties by type of fuels and keeping track of the related carbon tax component even if the tax is formally the same (e.g. Denmark); (ii) bundling together in the same amount revenues from all fuel excises together with the carbon tax component (e.g. Sweden); (iii) bundling together all energy excises including electricity together with the carbon tax (e.g. Portugal); (iv) separately reporting system charges or public service obligations as a tax; (v) separately reporting RES charges as a tax (e.g. Belgium); (vi) bundling together electricity excises with RES charges (e.g. Italy, Croatia).*"

[225] "Study on Energy Taxation Indicators", 2021, Economisti Associati and Nomisma Energia, available at https://op.europa.eu/en/publication-detail/-/publication/4609322a-56e1-11eb-b59f-01aa75ed71a1/language-en/format-PDF/source-186554625

According to Eurostat NACE classification, households are the main contributor to energy tax revenues with 55% of total energy taxes paid in 2020, down from 58% in 2008. Economic activities such as manufacturing, transportation, and retail energy supply through networks are only second in contributing to energy taxes, with their shares at 12%, 11% and 7% of total energy taxes, respectively.

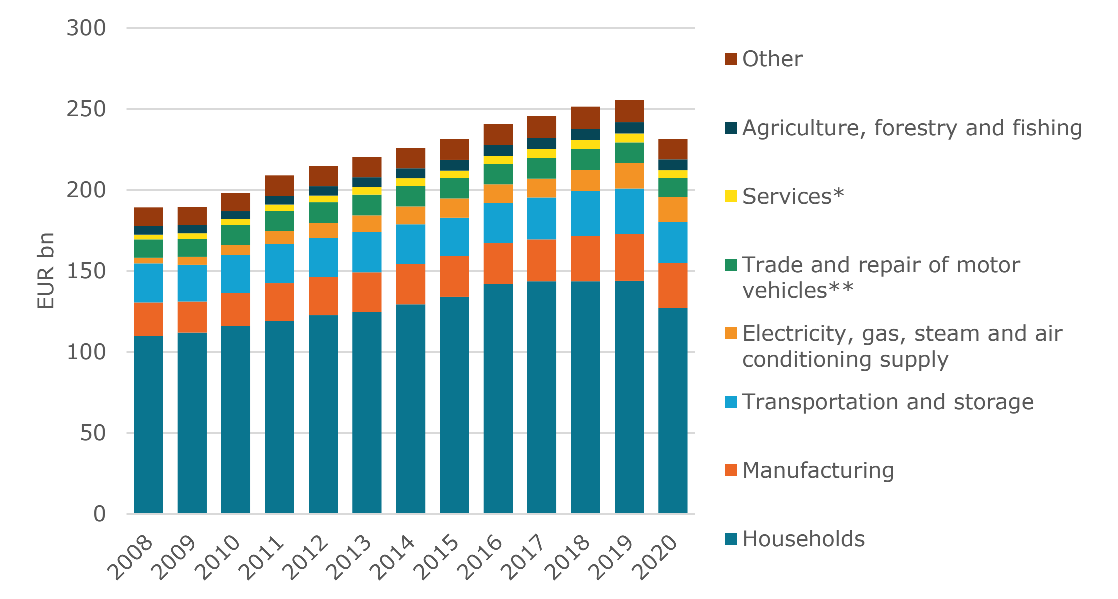

Figure 203: Energy tax revenue by economic activity (NACE)

Source Eurostat (data series env_ac_taxind2)
**: Services (except wholesale and retail trade, transportation and storage)*
***: Wholesale and retail trade; repair of motor vehicles and motorcycles*

Another interesting indicator to analyse the evolution of the energy tax revenue is the implicit tax on energy that is defined as the ratio between energy tax revenues and final energy consumption. This ratio represents the average energy tax revenue for 1 toe[226] of gross inland energy consumption in EU-27. Figure 4 shows that the EU's gross inland energy consumption has decreased by 6.5% between 2010 and 2019 (green line in the graph), which means a reduction of the tax base. Meanwhile the energy tax revenue has increased (see graphs above) which results to an increasing implicit energy tax rate both in nominal (blue bars in the graph below) and real terms (orange bars). Thus, the implicit energy tax rate in real terms (in euros 2021) increased from 151 EUR_{2021}/toe in 2010 to 177 EUR_{2021}/toe in 2014 and then stabilized around 180 EUR_{2021}/toe until 2020.

[226] Tonne(s) of oil equivalent, abbreviated as toe, is a normalized unit of energy. By convention it is equivalent to the approximate amount of energy that can be extracted from one tonne of crude oil. It is a standardized unit, assigned a net calorific value of 41 868 kilojoules/kg. See also: Eurostat glossary

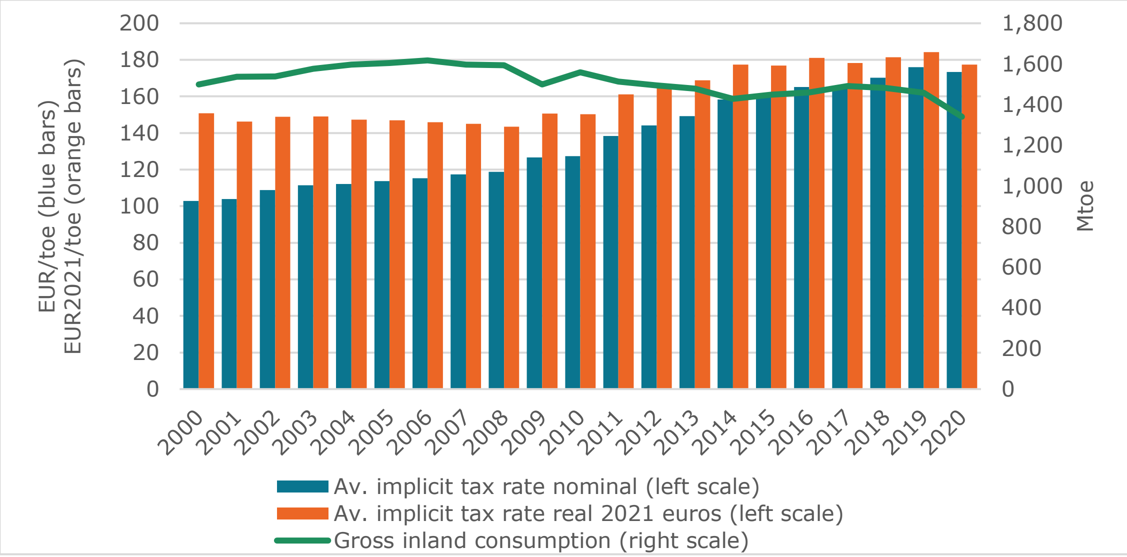

Figure 204: Average implicit energy tax rates in the EU-27

Source: Authors' calculations based on Eurostat data (env_ac_tax and nrg_100a)

On average, the implicit energy tax reached EUR 173/toe in 2020 (Figure 5), but there was a huge variation across Member States, from EUR 87/toe in Hungary to EUR 325/toe in Denmark.

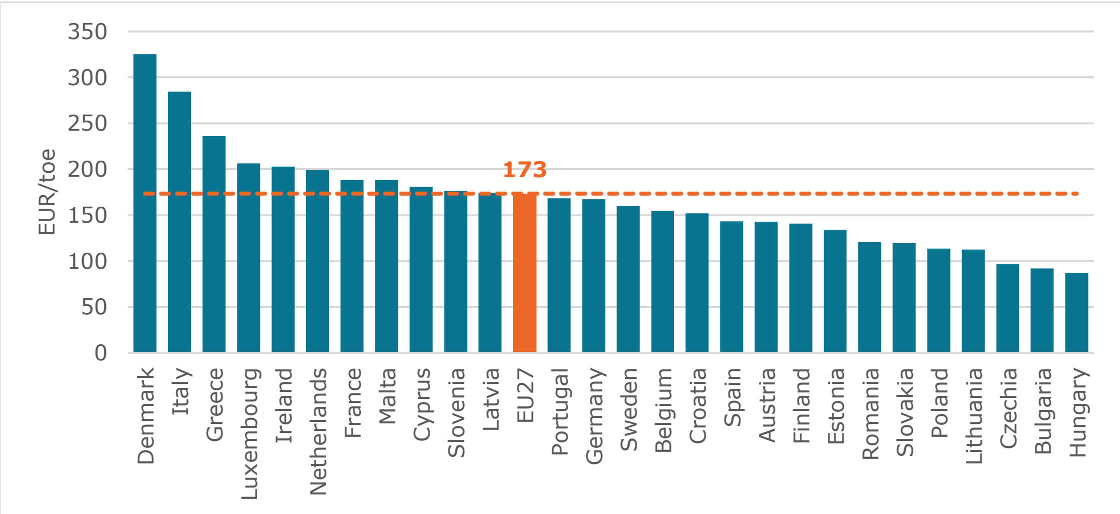

Figure 205: Average implicit tax on energy in 2020 (EUR/toe)

Source: Authors calculations based on Eurostat data (env_ac_tax and nrg_100a)

8.3 Excise duties

Excise duties are indirect taxes imposed on the sale or use of specific products, typically alcohol, tobacco, and energy products. All revenue from excise duties goes to the budgets of Member States. Excise duties are set in absolute values, i.e., as a fixed amount per quantity of the product (e.g. per liter/kg/GJ/MWh). Accordingly, assuming that the rates do not change, the revenue will depend on the consumption of the specific product. In contrast, price changes should not impact revenues unless they lead to a decrease of consumption.

Current EU rules for taxing energy products are laid down in Council Directive 2003/96/EC[227] (the Energy Taxation Directive). The Directive covers petroleum products (gasoline, gasoil, kerosene, LPG, heavy fuel oil), natural gas, coal, coke, and electricity when used as motor or heating fuel. In addition to establishing a common EU framework for taxing energy products, the Directive sets minimum excise duty rates. Member States are free to apply excise duty rates above these minima, according to their own national needs.

The Directorate-General for Taxation and Customs Union (DG TAXUD) regularly publishes the excise duty rates applicable in EU Member States[228] and the revenue from excise duties[229]. From 2010 to 2019 the excise duty revenues were constantly increasing from EUR 176 billion in 2010 to EUR 216 billion in 2019, which represents a 23% increase. In 2020, the reduction of energy consumption in the EU due to mobility restrictions as well as the scale-back of industrial production, reduced the underlying tax base of excise duties, leading to a 13% decrease of excise duties revenues. Excise duties revenues from mineral oils were the most impacted based on the decrease of transport energy consumption, and went down from EUR 173 billion in 2019 to EUR 153 billion in 2020.

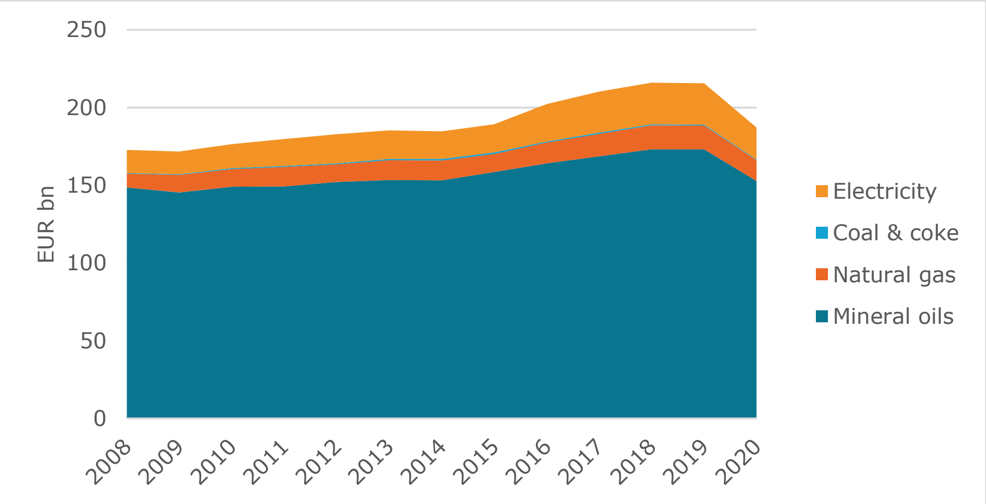

Figure 206: Excise duty revenues from energy consumption in the EU

Source: DG TAXUD, Excise duty receipts

227 Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:283:0051:0070:EN:PDF. Entered into force on 1 January 2004.

228 Excise duty rates applicable in the EU – Taxes in Europe database (TEDB) available at https://ec.europa.eu/taxation_customs/tedb/advSearchForm.html?taxType=EDU_ENERGY

229 https://taxation-customs.ec.europa.eu/system/files/2021-11/excise_duties_energy_products_en.pdf (at the time of writing the report this document included revenue data for the period 2008-2020)

If adjusted for inflation, excise duty revenues measured in 2021 euros remained relatively stable from 2008 to 2015 at around EUR_{2021} 207 bn. Between 2015 and 2018, however, real revenues increased by 11% reaching EUR_{2021} 229 bn. Excise duty revenues started falling in 2019 (-2%), especially during the COVID-19 pandemic, leading to a 15% decrease in 2020 at EU level.

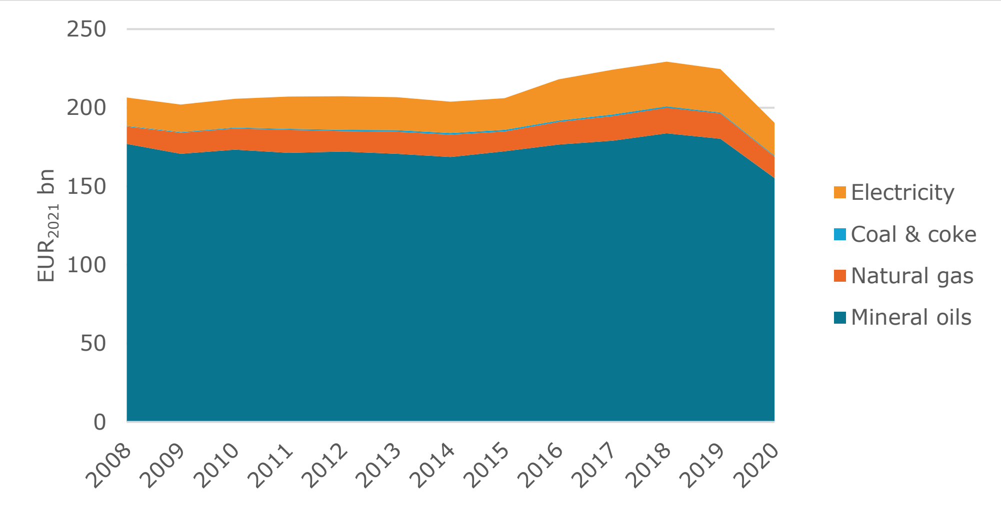

Figure 207: Excise duty revenues from energy consumption, adjusted for inflation (in 2021 euros)

Source: Authors calculations from DG TAXUD (excise duty receipts) and World Bank (deflator) data

The share of oil products of total revenues for the EU-27 decreased from 84.4% in 2010 to 81.6% in 2020, mainly compensated by natural gas and electricity. The share of natural gas increased from 6.5% to 7.2% and that of electricity raised from 8.9% to 11% between 2010 and 2020.

Unfortunately, as Austria and Germany do not provide excise duty receipts for each petroleum product, we cannot obtain a consolidated view of the revenue distribution between all the oil products at EU level. However, removing these two countries (that represent 25% of the EU's excise duty revenue from mineral oils), gasoil accounts for 47% of the total excise duty receipts, petrol for 21% and the other fuels for the remaining 2%.

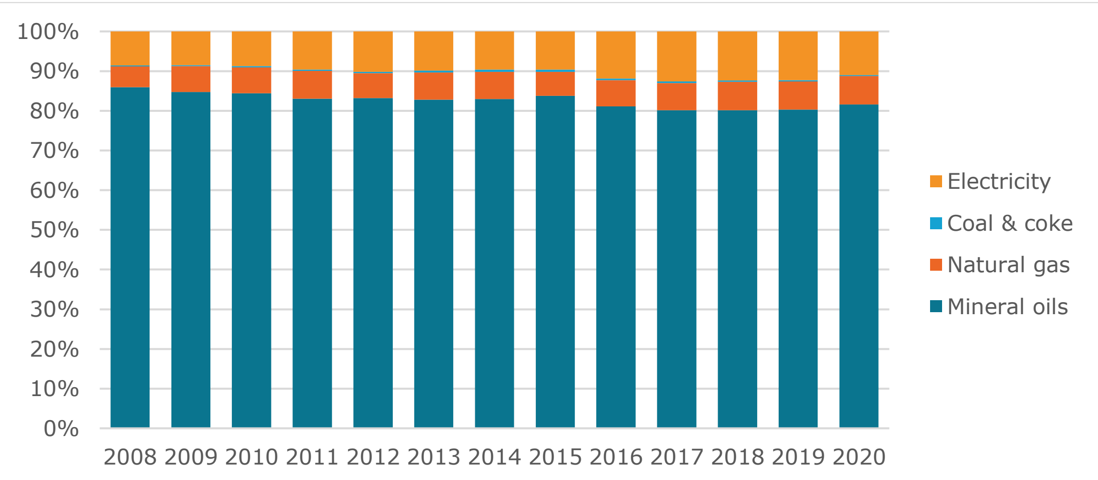

Figure 208: The share of excise duty revenues by energy product

Source: DG TAXUD, Excise duty receipts

Oil products make up most of the excise duty revenues in all Member States. Figure 9 shows that in 2020, oil products excise duty revenues represented more than 90% of the total revenues from excise duties in 19 Members States. Countries with the largest share of their excise duty revenues derived from natural gas are the Netherlands (38%), Austria (18%) and Italy (11%), while those relying more on electricity include Sweden (36%), Denmark (36%), Finland (25%) and France (19%).

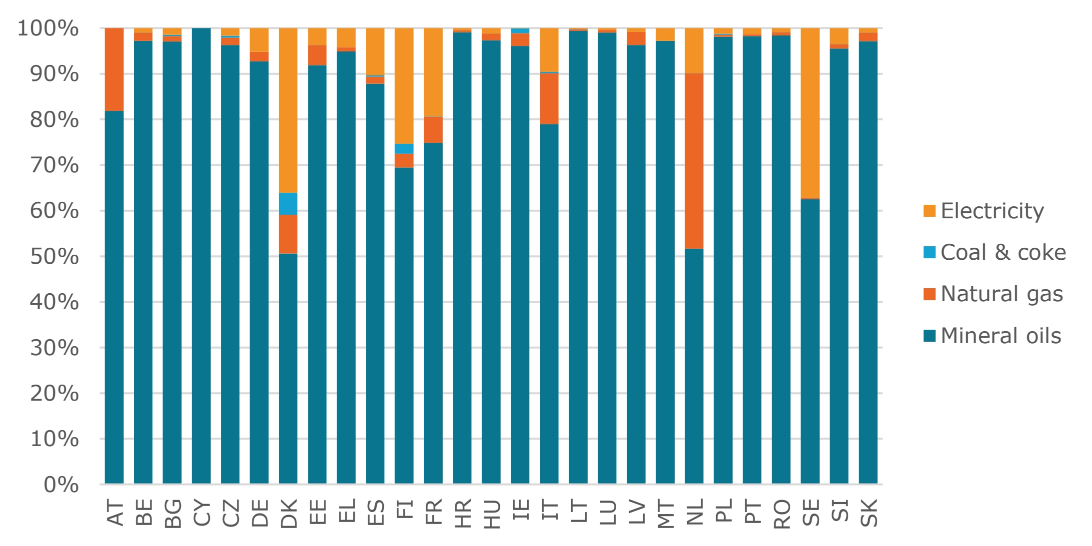

Figure 209: The share of excise duty revenues by energy product in 2020

Source: DG TAXUD, Excise duty receipts

The excise duty on **petrol** on average for the EU-27 increased by 21% between 2008 (EUR 45.8c/l) and 2021 (EUR 55.3c/l) (Figure 10). Due to the energy crisis, 15 MS reduced excise duties on gasoil between 2021 and 1st July 2022, leading to a 12% decrease on average in the EU-27. The largest falls have been recorded in Germany[230], Italy and Malta with drops reaching 45%, 35% and 34%, respectively.

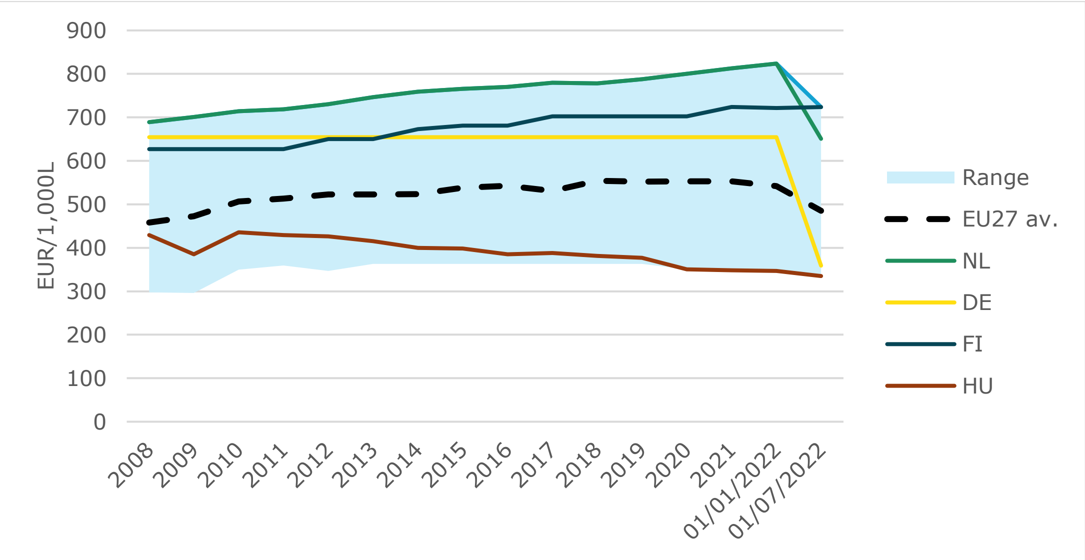

Figure 210: Excise tax rates for petrol in EU-27

Source: DG Taxation and Customs Union, https://ec.europa.eu/taxation_customs/tedb/

[230] The reduction in Germany was a temporal reduction during the months of June to August.

The excise duty on **gasoil (diesel)** on average for the EU-27 increased by 27% between 2008 and 2021, going up from EUR 34.2ct/l to EUR 43.5ct/l (Figure 11). As for gasoil, the excise duty rate was reduced by 12% on average in EU-27 between 2021 and 1st July 2022 in an attempt to offset the increasing prices of fuels, of which Italy, Portugal and Germany[230] implemented the largest with reductions of 40%, 35% and 30%, respectively.

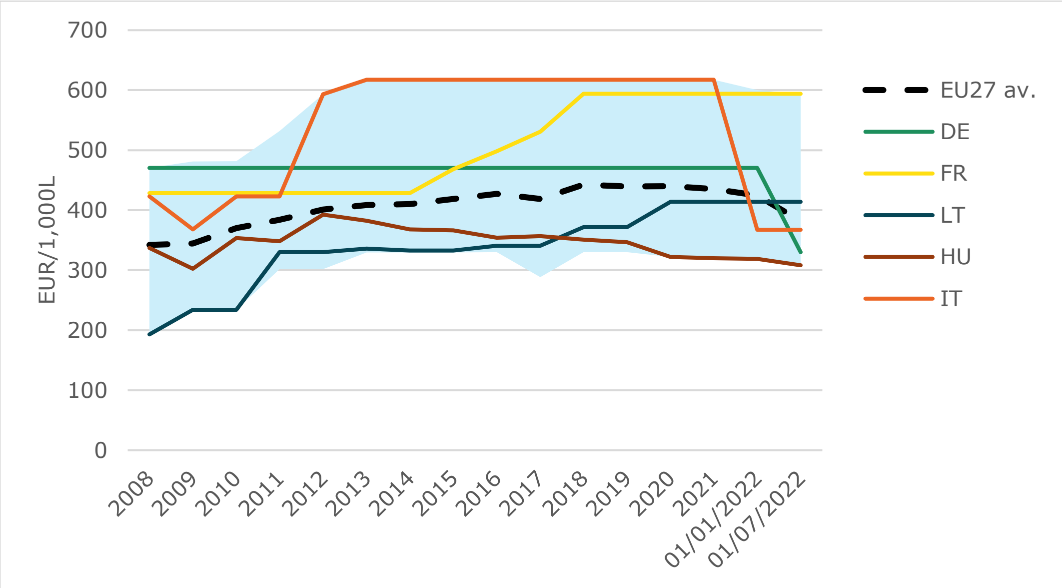

Figure 211: Excise tax rates for gasoil (diesel) propellant in EU-27

Source: DG Taxation and Customs Union, https://ec.europa.eu/taxation_customs/tedb/

The average excise duty on **electricity for households** (non-business use) for the EU-27 increased on average by 51% between 2008 and 2021 going up from EUR 10.4/MWh to EUR 15.7/MWh (Figure 12). This was driven by noticeable increases in the Netherlands, Denmark and Finland, and the inclusion of the fees financing the development of renewable technologies into the electricity excise taxes in Italy and France. Between 2021 and 1st July 2022, the EU-27 average excise duty rate on electricity shrunk by 23% as a consequence of cuts in 8 Member States (Austria, Hungary and the Netherlands implemented the largest decreases over this period).

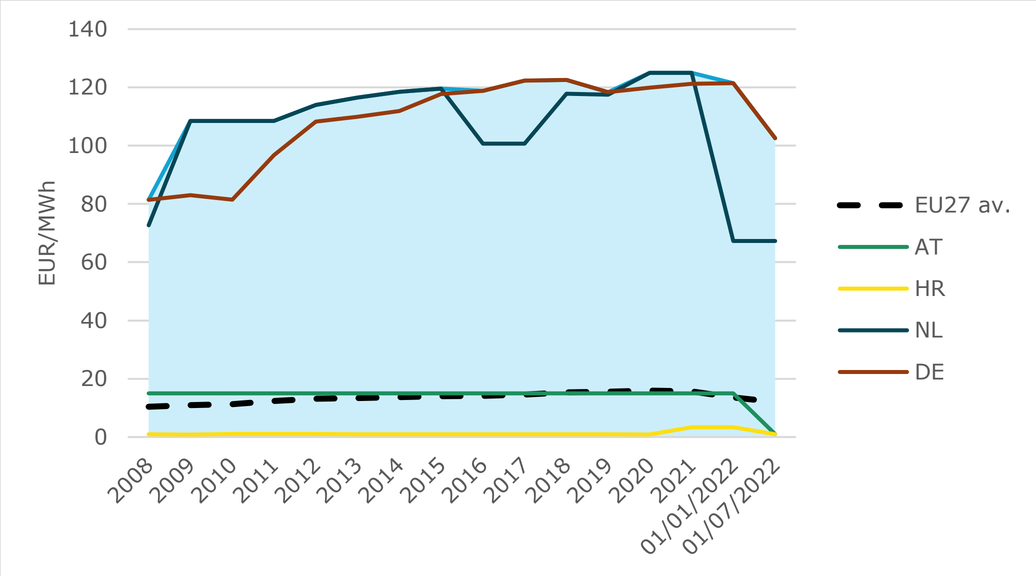

Figure 212: Excise tax rates for electricity for households (non-business use) in EU-27
Source: DG Taxation and Customs Union, https://ec.europa.eu/taxation_customs/tedb/

The average excise duty on **natural gas for households** (non-business use) across the EU-27 increased by 80% between 2008 and 2021, growing from EUR 1.3/GJ to EUR 2.3/GJ; and then decreased by 2% since 2021 (much lower than the drop reported for other fuels). In contrast to excise duty cuts on electricity, gasoil and petrol, only 4 Member States (Austria, Belgium, Hungary and Belgium) have lowered their excise duty rate on natural gas between 2021 and 1st July 2022.

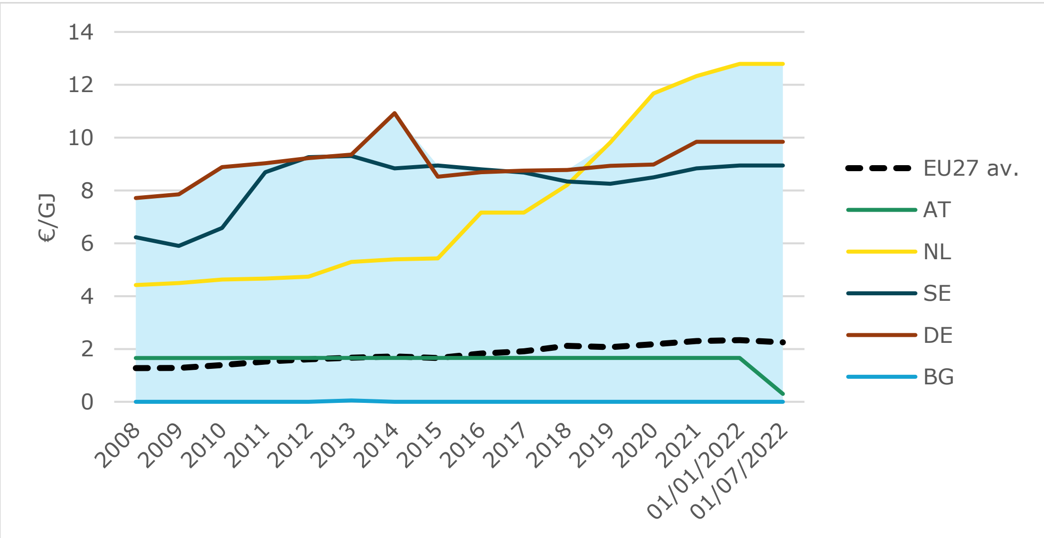

Figure 213: Excise tax rates for natural gas for households (non-business use) in EU-27
Source: DG Taxation and Customs Union, https://ec.europa.eu/taxation_customs/tedb/

8.4 Value added tax

The value added tax (VAT) imposed on energy products is another important source of government revenue. However, unlike for excise duties, there is no publicly available data for VAT revenues from energy products.

The VAT Directive (2006/112/EC)[231] requires that the standard VAT rate must be at least 15% and Member States can apply one or two reduced rates of at least 5% but only to goods or services listed in Annex III of the Directive (energy products are not in the list). However there are multiple exceptions to the basic rules, including the possibility of reduced rates for certain goods and services (e.g. Article 102 allows the use of reduced rate to the supply of natural gas, electricity and district heating, as well as several country-specific exceptions, including the permission to use “super reduced” rates under 5% (including for energy products).

The simple average standard rate of VAT on electricity in the EU-27 increased slightly from 17.5% in 2010 to 19.2% in 2021 (Figure 214); then it dropped to 17.2% due to cuts in several Member States, such as in Belgium, Ireland, the Netherlands, and Poland. In addition, several Member States (including Cyprus, Romania and Spain) have implemented VAT cuts for electricity consumer groups.

The average standard rate of VAT on **electricity** hides huge differences. Malta and Luxembourg have a rate of 5% and 8%, respectively, whereas Sweden and Hungary have a rate of 25% and 27%, respectively.

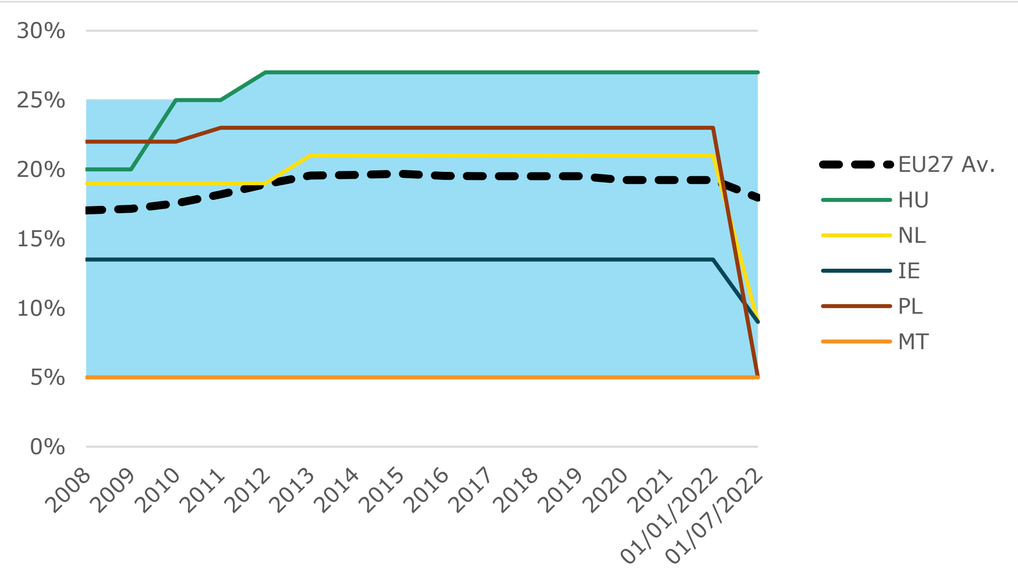

Figure 214: The average VAT rate for electricity in the EU-27

Source: DG Taxation and Customs Union, Bruegel, national sources

The simple average standard rate of VAT for **natural gas** in the EU-27 increased from 17.5% in 2010 to 19.7% in 2021 (Figure 215). Since then, it went down to 16.8% due to reductions in Belgium, Croatia, Ireland, the Netherlands and Poland. The Polish government, through the ‘Anti-Inflation Shield 2.0; measure, implemented the largest cut on VAT on natural gas from 8% to 0% from 1 February to 31 July 2022 after a first reduction from 23% to 8% in December 2021.

231 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:347:0001:0118:en:PDF

The average VAT rate conceals significant differences between Member States. Greece and Poland have the lowest rates at 6% and 0%[232], respectively, in 2022 whereas Hungary and Sweden have the highest with 27% and 25%, respectively.

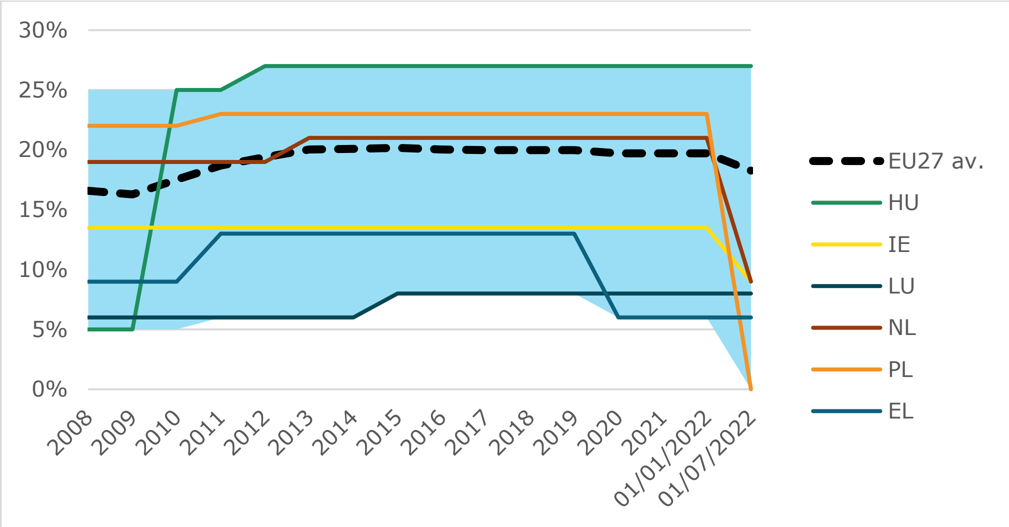

Figure 215: The VAT rate for natural gas in the EU-27

Source: DG Taxation and Customs Union, Bruegel, national sources

The simple average VAT rate for **heating gasoil** in the EU-27 went up from 19.6% to 21.1% between 2010 and 2021. Since then, only Portugal reduced its VAT on heavy fuel oil from 23% to 13% between 2021 and 1st July 2022.

Considering VAT cuts on the sale of petroleum product, we only identified reductions in Greece, Poland and Portugal in 2021 and 2022. Therefore, the simple average standard VAT rate on petroleum products has slightly increased for all the petroleum products over the past decade.

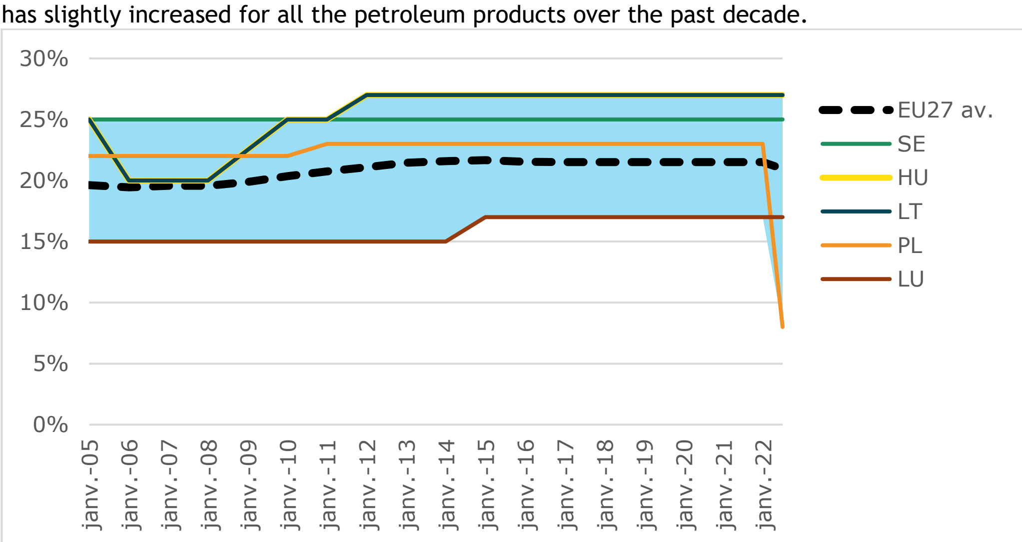

Figure 216: The VAT rate for heating gasoil in the EU-27

Source: DG Taxation and Customs Union

232 As of 31st July 2022.

The simple average VAT rate for **gasoil (diesel)** in the EU-27 (Figure 217) increased by 5.7% between 2010 and 2021 from 20.4% to 21.5%. The VAT rates for diesel are close together with only a range of 10 percentage points in 2021. Up to 31st July 2022, only Poland reduced the VAT on diesel through its Anti-Inflation Shield 2.0, going from 23% to 8%.

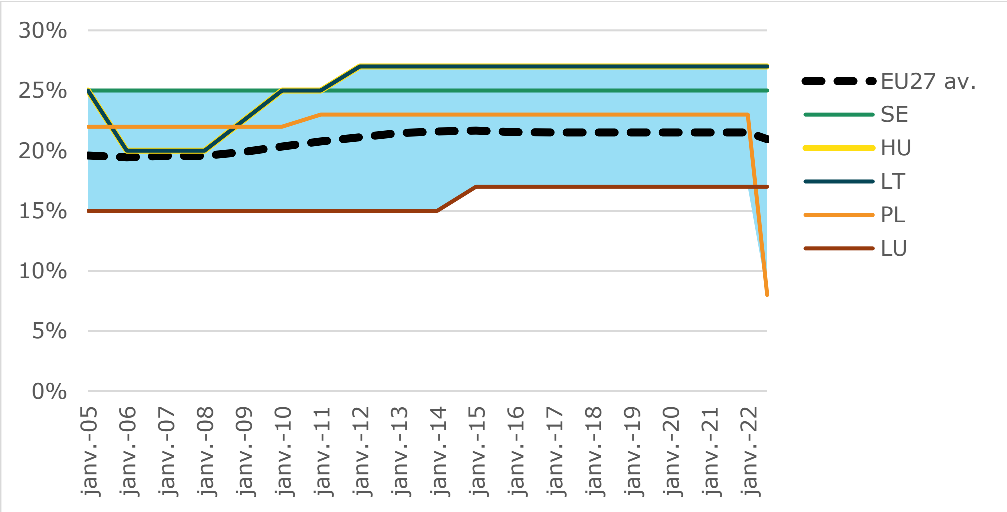

Figure 217: The VAT rate for gasoil (diesel) in the EU-27
Source: DG Taxation and Customs Union

The average VAT rate for **Euro-super 95** in the EU-27 (Figure 218) increased similarly to that of gasoil (diesel) from 20.4% to 21.6% between 2010 and 2021. In 2022, Poland, Greece and Finland decreased their VAT on Euro-super 95 from 23%, 24% and 24% to 8%, 20% and 21%, respectively, to fight inflation and rising fuel prices.

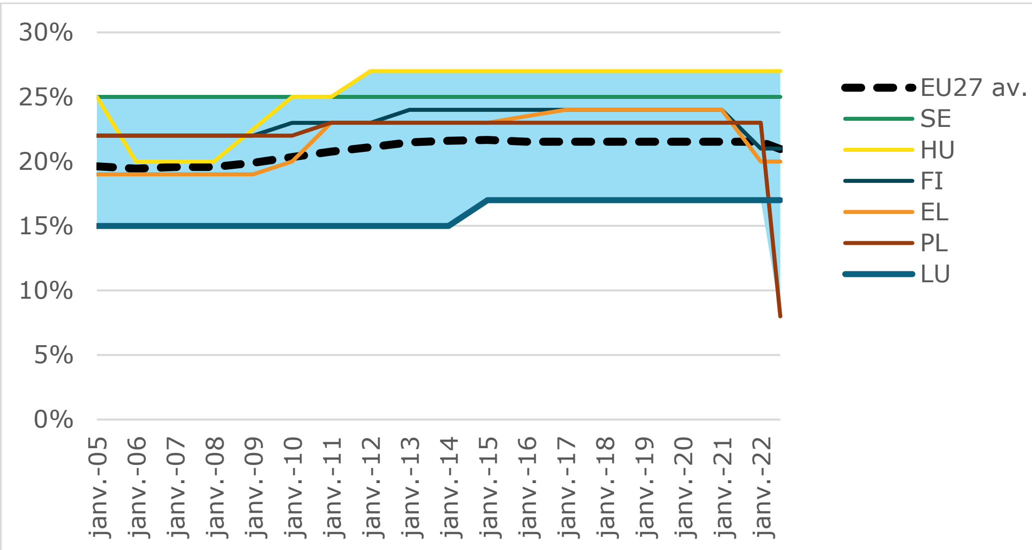

Figure 218: The VAT rate for Euro-super 95 in the EU-27
Source: DG Taxation and Customs Union

In December 2021[233], EU Finance Ministers agreed to update the current rules governing VAT rates for goods and services. These new rules[234] that came into force in April 2022, provide governments with more flexibility in the rates they can apply and ensure equal treatment between EU Member States.

8.5 Tax revenues from oil products

Oil products, especially motor fuels, are the main source of energy tax revenue for government budgets. Data from the Weekly Oil Bulletin[235] allows a detailed analysis of tax revenues from petroleum products, including an estimation of VAT revenues.

Our analysis covers the three main petroleum products sold in the retail sector between 2008 and 2020:

- gasoline (Euro-super 95),
- diesel (automotive gasoil) and
- heating oil (heating gasoil).

Due to the volatility of motor fuel prices, we calculated an average price as an arithmetic average of the weekly prices for each year and each Member State. The EU average price was then calculated as the weighted average of these, weighted by consumption in each Member State.

We estimated the tax revenues collected by Member States by multiplying average tax rate included in consumer prices with the consumption of each fuel converted to litres[236]

Since most companies can reclaim the VAT, so the calculated VAT revenue is a theoretical maximum; the actual VAT revenue collected by Member States must be significantly lower.

The estimated inflation-adjusted revenue from excise duties on oil products remained almost stable at around EUR_{2021} 180 billion up to 2018 and started to decrease in 2019 (Figure 219). As the VAT is an ad valorem tax, the estimated (theoretical) VAT revenue is fluctuating in line with the net price. Accordingly, the estimated (theoretical) VAT revenues decreased from EUR 92 billion in 2012 to EUR 59 billion euros in 2016 (a decrease of 36%), then increased again in the period 2017-2019.

In 2020, the COVID-19-related mobility restrictions lead to a decrease of oil products consumption and of fuel prices. Consequently, the estimated VAT revenues and excise duties decreased by 32% and 13%, respectively, compared to 2019. Gasoil and Euro-super 95 consumption, which are the main tax base of oil products excise duties, dropped by 15% and 13%, respectively, in 2020 in line with the global decrease of excise duties on oil products.

233 New rules on VAT rates offer Member States more flexibility while supporting the EU's green, digital and public health priorities, European Commission, available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6608

234 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022L0542&from=EN

235 https://energy.ec.europa.eu/data-and-analysis/weekly-oil-bulletin_en

236 Since consumption data is given in kt (kilotons), we were using a factor 1135.07 to convert 1 ton of Gasoline into litre of Gasoline and 1129.94 to convert 1 ton of Diesel and Heating oil into litres

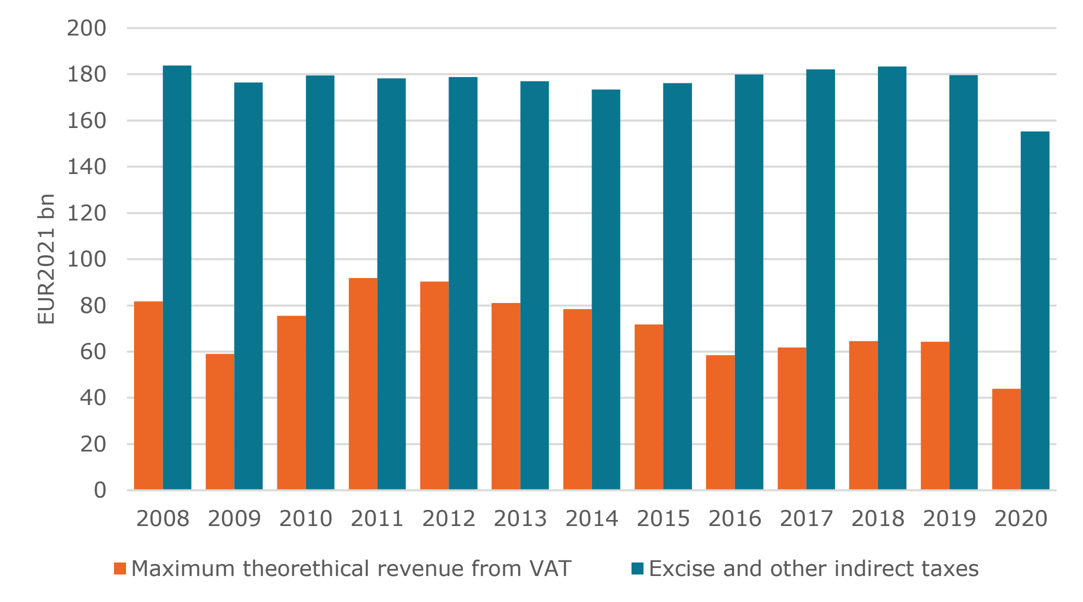

Figure 219: Estimated tax revenue from gasoline, diesel, and heating oil, in EUR$_{2021}$ bn

Source: DG TAXUD

8.6 Energy taxes, prices and incentives

In the following section, we present the results of a modelling exercise of the energy tax system based on a detailed inventory and analysis of energy-related taxes, levies and other fiscal measures in the EU. The main goal was to estimate tax revenues by economic sector and subsector to analyse the contribution of each of them to the total revenues from energy taxes. We also aimed to estimate the level of taxation by energy use.

For this exercise, we have used energy consumption data from Eurostat, complemented by Odyssee[237] data to refine energy consumption data in the road transport sector. These data have then been combined with the actual tax rates taken from DG TAXUD and national sources. Our approach had four steps:

1. Identifying relevant sectors and energy products in Eurostat (top-down data).
2. Mapping tax rates from national sources to the sectors-products selected in step one.
3. Converting energy volumes from Eurostat, which are in ktoe, to the tax rate units collected.
4. Estimating tax revenues.

Step 1: Identifying relevant sectors and energy products

The first step was to identify relevant sectors in Eurostat. Final energy consumption data for 2008-2020 was pulled from Eurostat[238] for each EU MS by economic sector by energy product. Industrial sector data was aggregated into Energy-intensive industry ('EII'), non-energy-intensive industry ('non-EII'), mining, and construction (Table 1) – these categories align with categories at which energy taxes on industry are typically applied by EU MS. Eurostat does not identify which industries are EIIs, and which are not. It was therefore necessary for us to do so, otherwise we could not distinguish between taxes on EIIs and non-EIIs in the project database.

237 https://www.odyssee-mure.eu/

238 https://ec.europa.eu/eurostat/data/database

We then sorted energy product data from Eurostat by volume in each sector for the EU-27 in total to identify those products with the highest consumption in each sector. These were kept for the database and are as shown in Table 1 in the second column.

NRG_BAL_LABEL	Sector short label
Final consumption - industry sector - iron and steel - energy use	Indu-EII
Final consumption - industry sector - chemical and petrochemical - energy use	Indu-EII
Final consumption - industry sector - non-ferrous metals - energy use	Indu-EII
Final consumption - industry sector - non-metallic minerals - energy use	Indu-EII
Final consumption - industry sector - transport equipment - energy use	Indu-non-EII
Final consumption - industry sector - machinery - energy use	Indu-non-EII
Final consumption - industry sector - mining and quarrying - energy use	Indu-Mining
Final consumption - industry sector - food, beverages and tobacco - energy use	Indu-non-EII
Final consumption - industry sector - paper, pulp and printing - energy use	Indu-EII
Final consumption - industry sector - wood and wood products - energy use	Indu-EII
Final consumption - industry sector - construction - energy use	Construction
Final consumption - industry sector - textile and leather - energy use	Indu-EII
Final consumption - industry sector - not elsewhere specified - energy use	Indu-non-EII
Final consumption - transport sector - rail - energy use	Trans-rail
Final consumption - transport sector - road - energy use	Trans-road-passenger
	Trans-road-freight
Final consumption - transport sector - domestic aviation - energy use	Trans-air
Final consumption - transport sector - domestic navigation - energy use	Trans-water
Final consumption - other sectors - commercial and public services - energy use	Services
Final consumption - other sectors - households - energy use	Residential
Final consumption - other sectors - agriculture and forestry - energy use	Agriculture
Final consumption - other sectors - fishing - energy use	Fishing

Table 34: Energy using sectors from Eurostat (left column) and the sector assignment for the project database (right column)

The next step was to update the taxation mapping developed during the previous study on this topic[239] based on the Energy Taxation Directive 2003 framework leveraging excise tax rates provided by TAXUD[240] and Eurostat energy consumption data.

Although the previous study from 2018 demonstrated that this approach has limitations because it cannot cover the tax expenditures due to reduced/exempted tax bases granted by MS, it is quite properly covering the tax expenditures due to reductions/exemptions of tax rates. Indeed, while explicit mentioning of partial/full exemptions of any tax base is often difficult to identify and to quantify in official publications released by MS, the apparent tax rates paid by the various economic actors are generally available.

Table 2 shows how the tax bases we have identified in Eurostat match the harmonised tax bases currently in effect under the ETD.

[239] Energy costs, taxes and the impact of government interventions on investments, available at https://op.europa.eu/en/publication-detail/-/publication/39fa0090-1750-11eb-b57e-01aa75ed71a1/language-en
[240] Excise duty rates applicable in the EU – Taxes in Europe database (TEDB), available at https://ec.europa.eu/taxation_customs/business/excise-duties-alcohol-tobacco-energy/excise-duties-energy_en

Eurostat		ETD/CIRCABC	
Sector	**Energy product/carrier**	**Sector**	**Energy product/carrier**
Agriculture and forestry	Electricity	Electricity	Business use
	Natural gas	Natural gas	Motor fuel for agricultural
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Motor fuel for agricultural
	Fuel oil	Heavy fuel oil	Agriculture, horticulture, pisciculture, forestry
Fishing	Electricity	Electricity	Agriculture, horticulture, pisciculture, forestry
	Natural gas	Natural gas	Agriculture, horticulture, pisciculture, forestry
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Agriculture, horticulture, pisciculture, forestry
	Fuel oil	Heavy fuel oil	Agriculture, horticulture, pisciculture, forestry
Commercial and public services	Electricity	Electricity	Business use
	Natural gas	Natural gas	Industrial/Commercial use
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Industrial/Commercial use
	Fuel oil	Heavy fuel oil	Industrial/Commercial use
Households	Electricity	Electricity	Non-business use
	Natural gas	Natural gas	Heating - Non business use
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Heating - Non business use
	Fuel oil	Heavy fuel oil	Heating - Non business use
Transport sector - road - personal	Electricity		
	Natural gas	Natural gas	Propellant
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol/Leaded petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Propellant
Transport sector - road - freight	Electricity		
	Natural gas	Natural gas	Propellant

Eurostat		ETD/CIRCABC	
Sector	Energy product/carrier	Sector	Energy product/carrier
			Busses
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol/Leaded petrol
	Other kerosene	Kerosene	Propellant
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Propellant
Transport sector - rail	Electricity	Electricity	Railways
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Railways
Transport sector - domestic navigation	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol/Leaded petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Propellant
	Fuel oil	Heavy fuel oil	Propellant
Transport sector - domestic aviation	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol/Leaded petrol
Energy Intensive Industries (EII)*	Electricity		
	Natural gas	Natural gas	Industrial/Commercial use
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Industrial/Commercial use
	Fuel oil		
Non-energy Intensive Industries (non-EII)*	Electricity		
	Natural gas	Natural gas	Industrial/Commercial use
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Industrial/Commercial use
	Fuel oil		
Industry sector - construction	Electricity		
	Natural gas	Natural gas	Industrial/Commercial use
	Motor gasoline (excluding biofuel portion)	Gasoline	Unleaded Petrol
	Gasoil and diesel oil (excluding biofuel portion)	Gasoil	Industrial/Commercial use

Table 35: Eurostat energy consumption data matched with current ETD harmonized tax bases

Step 2: Mapping tax rates

Tax rates, along with the tax rate units (litre, ton, etc.) from DG TAXUD and national sources, were matched with the appropriate sector-product pairs for each tax. Tax exemptions and reductions due to partial/full exemptions of tax rates were also accounted for in this step.

Step 3: Energy volume conversion

Eurostat reports energy volumes in ktoe, but tax rates are reported in various liquidation units. Therefore, energy volumes needed to be converted to appropriate liquidation units for each tax. We performed these conversions using energy content data from Eurostat[241].

Step 4: Tax revenue estimation

Tax revenues were then estimated as the product of converted energy volumes and tax rates. We checked our estimates against Eurostat National Tax List (TNL) data on revenues for each tax to ensure our estimates are reasonably consistent. Where possible, especially for renewable support, we documented different sources between our estimates and the reported data.

Analysis

Taxes on energy consumption analysed in this section include:

- Excise taxes on fuels.
- Non-tax levies on fuel purchases, such as on natural gas and electricity bills, used to finance renewable energy sources (RES) (e.g., the Renewable Energy Sources Act ('EEG') in Germany)
- Environmental charges such as carbon taxes (note: the EU ETS is not covered in this section)
- All other taxes, levies and fiscal measures that end consumers pay when they consume energy.

Reported tax rates are taken from DG TAXUD and official national sources such as energy and finance ministries. The full list of the taxes considered in this research can be found in the annexes. Energy products which are considered are: gasoil, petrol, fuel oil, natural gas and electricity.

Reported tax rates

MS reported total tax rates, calculated as the total of energy tax revenues divided by the total energy consumption, ranged in 2020 from EUR_{2021} 13/MWh in Hungary to EUR_{2021} 45/MWh in Denmark with a median of EUR_{2021} 24/MWh (Figure 220). The total reported tax rate has slightly shrunk in the EU-27 from EUR_{2021} 33/MWh in 2015 to EUR_{2021} 31/MWh in 2020, mainly due to the historically low level of revenue from excise duties in road transport because of the mobility restrictions linked to Covid-19. In addition to this specific effect, we also note remarkable drops in countries like Denmark[242] and Italy[243] that are also explained by reduction of the cost the RES non-tax levy over this period. In contrast, countries like France and the Netherlands record increases of their reported total tax rate due to increases in excise duties on fossil fuels[244].

[241] Eurostat, Energy balance guide, Methodology guide for the construction of energy balances & Operational guide for the energy balance builder tool, available at https://ec.europa.eu/eurostat/documents/38154/4956218/ENERGY-BALANCE-GUIDE-DRAFT-31JANUARY2019.pdf/cf121393-919f-4b84-9059-cdf0f69ec045

[242] Indeed, the Danish government has decided to gradually phase out the charge financing the development of renewable technologies (called "PSO") to reduce consumer electricity bills. From 2022, renewable projects will be directly part of the State budget and won't be bear by electricity end-users.

[243] The cost of policies supporting the development of renewable technologies is decreasing in Italy from € 17.7 billion in 2016 to € 13.5 billion in 2020.

[244] France started to apply a carbon tax (included in the excise duty) as from 2015, while The Netherlands has strongly raised in excise duty on natural gas which represented 45% of its final consumption in 2020.

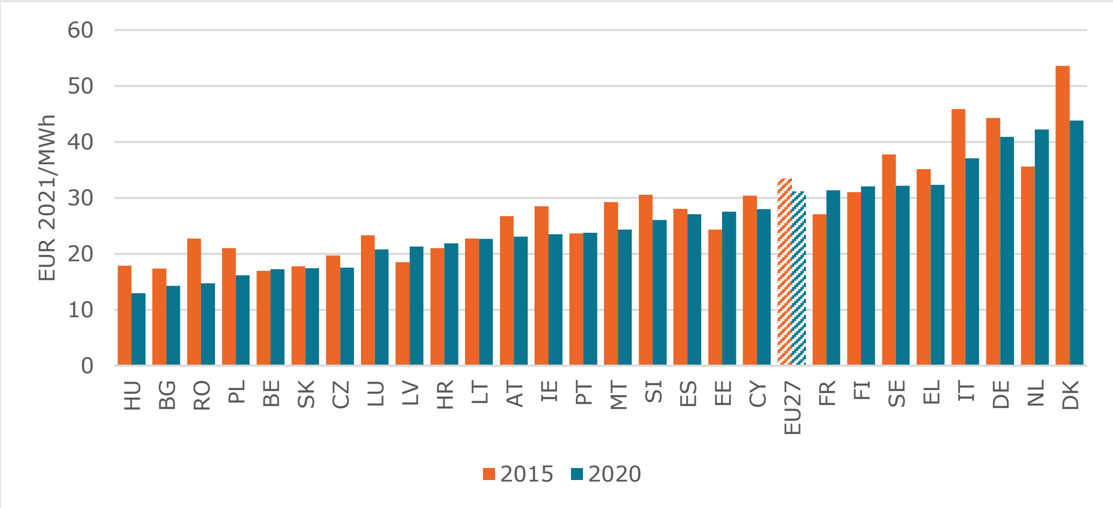

Figure 220: Total tax rates on energy consumption in EU-27 in 2015 and 2020 (EUR$_{2021}$/MWh)

Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

Tax rates by sector

Overall, the share of energy consumption by sector remained the same between 2010 and 2020 (Table 3), with a noticeable decrease of the share of personal road transport between 2019 and 2020 going from 20.9% of the total energy consumption to 18.9% in 2020 (Covid-19).

Sector	2010	2019	2020
Fishing	0.2%	0.2%	0.2%
Mining	0.4%	0.4%	0.5%
Trans-water	0.7%	0.6%	0.5%
Trans-rail	0.8%	0.7%	0.7%
Construction	0.8%	1.3%	1.3%
Agriculture	2.8%	3.2%	3.4%
Non-EII	7.8%	7.6%	7.7%
Trans-road-freight	12.9%	13.6%	13.2%
EII	13.8%	13.9%	14.4%
Services	15.8%	14.9%	14.9%
Trans-road-personal	19.3%	20.9%	18.9%
Households	24.8%	22.6%	24.3%

Table 36: Share of energy consumption by sector, 2010, 2019 and 2020

Source: Authors calculation from Eurostat and Odyssee

Tax rates by sector for the EU-27 ranged from EUR_{2021} 4/MWh for energy-intensive industries (EII) to EUR_{2021} 53/MWh for personal road transport (Figure 221). The low tax rate observed for the energy-intensive industry sector is mainly explained by numerous tax reductions and exemptions in almost all Member States, in particular on RES non-tax levies. Rates increased the most, in absolute terms, in the households, services and non-energy-intensive industry sectors because they bear the largest portion of the cost of renewable policies, while they benefit from almost no tax exemptions. The total tax rate changes in water transport, EII, and mining were small between 2010 and 2020. However, road transport (personal and freight) has remained the most taxed sector since 2010, while air transport still benefits from an almost complete tax exemption on the consumption of kerosene.

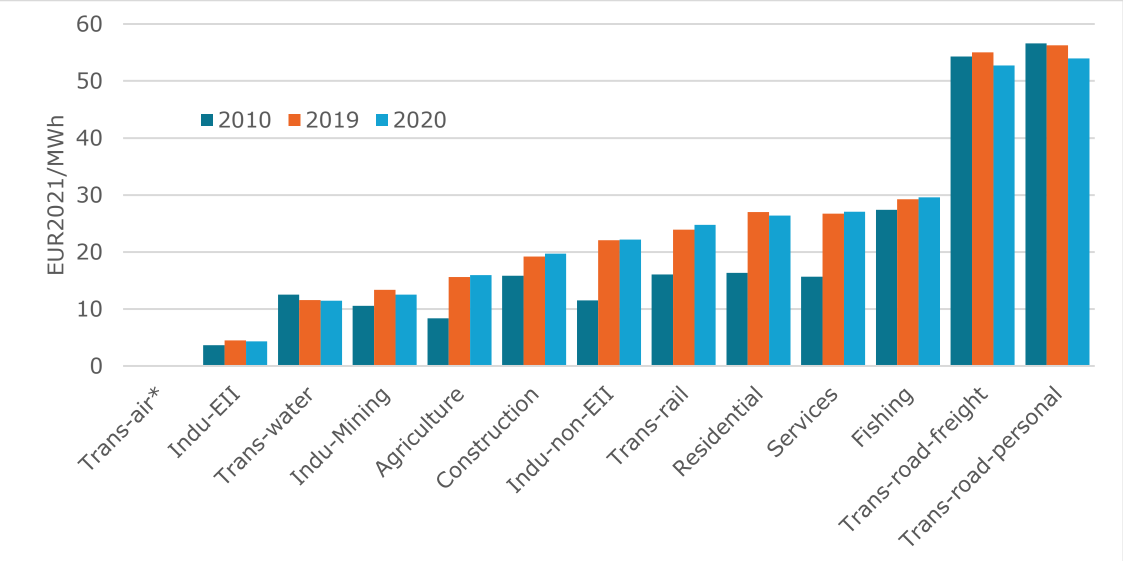

Figure 221: Tax rates by sector in EU-27, 2010, 2019 and 2020 (EUR_{2021}/MWh)

Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

Personal road transport is the most taxed sector: the average tax rate for personal road transport for the EU-27 as a whole increased by 10% between 2010 and 2020 to reach EUR_{2021} 53/MWh, ranging from EUR_{2021} 34/MWh in Bulgaria to EUR_{2021} 68/MWh Finland in 2020 (Figure 222).

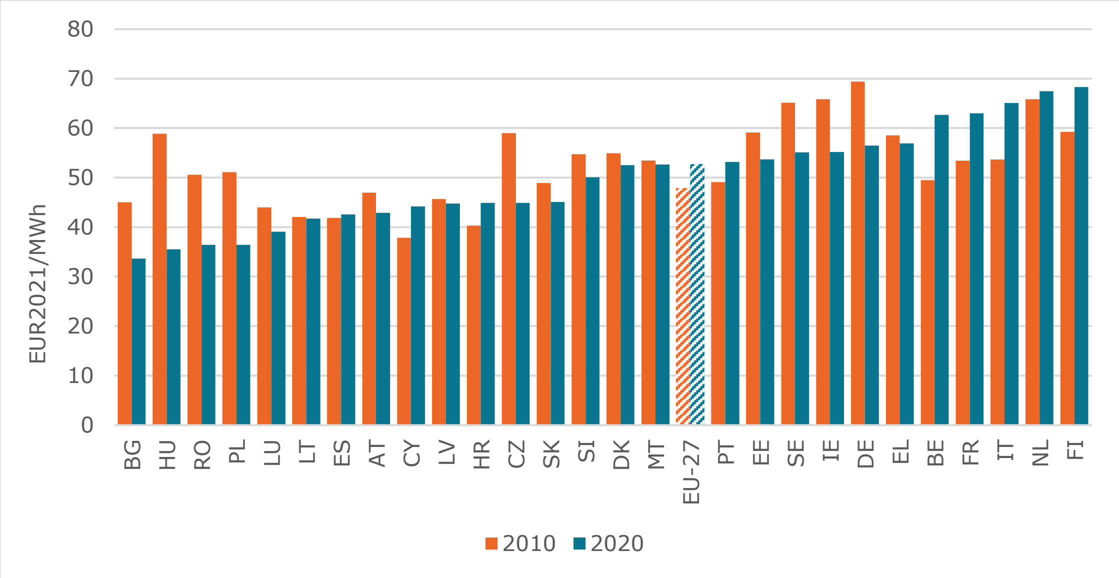

Figure 222: Effective tax rate for personal road transport in EU-27, 2020 (EUR_{2021}/MWh)
Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

Tax rates by fuels

Total tax rates by fuel for the EU-27 as a whole, range from EUR_{2021} 5/MWh (fuel oil) to EUR_{2021} 69/MWh (petrol, 2020 data, Figure 223). **Petrol or gasoline**, which is mainly consumed for road transport, is by far the most taxed product; although the total tax rate applied to this product has experienced a moderate decrease over the period 2010-2020. **Gasoil or diesel**, which is consumed in various sectors, has seen its total tax rate increase by nearly 25% mainly due to the increase in excise duty in the road transport sector, which brought it nearer to gasoline's tax rate. The total tax rate on **electricity** for the EU-27 as a whole has doubled from EUR_{2021} 15/MWh in 2010 to EUR_{2021} 33/MWh in 2020; because of the growth of renewable charges, which have been borne by electricity consumers only. The total tax on natural gas and fuel oil remains at a level well below that of other energy products.

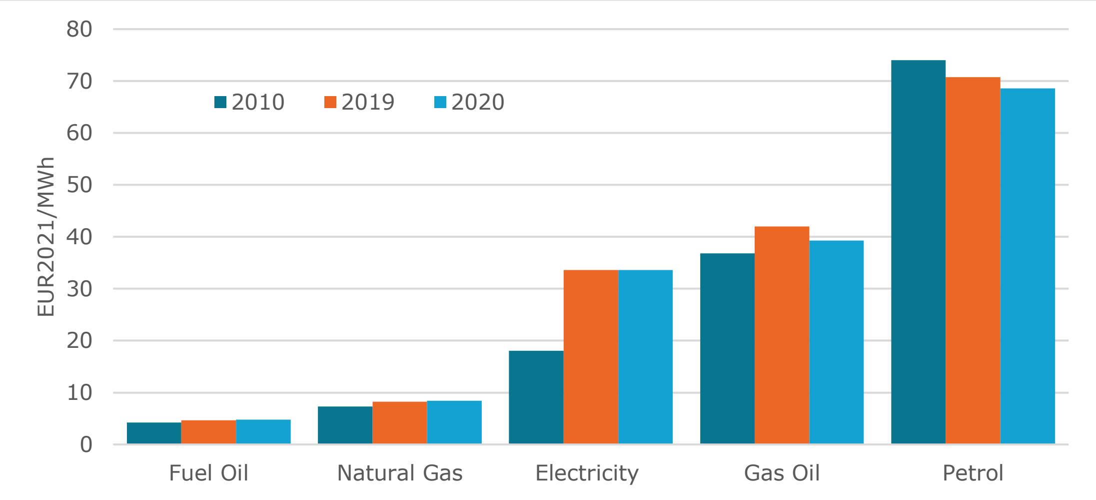

Figure 223: Reported total tax rates in EU-27, by fuel, 2010, 2019 and 2020 (EUR$_{2021}$/MWh)

Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

Figure 224 show how tax rates on key fuels are distributed among the EU-27. Each blue-filled box represents the interquartile range and the bar in each box represents the median tax rate of the fuel in EU-27 in 2020. The median tax rate in EU-27 in 2020 on gasoline was EUR$_{2021}$ 60/MWh, on gasoil (diesel) EUR$_{2021}$ 38/MWh, while the median tax rate on natural gas was EUR$_{2021}$ 1.8/MWh, and on electricity EUR$_{2021}$ 4.5/MWh[245]. The box plot on tax rate on electricity shows that 75% of the MS have a tax rate below EUR$_{2021}$ 17.6/MWh. The box plot on tax rate on natural gas highlights that most of the tax rates are concentrated around the median value of EUR$_{2021}$ 3/MWh.

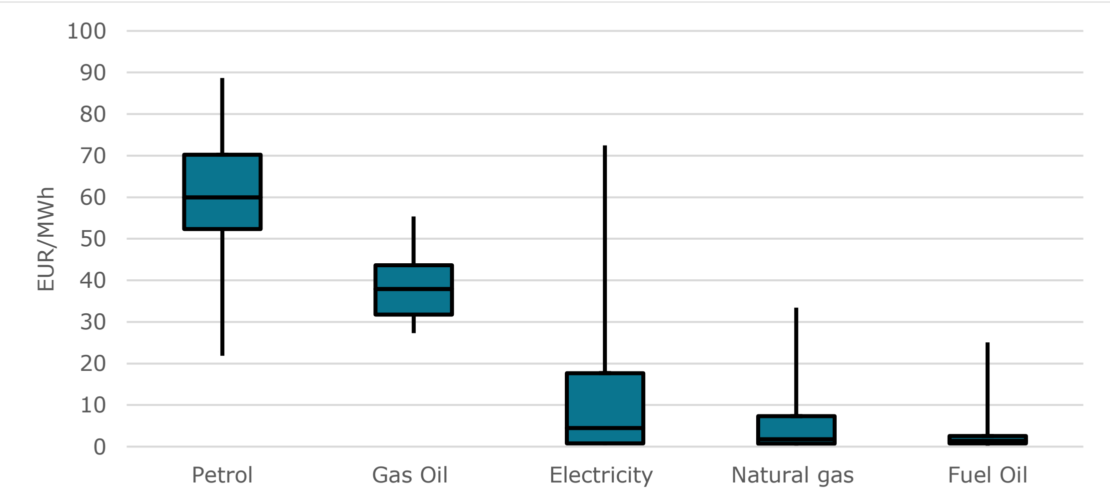

Figure 224: Distribution of reported tax rates for key fuels, in EU-27 in 2020 (EUR/MWh)

Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

Taxes on electricity and natural gas

The distribution of taxes on electricity highlights huge disparities among Members States (Figure 225). Half of the MS tax electricity below EUR$_{2021}$ 4.5/MWh whereas only seven MS exceeds the 75th percentile. The highest tax rate of EUR$_{2021}$ 72/MWh was reported for Germany. The average EU-27 tax rate on

[245] Note that energy inputs to the electricity sector are not taxed to avoid double taxation - only the final consumer is taxed on electricity consumption, not the power producer on the consumption of input fuels.

electricity increased by 116% going from EUR_{2021} 15/MWh in 2010 to EUR_{2021} 33/MWh in 2020. However, the median only increased by 40% going from EUR_{2021} 3.2/MWh in 2010 to EUR_{2021} 4.5/MWh in 2020.

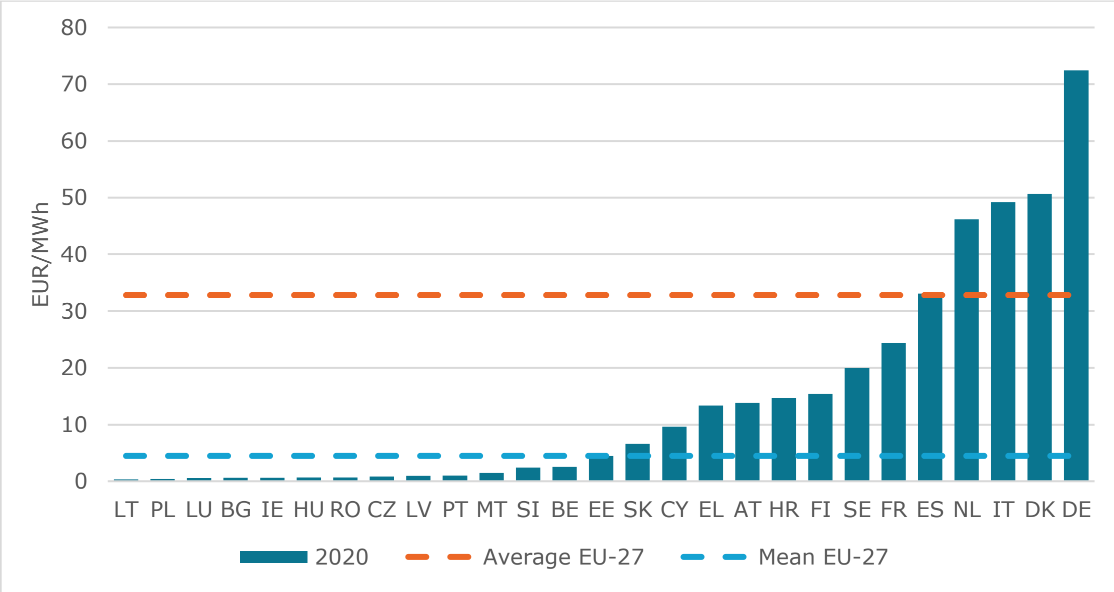

Figure 225: Effective tax rate on electricity in EU-27 in 2020

Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

The tax rates on natural gas in 2020 ranged from zero to EUR_{2021} 37/MWh in Sweden in 2020. Overall, the average tax rate on natural gas in the EU-27 was EUR_{2021} 8.2/MWh in 2020. It increased by 34% going from EUR_{2021} 6.1/MWh in 2010 to EUR_{2021} 8.2/MWh in 2020.

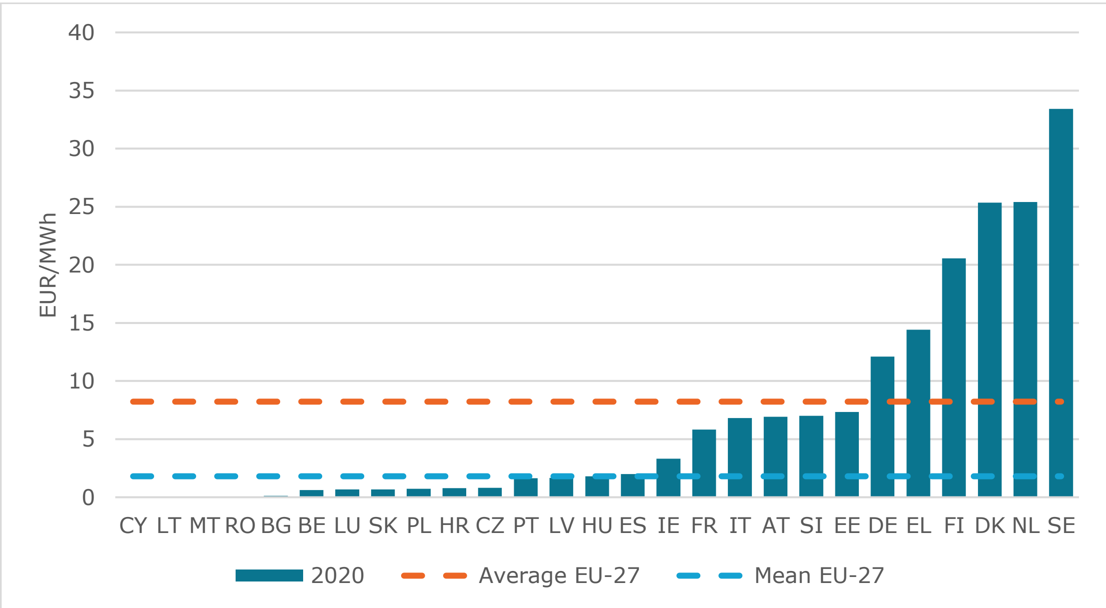

Figure 226: Effective tax rate on natural gas in the EU-27 in 2020

Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

Tax revenues by sector

Road transport (freight and personal) accounts for 55% of energy tax revenues in EU-27, followed by households with 21%, then services with 13% in 2020. On one side, the road transport sectors account for at least 80% of energy-related tax revenue in 14 Member States (BE, BG, CY, CZ, IE, LT, LU, LV, MT, PL, PT, RO, SI, and SK). On the other side, they account for less than half of the tax revenue in four Member States in 2020 (DE, DK, NL, and SE). The households account for at least 25% of total tax revenue on energy consumption in 6 Member States (DE, DK, NL, SE, and ES).

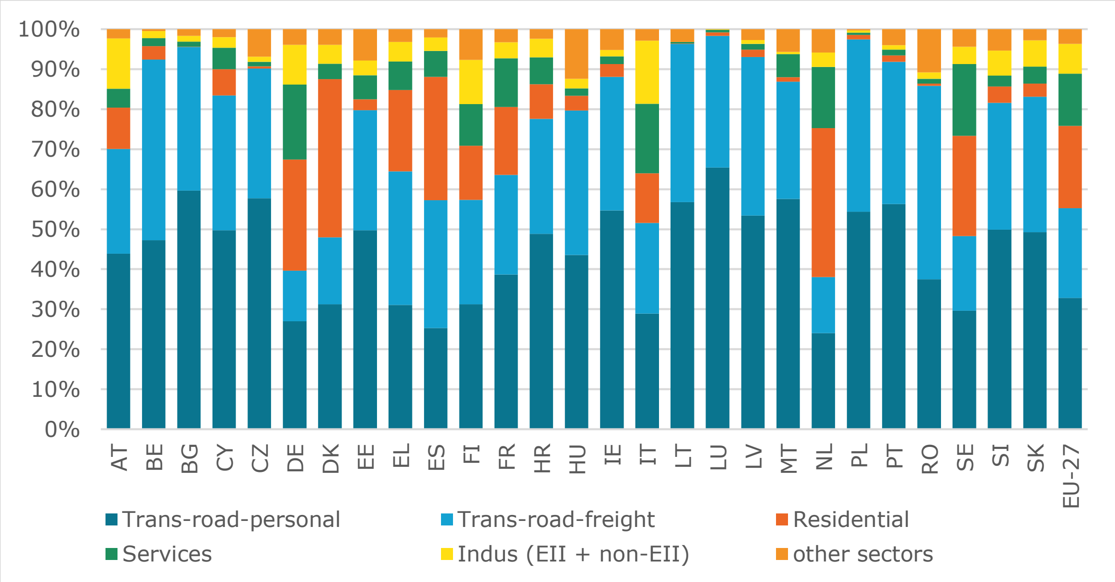

Figure 227: Share of reported total tax revenue by sector in EU MS, 2020

Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

In 2020, energy-intensive industries (EIIs) paid the lowest per unit tax rates, while road transport sectors paid the most. EIIs account for 14% of energy consumption in EU-27 and 2% of tax revenue. Agriculture accounts for 3% of energy use and 1.7% of tax revenue while road transport (freight and personal) accounts for 32% of energy consumption and 55% of tax revenue.

Figure 228 shows the Revenue/Use (RU) factors by sector in the EU-27. The RU factor is a measure of energy tax proportionality. It is calculated as the natural logarithm of the ratio of the share of tax revenue to the share of energy consumption:

RU Factor = Ln (Share of total tax revenue / Share of total energy consumption)

An RU factor of zero means the sector's share of taxes on energy consumption is proportional to the share of energy it consumes. A factor of less than zero means the sector pays less taxes on energy relative to the amount it consumes, and a factor of greater than zero means the sector pays more taxes relative to the amount it consumes. If all sectors paid taxes on consumption proportional to what they consume they would be aligned with the x-axis.

Taxes related to road transport in 2020 were proportionally higher than energy consumed for this purpose. On the other hand, taxes paid by the EIIs, agriculture and non-EIIs were less relative to the energy consumption in these sectors, in 2020. Agriculture, non-EIIs, rail transport, households and services are paying more taxes in 2020 relative to what was consumed than in 2010.

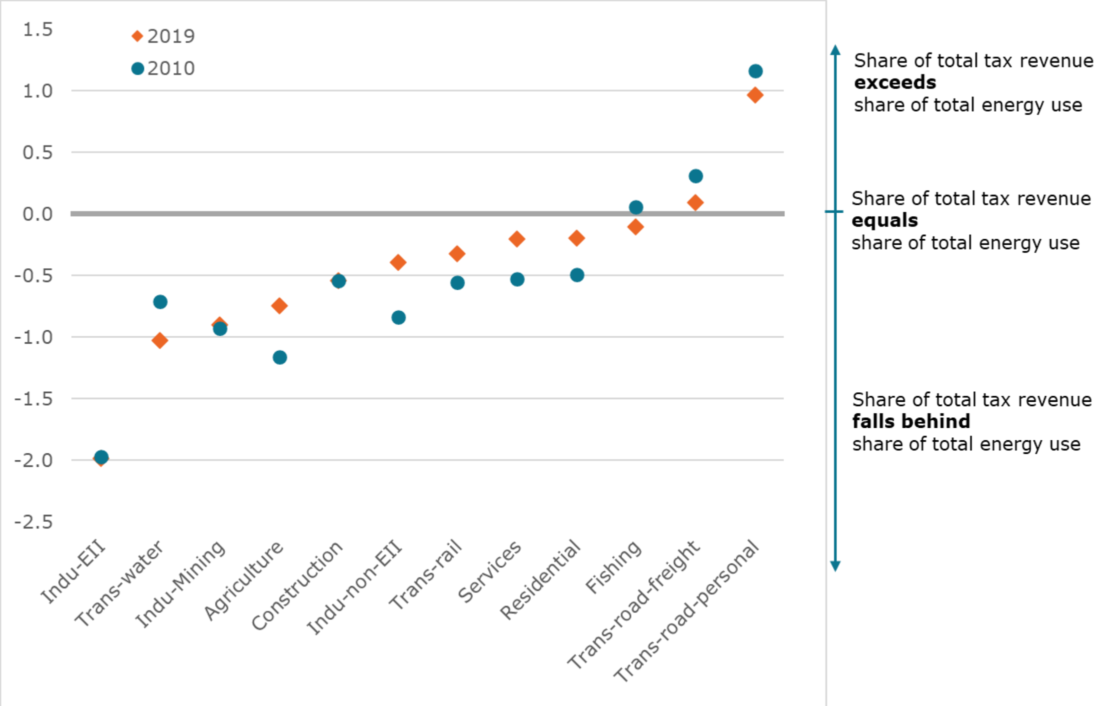

Figure 228: Revenue/Use factors by sector for the EU-27 (2020)
Source: Authors calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

Tax revenue by type

Three-quarters of revenues from energy taxes in the EU-27 were from excise taxes in 2020, and 22% from renewable support. Excise taxes account for at least 90% of revenues in 16 MS. Renewable support accounts for 34% of total revenue in Germany, 21% in France, 25% in Italy, while environmental charges make 30% of total revenue in Sweden, 29% in Finland and 12% in Ireland.

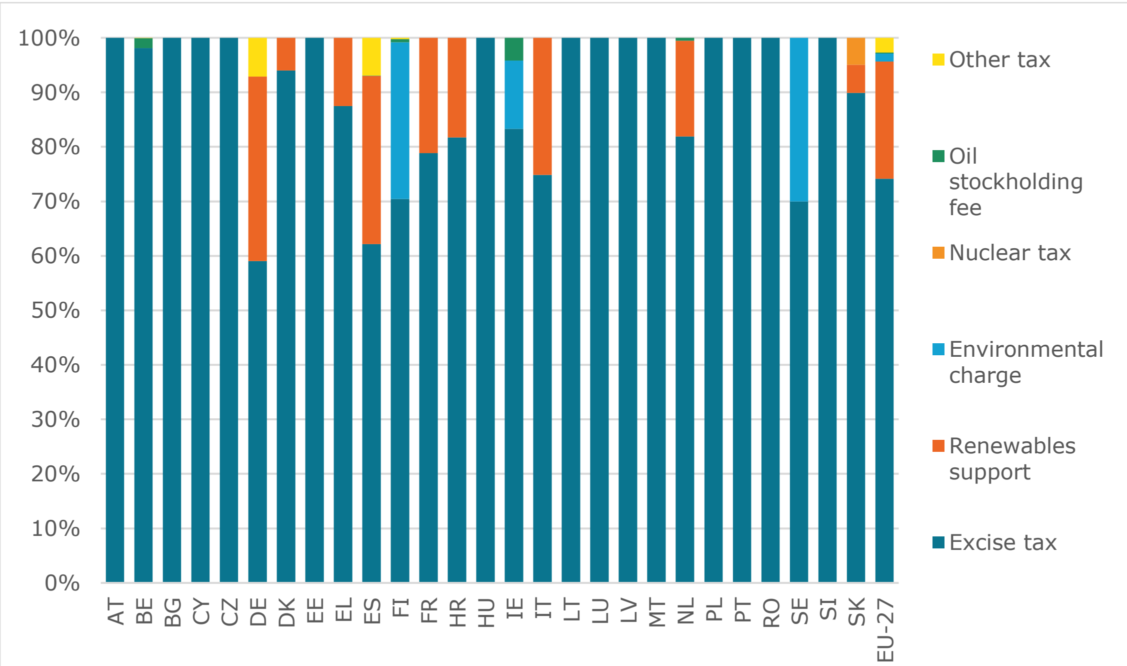

Figure 229: Distribution of revenues from taxes on energy use by tax type in the EU-27 (2020)
Source: Authors' calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

There were EUR 64 billion in additional revenues from taxes on energy consumption in 2019 compared to 2010 (Figure 230). Additional revenues from excise taxes accounted for EUR 26 billion, or 41% of the increase. Additional revenues from renewable support accounted for EUR 37 billion or 57% of the increase, mainly from the renewable energies surcharge on electricity (EEG) in Germany, fees to support renewable energy sources in Italy[246] and in France[247].

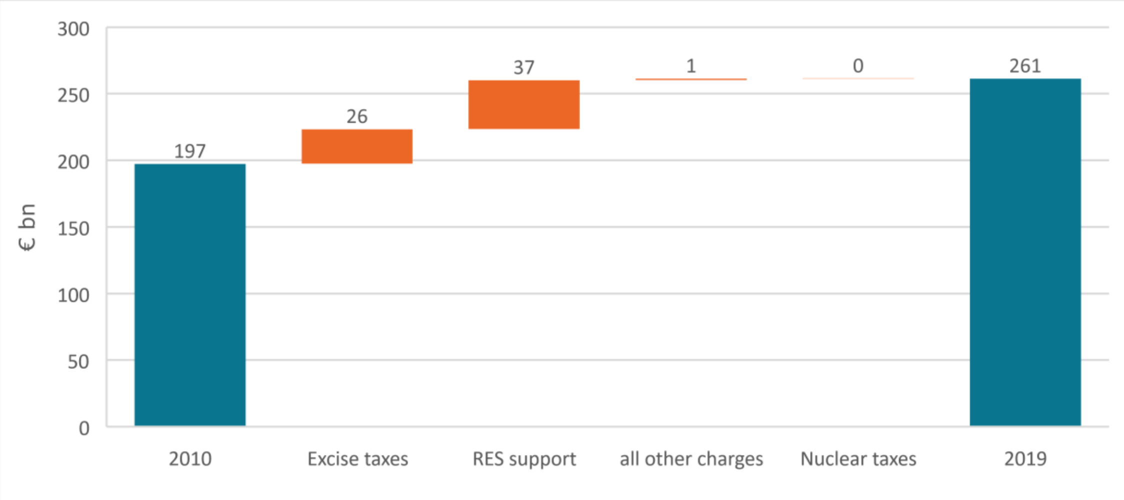

Figure 230: Decomposition of additional revenues from taxes on energy use in 2019 vs 2010 (EUR billion)

Source: Authors' calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

The 9% decrease of total revenues from energy consumption between 2019 and 2020 is due to a decrease of revenues from excise taxes (Figure 231). Excise duties revenues are directly related to energy consumption and road transport (freight and personal), which makes up roughly 75% of excise revenue and which were restricted due to Covid-19 lockdowns. EUR 20 billion out of EUR 21 billion decrease came from the excise revenues from road transport.

Figure 231: Decomposition of additional revenues from taxes on energy use in 2020 vs 2019 (EUR billion)

Source: Authors' calculations based on Eurostat, Odyssee, DG TAXUD and national sources data

[246] Oneri di sistema sulle energia rinnovabili
[247] CSPE

8.7 International comparisons

To position the tax policy of EU Member States against its major economic partners, we use data on energy taxes provided by the OECD, which provides energy tax data and indicators using definitions similar to those of Eurostat, allowing us to make direct consistent comparisons.

However, it should be noted that while the OECD covers all the countries of the world, few of them provide complete data series. Thus, only four EU neighbouring countries (Iceland, Norway, Turkey and the United Kingdom) and only five non-European G20 countries (the South Africa, Argentina, Canada, USA and Japan) provide data that can be used in such analysis. Many of the economic partners of the EU could not be treated within the framework of this analysis due to lack of data. This is particularly the case for Brazil, China, India, Indonesia, Mexico, Russia, Saudi Arabia and South Korea.

When it comes to timeline, we have chosen to use 2019 as the reference year for the comparisons. Indeed, the last year for which data is available is 2020 but it cannot be considered as a reference year due to the Covid-19 pandemic which has significantly affected energy demand and therefore revenue from consumption taxes on energy.

The analysis of the evolution of revenues from energy taxes between 2008 and 2019 in real terms (euros 2021) shows that most countries have seen their energy tax revenues increase. However, the growth observed in EU countries significantly exceeds that of Canada, the USA and Japan (see Figure 33).

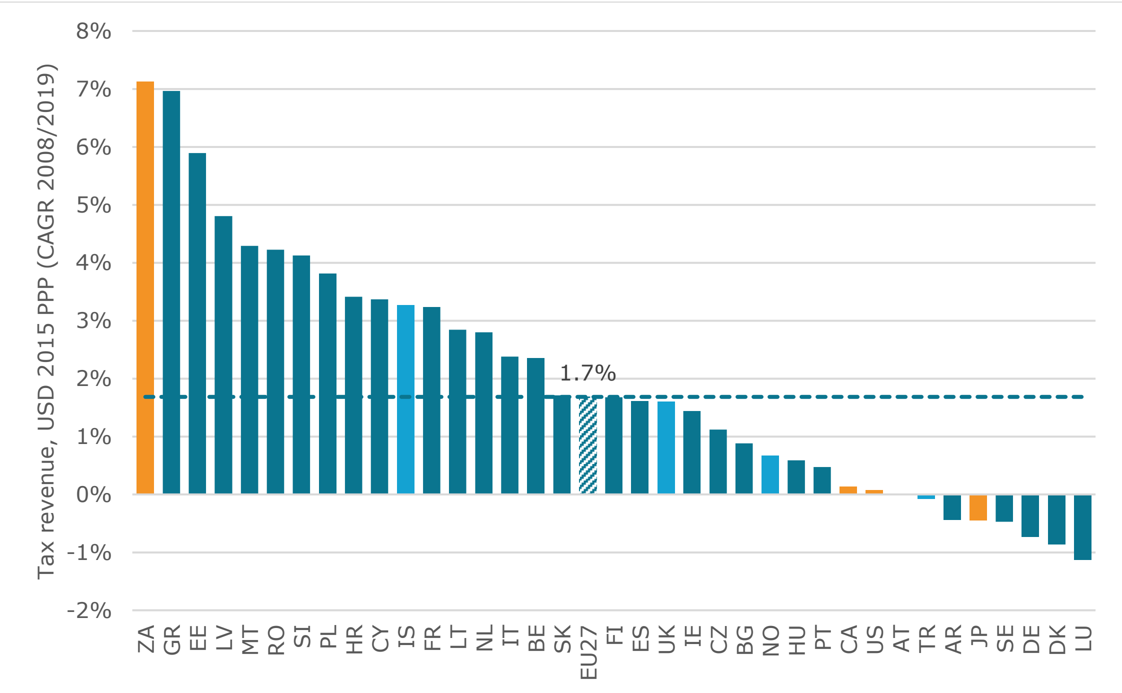

Figure 232: Energy tax revenue evolution (CAGR 2008/2019, in USD 2015 PPP)

Source: Authors' calculations based on OECD and Eurostat data

Energy tax revenue as a percentage of the GDP

The first interesting indicator for comparing countries is the percentage that energy taxes represent in relation to domestic GDP. Figure 233 shows that the energy tax revenues-to-GDP ratio is much higher in the EU-27 (as a whole), except South Africa. This ratio is even significantly higher than that of Japan, a country that is also a major energy importer, and those of Canada and the USA (both net energy exporters).

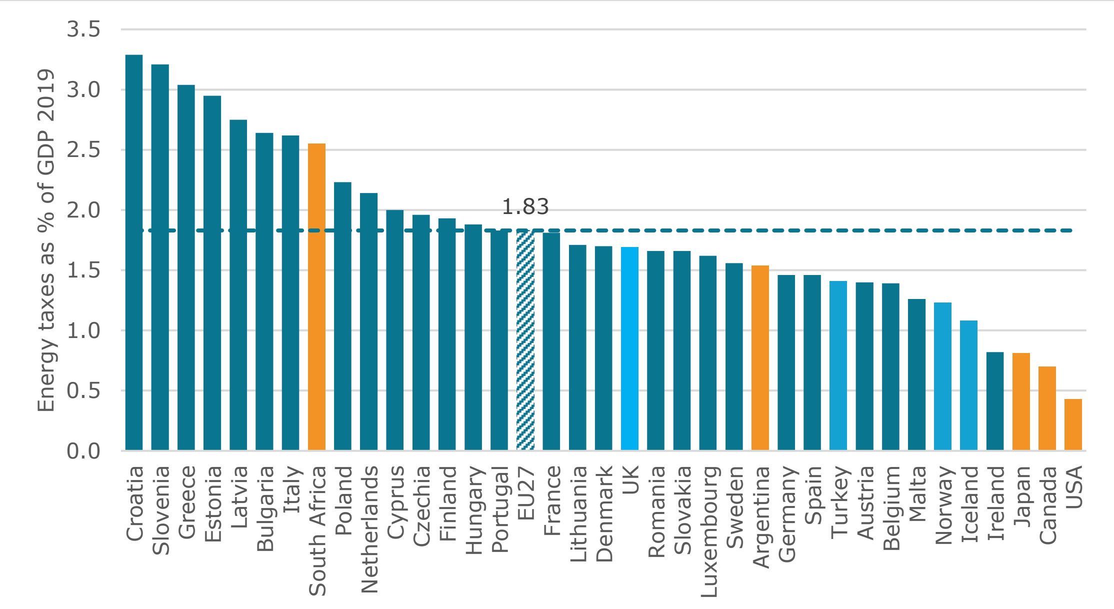

Figure 233: Energy tax revenue as a percentage of GDP in 2019 (%)

Source: Authors' calculations based on OECD and Eurostat data

The evolution of the energy tax revenue-to-GDP ratio between 2008 and 2019 (Figure 234) shows a slight rise for the EU as a whole, which means that revenues from energy taxes have grown at roughly the same rate as GDP. The opposite movement is observed with most of our economic partners, which recorded a falling ratio over the same period. This is especially true for all the non-European countries, except South Africa, that all report negative figures meaning that their economic growth has exceeded that of their energy tax revenue.

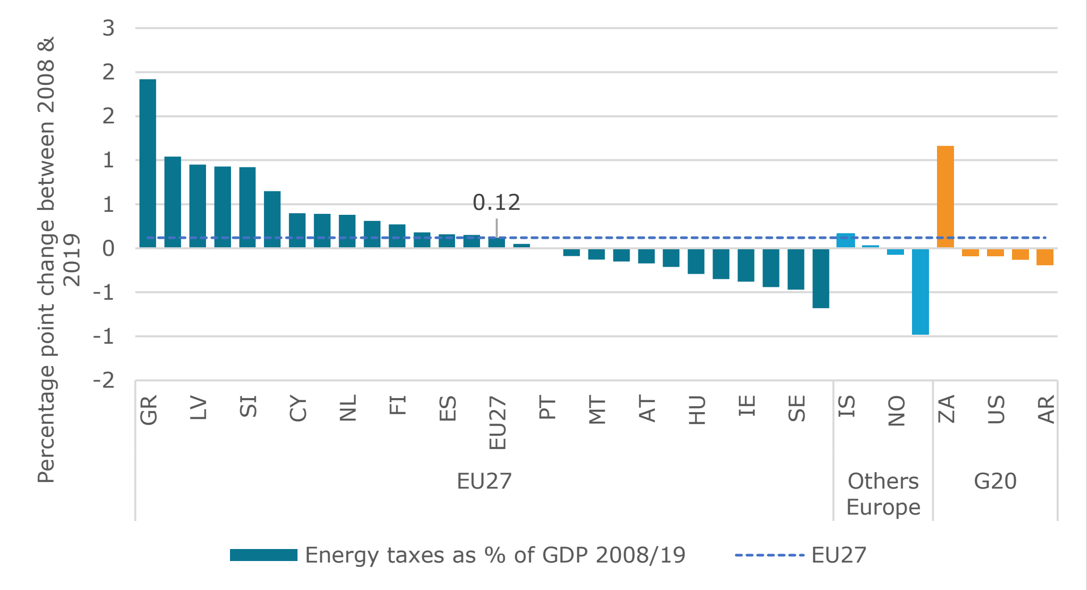

Figure 234: Energy tax revenue as a percentage of GDP evolution between 2008 and 2019 (percentage point)

Source: Authors' calculations based on OECD and Eurostat data

Energy tax revenue as a percentage of total tax revenue

The second indicator used is the ratio between energy tax revenue compared to total tax revenue, measuring the dependence of State budget yields from energy taxes.

As for the energy tax revenue-to-GDP, the EU ratio is significantly higher than that of our major economic partners (Canada, Japan and the USA), which show levels almost twice as low as those of the EU. This therefore means that EU Member States are more dependent on energy tax revenues than their partners to balance their budgets.

As previously demonstrated, fossil fuel taxes represent the most important tax base of Member States. Therefore, they are more dependent on their economic partners for the consumption of fossil fuels to finance their budgets. This must be questioned in the light of the EU's ambition for carbon neutrality, which implies drastically reducing the consumption of fossil fuels, and therefore eroding the income derived from it (unless also drastically increasing taxes on these energies).

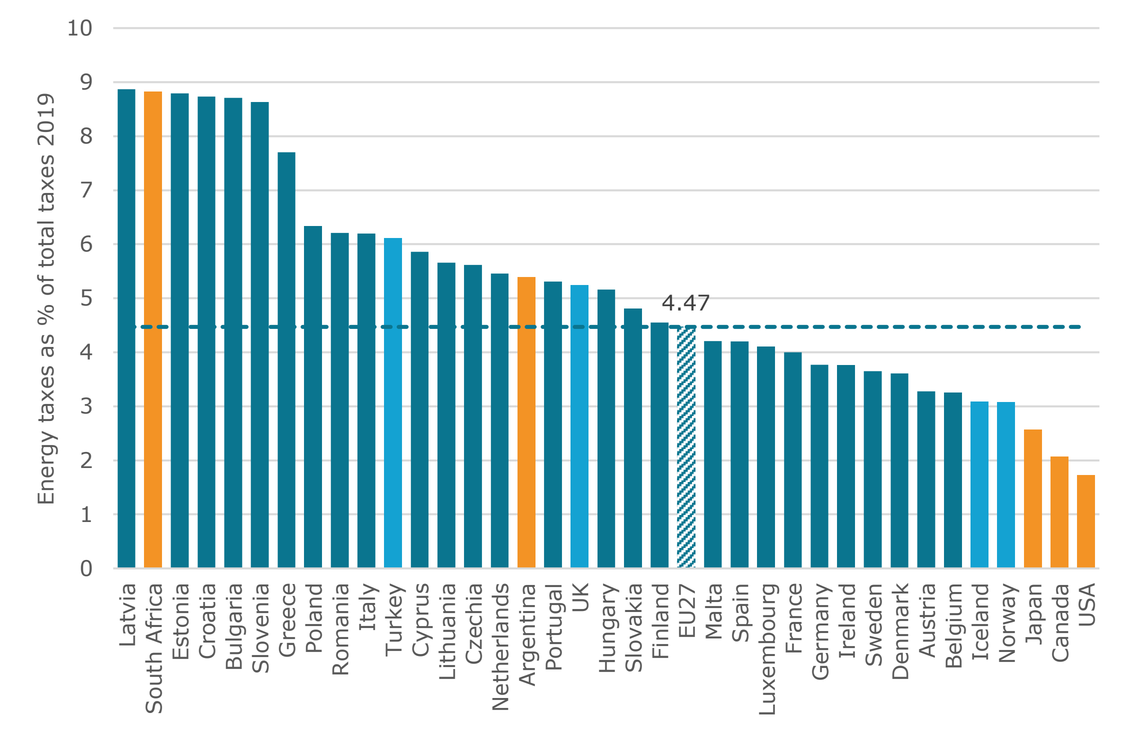

Figure 235: Energy tax revenue as a percentage of total tax revenue in 2019 (%)

Source: Authors' calculations based on OECD and Eurostat data

The evolution of the energy tax-to-total tax revenue ratio also shows a slight increase in the EU in 2008 and 2019, therefore a slight increase in the share of energy taxation in all tax revenue. This trend is also opposite in non-European G20 countries.

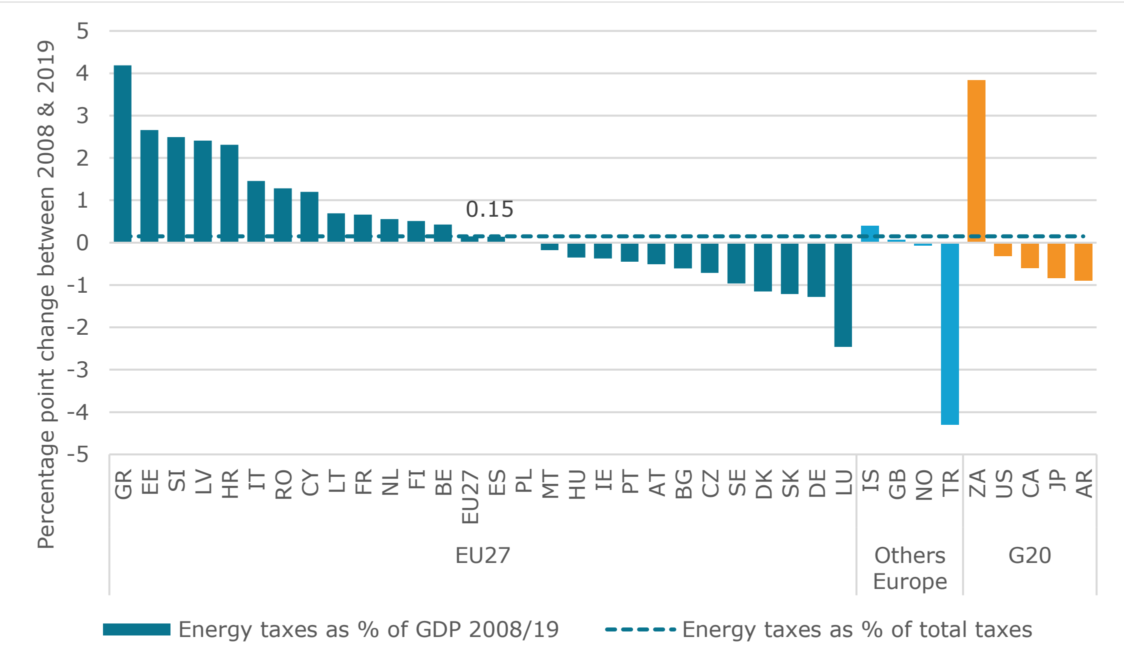

Figure 236: Energy tax revenue as a percentage of total tax revenue between 2008 and 2019 (percentage point)

Source: Authors' calculations based on OECD and Eurostat data

In addition to this global international comparison, we provide an overview of the energy taxation systems in the USA and Japan.

The United States

In the US, revenues from energy taxes reached USD 155 billion in 2019, of which

- 32% (USD 50 billion) come from excise taxes imposed by the States on road transport fuel consumption (mainly gasoline);
- 24% (USD 37 billion) from the excise tax levied by the federal administration on fuels for road transport;
- 7% (USD 10.5 billion) from royalties drawn on onshore and offshore oil and gas production; and
- 37% (USD 57.5 billion) of miscellaneous taxes.

The excise taxes levied by the federal administration and those of the states represented the largest amount of revenue; therefore we have focused our analysis on the evolution of these two taxes. The analysis of the evolution of excise taxes for gasoline and diesel shows that the tax rates have increased little for the States, while the rates imposed by the Federal Administration have not changed since 1993.

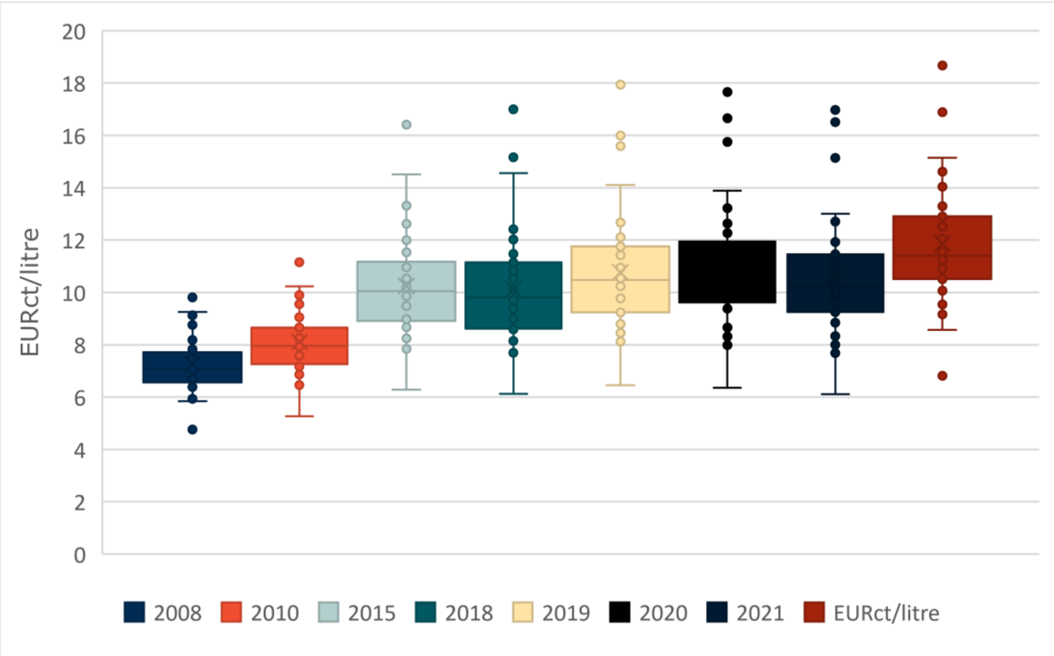

Figure 237: Evolution of excise taxes (States + Federal) on petrol between 2008 and 2022 (EURc/liter)

Source: Authors' calculations based on US Federal Tax Administration

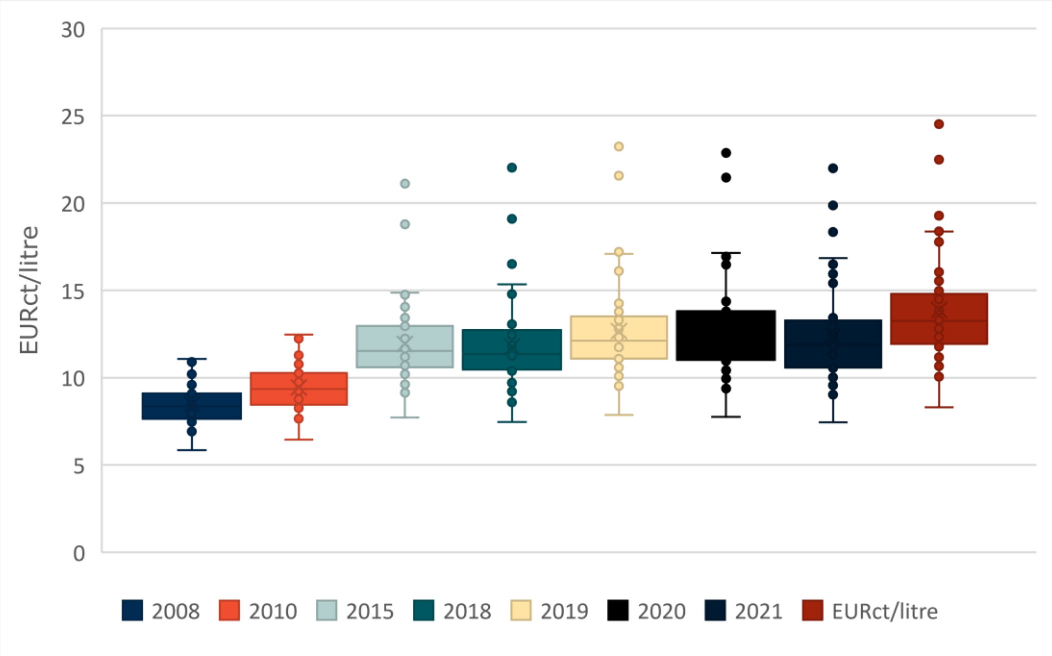

Figure 238: Evolution of excise taxes (States + Federal) on gasoil between 2008 and 2022 (EURc/liter)

Source: Authors' calculations based on US Federal Tax Administration

Looking at the tax levels and their evolution with those of the EU Member States, we note a significant difference. Indeed, the EU-27 average excise rate is five times higher for petrol (Figure 239) and three times higher for gasoil (Figure 240), and this on the whole period 2008-2022.

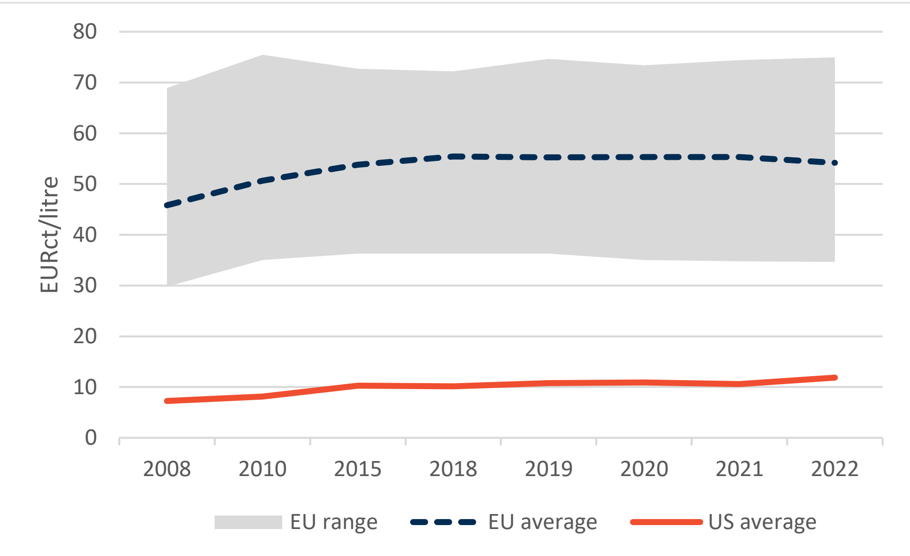

Figure 239: Evolution of excise taxes on petrol in the EU and the USA between 2008 and 2022 (EURc/liter)

Source: Authors' calculations based on US Federal Tax Administration and DG TAXUD

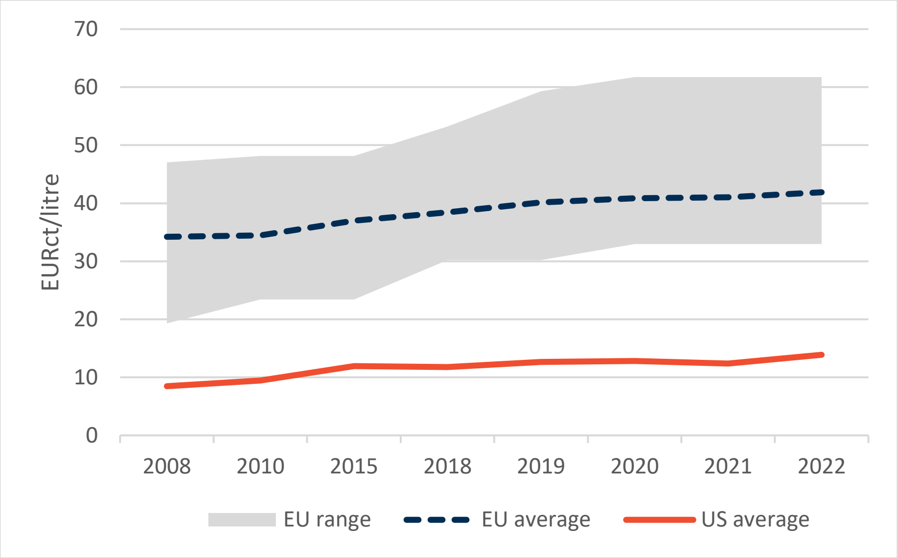

Figure 240: Evolution of excise taxes on gasoil in the EU and the USA between 2008 and 2022 (EURc/liter)

Source: Authors' calculations based on US Federal Tax Administration and DG TAXUD

Japan

As in many countries, taxes on road transport consuming petroleum products represent the vast majority (75% in 2018) of energy tax revenues in Japan. Revenues have been relatively stable since 2008, in particular because the excise rates on gasoline (Gasoline tax) and diesel (Diesel oil delivery tax) have not changed since April 2010.

However, Japan stands out because it is one of the few OECD countries, if not the only one, to apply a double taxation on fossil fuels burned to produce electricity (Petroleum and coal tax) as well as on final consumption of electricity (Electric power tax). It stands out because it is also one of the few countries in the world to apply an excise tax on kerosene consumption for internal flights (Aviation fuel tax).

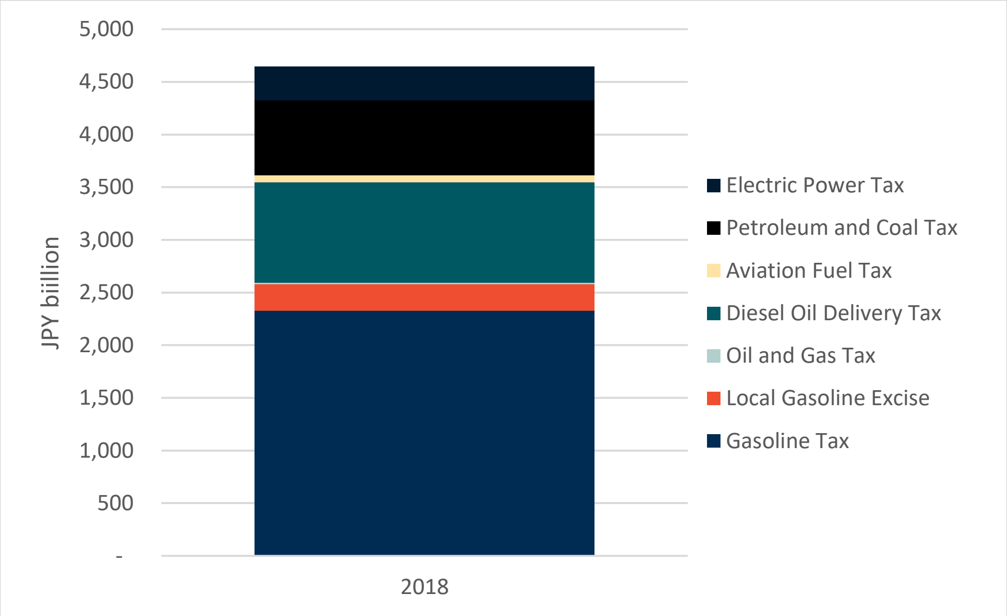

Figure 241: Energy tax revenues in Japan in 2018 (JPY billion)

Source: Authors' calculations based on Japan Ministry of Environment.

8.8 Annex: Taxes on energy consumption included in the analysis

Country	Tax or non-tax levy name
Austria	Tax on mineral oils
Austria	Tax on energy - electricity
Austria	Tax on energy - natural gas (1000 m^3)
Austria	Tax on energy - coal
Austria	Emergency stock fee
Belgium	Excise duties on mineral oils
Belgium	Federal contribution on electricity and natural gas
Belgium	Stockholding fee
Belgium	Social heating fund fee
Belgium	BOFAS fee
Bulgaria	Excise tax on oil products
Bulgaria	Excise tax on electricity
Bulgaria	Excise tax on natural gas
Croatia	Excise duties on mineral oils
Croatia	Excise duties (NG, electricity)
Croatia	Fee for Incentivizing Electricity Production from Renewable Energy Sources and Cogeneration
Cyprus	Excise Hydrocarbon Oils
Cyprus	Excise tax on electricity
Czech Republic	Excise duty on mineral oil products
Czech Republic	Excise Tax Power
Czech Republic	Excise tax on natural gas
Denmark	Excise duties on oil products
Denmark	Electricity tax
Denmark	Natural gas tax
Denmark	Public Service Obligations
Estonia	Fuel excise
Estonia	Excise duties on electricity
Finland	Energy content tax (oil products)
Finland	Energy content tax (elec, natural gas)
Finland	Carbon dioxide tax (oil products)
Finland	Carbon dioxide tax (elec, natural gas)
Finland	Strategic stock fee (oil products)
Finland	Strategic stock fee (elec, natural gas)
Finland	Oil pollution fees
France	Domestic duty on energy products
France	Other domestic duties
France	Tax on electric energy
France	Contribution to the public service of electricity (CSPE)
Germany	German Energy Tax Law

Germany	Electricity Tax Act
Germany	EEG surcharge
Germany	CHP levy
Germany	Concession fee levy
Germany	Individual grid charges levy
Germany	Interruptible loads levy
Greece	Excise duties on oil products and natural gas
Greece	Excise duties on electricity
Greece	Special Gaseous Emissions Reduction Fee
Hungary	Excise duties
Ireland	Mineral Oil Tax (Non-carbon charge component)
Ireland	Mineral Oil Tax (Carbon charge component)
Ireland	Natural Gas Carbon Tax (NGCT) - gross calorific value
Ireland	Electricity tax
Ireland	National Oil Reserve Agency
Italy	Excise duty on mineral oils
Italy	Fee to support renewable energy sources (A3 component)
Italy	Excise duty on electricity
Italy	Excise tax on natural gas
Latvia	Excise tax on oil products
Latvia	Excise on electricity
Lithuania	Excise tax on oil products
Luxembourg	Taxe d'accise (incl. U.E.B.L. + autonomous)
Luxembourg	Autonomous taxes (electricity, natural gas,)
Malta	Excise Levies - Petroleum
Malta	Excise on electricity
Netherlands	Excise duty on mineral oils
Netherlands	Energy tax (electricity and natural gas)
Netherlands	Sustainable energy surcharge (Opslag duurzame energie)
Netherlands	Oil stockholding fee
Poland	Excise taxes on oil products
Poland	Fuel surcharge
Poland	Excise duty (electricity, natural gas)
Portugal	Tax on oil and energy products
Romania	Excise duty on energy products
Romania	Excise duty on electricity
Slovakia	Taxes mineral oils
Slovakia	Taxes on energy - natural gas
Slovakia	Taxes on energy - electricity
Slovakia	Taxes on energy - electricity (System operation tariff)
Slovakia	Levy to nuclear energy fund
Slovenia	Excise duties on oil products
Slovenia	Excise duties (natural gas, electricity)
Spain	Special Tax on Hydrocarbons
Spain	Retail sale tax for certain hydrocarbons

Spain	Tax on Fuels derived from petroleum products
Spain	Special tax on electricity
Spain	Fees for Regimen retributivo especifico
Spain	Contributions to the petrol products' strategic reserve corporation
Sweden	Energy tax (fuel oils)
Sweden	CO_2 tax (fuel oils)
Sweden	CO_2 tax (gas)
Sweden	Energy tax on natural gas
Sweden	Taxes on electrical power

9 Analysis of energy prices

9.1 Introduction

This section focuses on identifying which factors affect the wholesale electricity price, the natural gas, and the diesel prices, and by how much. Ordinary Least Squares (OLS) regression methods on time series and in panel data [multi-dimensional data (cross-section and time-series data)] have been applied and hourly, monthly, and yearly data have been collected and used. The period examined is the 2015 – 2021 and is split to two periods 2015 – 2019 and 2020 – 2021 to examine the impact of the latest energy price surge. The speed and the magnitude of the pass-through rate from the wholesale price to retail price is also examined for the electricity and the natural gas prices. The analysis has not considered explicitly national or EU policies that may have been applied to alleviate the energy price surge. Energy policies, such as the recent gas price cap for Spain and Portugal that has been approved in March by the EU, have a significant impact on energy prices. Section 9.2 presents the main methodology used for each energy product examined, sections 9.3, 9.4, and 9.5 include the econometric[248] results and section 9.6 provides conclusions.

9.2 Methodology

The following main topics have been analysed:

- **Electricity Price Factors**: Carbon price, natural gas price, electricity generation, power mix, nuclear unavailability and the cooling degrees days.
- **Pass through - electricity**: Speed and magnitude of pass-through rate of wholesale to retail electricity price.
- **Gas Price Factors**: Carbon price, LNG price, crude oil price, natural gas (NG) Storage and imports of natural gas.
- **Pass through - gas**: Speed and magnitude of pass-through rate of wholesale to retail gas price.
- **Oil Price Factors**: Oil imports, GDP per capita, carbon price and natural gas price.

9.2.1 *Wholesale electricity price*

For the wholesale electricity price, annual panel data were used to derive EU average estimates, monthly data to derive estimates at EU member state level, and hourly data by EU member state as we found that these explain the electricity price variability better (i.e., reducing the standard deviation of the estimates). Table 37 presents the data and the variables used in each estimation.

Table 37: Data and variables by estimation

	Hourly Data	Monthly Data	Yearly data
Period	Two periods examined: 2015 - 2019, 2020 - 2021	2015 - 2021	2015 - 2021
Countries	22[249] EU member states	22[250] EU member states	22 EU member states
Methodology	OLS regression	OLS regression	OLS with fixed effect
Dependent Variable	Wholesale electricity price (€/MWh)	Wholesale electricity price (€/MWh)	Log of wholesale electricity price (€/MWh)

[248] All estimates have been performed using the commercial software Eviews11
[249] Incomplete data for Croatia, Cyprus, Luxemburg, Malta, and Sweden.
[250] Incomplete data for Croatia, Cyprus, Luxemburg, Malta, and Sweden.

independent variables	• Electricity price (€/MWh) • Carbon Price (€/tonCO2) • Price of natural gas (€/MWh) • Total electricity generation (MWh) • Share of coal-fired to total electricity generation (%) • Share of gas-fired to total electricity generation (%) • Share of wind and solar to total electricity generation (%)	• Electricity price (€/MWh) • Carbon Price (€/tonCO2) • Price of natural gas (€/MWh) • Total electricity generation (MWh) • Share of coal-fired to total electricity generation (%) • Share of gas-fired to total electricity generation (%) • Share of wind and solar to total electricity generation (%) • Nuclear unavailability's (MWh unavailable in a month)	• Renewable share in electricity generation (%) • Electricity consumption per capita (KWh/person) • Log Price natural gas (€/MWh) • Cooling degree days index • Log carbon price (€/tonCO2)

The mathematical formulation for the hourly data estimates is:

$$P\_ELE_{t,c} = \beta_0 + \beta_1 * P_{CP_{t,c}} + \beta_2 * P_{NG_{t,c}} + \beta_3 * ELE_{TOT_{t,c}} + \beta_4 * SHR_{COAL_{t,c}} + \beta_5 * SHR_{GAS_{t,c}} + \beta_6 * SHR_{WS_{t,c}} + \varepsilon_t$$

where:

$P\_ELE_{t,c}$: Wholesale Electricity price (€/MWh)

$P_{CP_{t,c}}$: Carbon Price (€/tonCO2)

$P_{NG_{t,c}}$: Price of natural gas (€/MWh)

$ELE_{TOT_{t,c}}$: Total electricity generation (MWh)

$SHR_{COAL_{t,c}}$: Share of coal-fired to total electricity generation (percentage points)

$SHR_{GAS_{t,c}}$: Share of gas-fired to total electricity generation (percentage points)

$SHR_{WS_{t,c}}$: Share of wind and solar to total electricity generation (percentage points)

Indexes t and c stand for time and country, respectively. The mathematical formulation for the monthly data estimates is:

$$D\left\{log\left(\frac{P_{ELE_{t,c}}}{P_{ELE_{t-12,c}}}\right)\right\} = \beta_0 + \beta_1 * \mathrm{D}\left\{\log\left(\frac{P_{CP_{t,c}}}{P_{CP_{t-12,c}}}\right)\right\} + \beta_2 * \mathrm{D}\left\{\log\left(\frac{P_{NG_{t,c}}}{P_{NG_{t-12,c}}}\right)\right\} + \beta_3 * \mathrm{D}\left\{\log\left\{\frac{ELE_{TOT_{t,c}}}{ELE_{TOT_{t-12,c}}}\right)\right\} + \beta_4 * (SHR_{COAL_{t,c}} - SHR_{COAL_{t-12,c}}) + \beta_5 * (SHR_{GAS_{t,c}} - SHR_{GAS_{t-12,c}}) + \beta_6 * (SHR_{WS_{t,c}} - SHR_{WS_{t-12,c}}) + \beta_7 * \mathrm{D}\{\log(\frac{NUC_{UN_{t,c}}}{NUC_{UN_{t-12,c}}})\} + \varepsilon_t$$

where:

$NUC_{UN_{t,c}}$: Nuclear unavailability's (MWh unavailable in a month)

D: Stands for the monthly difference of the variable

The mathematical formulation for the yearly data estimates is:

$$\log P\_ELE_{t,c} = \beta_0 + \beta_1 * \log P_{CP_{t,c}} + \beta_2 * \log P_{NG_{t,c}} + \beta_3 * \log ELE_{CAP_{t,c}} + \beta_4 * SHR_{RES_{t,c}} + \beta_5 * CDD_{t,c} + \varepsilon_t$$

where:

$ELE_{CAP_{t,c}}$: electricity consumption per capita (KWh/person)

$SHR_{RES_{t,c}}$: renewable share in electricity generation (renewables electricity production (eprpddiv), and Hydroelectric production (ehypd))

$CDD_{t,c}$: Cooling degree days index

9.2.2 Electricity: Speed of pass-through rate between wholesale and retail prices

An Autoregressive Distributed Lag (ARDL) model has been used to identify the speed and the magnitude of pass-through rate from wholesale price to retail price. Monthly time series data for the EU weighted average price have been used. The selection of the lags used in the model is based on the Akaike minimum information criterion.

The mathematical formulation used is:

$$PRE_{t,c} = \beta_0 + \beta_1 * t + \beta_2 * PWE_{t,c} + \sum_{j=1}^{m} \gamma_j * PRE_{t-j,c} + \sum_{i=1}^{k} \delta_i * PWE_{t-i,c} + \varepsilon_t$$

where:

$PRE_{t,c}$: electricity retail price (€/MWh)

$PWE_{t,c}$: electricity wholesale price (€/MWh)

ε_t: the error term

m stands for the number of lags for the dependent variable

k stands for the number of lags for the independent variable

9.2.3 Wholesale natural gas price

For the wholesale natural gas price, we used panel yearly data. The mathematical formulation used is:

$$\log P\_GAS_{t,c} = \beta_0 + \beta_1 * \log P_{CP_{t,c}} + \beta_2 * \log P_{COIL_{t,c}} + \beta_3 * \log NGS_{t,c} + \beta_4 * \log IMP_{t,c} + \varepsilon_t$$

where:

$P\_GAS_{t,c}$: natural gas price (€/MWh)

$P_{CP_{t,c}}$: Carbon Price (€/tonCO2)

$P_{COIL_{t,c}}$: Price of crude oil (€/bbl)

$NGS_{t,c}$: Natural gas storage (TWh)

$IMP_{t,c}$: Imports of natural gas (million cubic meters)

9.2.4 Gas: Speed of pass-through rate between wholesale and retail prices

An Autoregressive Distributed Lag (ARDL) model has been used to identify the speed of pass-through rate from wholesale price to retail price. All estimates have been performed by using Eviews11. Monthly time series data for the EU weighted average price have been used. The selection of the lags used in the model is based on the Akaike minimum information criterion.

The mathematical formulation used is:

$$PRG_{t,c} = \beta_0 + \beta_1 * t + \beta_2 * PWG_{t,c} + \sum_{j=1}^{m} \gamma_j * PRG_{t-j,c} + \sum_{i=1}^{k} \delta_i * PWG_{t-i,c} + \varepsilon_t$$

where:

$PRG_{t,c}$: natural gas retail price (€/MWh)

$PWG_{t,c}$: natural gas wholesale price (€/MWh)

ε_t: the error term

m stands for the number of lags for the dependent variable

k stands for the number of lags for the independent variable

9.2.5 Diesel Oil price

For the diesel price, we used panel yearly data. The mathematical formulation used is:

$$\log P\_OIL_{t,c} = \beta_0 + \beta_1 * \log P_{CP_{t,c}} + \beta_2 * \log P_{LNG_{t,c}} + \beta_3 * IMP_{t,c} + \beta_4 * GDPC_{t,c} + \varepsilon_t$$

where:

$P\_OIL_{t,c}$: diesel oil price (€/liter)

$P_{CP_{t,c}}$: Carbon Price (€/tonCO2)

$P_{NG_{t,c}}$: Price of natural gas (€/MWh)

$IMP_{t,c}$: Imports of oil (million barrels)

$GDPC_{t,c}$: GDP per capita (thousand € per person)

9.3 Impact on electricity prices

Key findings

1. Hourly data explain better the electricity price variability as compared to monthly or yearly data.
2. The natural gas price, the carbon price, the total electricity generation, and the shares of renewable are found statistically significant in almost all cases.
3. Electricity price increases by an increase in natural gas price, carbon price and total electricity generation.
4. Electricity price decreases by an increase in the share of renewables.
5. In the period between 2019 and 2021, a sudden change in the wholesale price would take 2 months to pass through to the retail price in industries were the magnitude of the pass-through rate is 0.39.

9.3.1 Wholesale electricity price estimates

Yearly data estimates indicate that the electricity consumption per capita, the price of natural gas and the carbon price each have a positive relationship with the wholesale electricity price, whereas the renewable share in electricity generation has a negative impact. Empirically the relationship between temperature and electricity price is verified[251,252]. In our case the yearly/monthly observations mask important information hence we found no statistically significant estimates. The aggregated character of the variable may hide important information, which highlights the importance to have hourly data on the cooling degree index which possibly have a strong relationship at peak electricity demand hours. Based on the results of the OLS panel regression with fixed effects[253] the following coefficients were estimated:

$$\log P\_ELE_{t,c} = -6.6 + 0.2 * \log {P_{CP}}_{t,c} + 0.5 * \log {P_{NG}}_{t,c} + 0.98 * \log {ELE_{CAP}}_{t,c} - 0.004 \; * {SHR_{RES}}_{t,c} + 0 * CDD_{t,c}$$

Where:

$P\_ELE_{t,c}$: Wholesale Electricity price (€/MWh)

${P_{CP}}_{t,c}$: Carbon Price (€/tonCO2)

${P_{NG}}_{t,c}$: Price of natural gas (€/MWh)

${ELE_{CAP}}_{t,c}$: electricity consumption per capita (KWh/person)

${SHR_{RES}}_{t,c}$: renewable share in electricity generation (renewables electricity production (eprpddiv), and Hydroelectric production (ehypd))

$CDD_{t,c}$: Cooling degree days index

Estimates are found statistically significant at a 1% level of significance. In particular:

- A 1% increase in carbon price results in a 0.2% increase in electricity price
- A 1% increase in natural gas price results a 0.5% increase in electricity price
- A 1% increase of electricity consumption per person results a 0.98% increase in electricity price
- A 1% change in the share of renewable energy generation results a 0.004% decrease in electricity price.

[251] Knittel CR and Roberts MR (2005), "An empirical examination of restructured electricity prices", Energy Economics., sep, 2005. Vol. 27(5), pp. 791-817. Elsevier BV.

[252] Kropyvnytskyy A (2016), "An Empirical Study of Electricity Price and Temperature"

[253] Fixed Effects allow intercept to vary across countries. Based on this approach, the estimator used is consistent with an unknown country characteristic that allows heterogeneity across countries.

In these estimates, the variables have cross section N larger than time T. Table 38 presents the main statistical properties of the residual of the estimates for the electricity price:

Table 38: Statistical properties of the residual - Unit root test

Series: RESID01 Workfile: PANEL_ENERGY_PRICES::Untitled\

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph

Panel Unit Root Test on RESID01

Panel unit root test: Summary
Series: RESID01
Date: 11/04/22 Time: 17:24
Sample: 2008 2021
Exogenous variables: None
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-11.8333	0.0000	25	250
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	198.163	0.0000	25	250
PP - Fisher Chi-square	193.233	0.0000	25	257

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Monthly data was used to increase the degrees of freedom and derive estimates at the EU member state level. To check the stationarity of the variables unit root tests applied in the series and has been identified non-stationary in levels or year-by-year differences while is stationary in monthly and monthly difference of the annual growth rate. The estimations have been done in monthly difference of the annual growth rate.

Table 39 presents the beta coefficient of the statistically significant estimates by EU member state where data were available. Empty boxes relate to statistically no significant estimates at 5% level of significance.

Table 39: Estimates based on monthly data - impact on wholesale electricity price (statistically significant estimates at 5%)

	D [log (P_GAS/P_GAS (-12))]	D [log (P_CP/P_CP (-12))]	D [log (ELE_TOT/ELE_TOT (-12))]	D [(SHR_COAL-SHR_COAL (-12))]	D [(SHR_GAS-SHR_GAS (-12))]	D [(SHR_WS-SHR_WS (-12))]
AT	0.39	0.29			0.01	
BE	0.76		0.15	n/a	0.01	
BG		1.31				
CZ	0.34	0.61			0.03	
DE	0.41	0.34	0.20		0.04	-0.01
DK	0.44		0.09		0.01	-0.01
EE	0.36					-0.03
GR		0.39	0.17			
ES	-0.30	0.67	0.20	0.03	0.02	

FI			-0.66	0.02		
FR	0.65	0.38			0.08	
HU		0.72	0.94		0.03	
IE		0.59	0.12	0.01	0.01	
IT	0.71				0.01	
LT		0.58		n/a	0.01	
LV		0.36		n/a	0.00	-0.03
NL	0.58	0.27	0.09			
PL		0.50				
PT	0.31	0.53	0.09	0.02	0.01	0.01
RO						
SI					0.20	
SK				0.08		

The results of the OLS regression using monthly data confirm the main findings of the estimations using yearly data, that is:

- Total electricity generation, carbon price and natural gas prices are the main factors that are related positively to the electricity price
- The share of renewable energy sources, and more specifically the share of wind and solar power generation, impact negatively the electricity price.

Estimates for Estonia, Finland, and Slovenia were not possible as there was missing data in electricity prices (Estonia and Slovenia) and gas prices (Finland).

It should be noted that the monthly data fail to capture day-by-day or hour-by-hour factors that may have important statistical information which explain better the electricity price variability. By extending our analysis to hourly data, we confirmed this argument as we found statistically significance estimates to almost all cases. Table 40 presents the beta coefficient of the statistically significant estimates at 1% level of significance by EU member state.

Table 40: Estimates based on hourly data - impact on wholesale electricity price (statistically significant estimates at 1%)

	$P_{CP_{t,c}}$		$P_{NG_{t,c}}$		$ELE_{TOT_{t,c}}$		$SHR_{COAL_{t,c}}$		$SHR_{GAS_{t,c}}$		$SHR_{WS_{t,c}}$	
Units	€/tonCO2		€/MWh		MWh		p.p		p.p		p.p	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
AT	0,79	0,10	1,35	1,99	0,004	0,011	0,23	-4,06	0,15	0,73	-0,42	-0,72
BE	0,25	0,45	2,07	1,84	0,005	0,010	n/a	n/a	0,80	-0,43	-0,03	-1,39
BG	1,02	0,75	n/a	2,18	0,010	0,014	0,43	0,51	-1,95	-0,64	0,15	n/a
CZ	0,46	2,16	0,95	1,21	0,003	0,010	0,29	0,18	1,94	1,75	0,04	-0,99
DE	1,13	0,67	0,74	1,30	0,001	0,001	-0,22	-0,21	0,45	0,85	-0,91	-1,46
DK	0,94	0,95	0,57	0,88	0,001	0,002	-0,11	1,15	-0,12	3,98	-0,38	0,22
EE	1,45	1,38	-0,12	0,31	0,013	0,150	0,78	-1,00	3,50	37,78	0,33	-1,48
ES	0,71	2,80	n/a	2,75	0,001	0,001	0,98	2,86	0,19	1,65	-0,27	-0,23
FI	0,88	n/a	1,14	n/a	0,003	n/a	0,46	n/a	-1,36	n/a	-0,69	n/a

FR	0,57	0,63	1,49	1,73	0,000	0,000	2,21	5,79	2,24	4,93	-0,46	-0,73
GR	0,49	n/a	1,05	2,94	0,004	0,011	0,07	-0,35	0,25	n/a	-0,13	-0,82
HU	0,31	0,88	0,94	2,25	0,006	0,017	0,37	n/a	1,24	1,64	-0,48	-0,17
IE	0,81	3,68	1,29	0,84	0,012	0,011	n/a	-0,64	0,29	-0,15	-0,33	-0,79
IT	-0,43	0,36	1,57	2,08	0,001	0,002	0,12	0,45	0,56	n/a	-0,22	-0,97
LT	0,66	0,97	0,26	1,60	0,004	0,058	n/a	n/a	-0,23	-0,18	-0,34	-0,82
LV	0,62	1,39	0,62	0,93	0,014	0,044	n/a	n/a	0,17	0,31	-0,48	-0,55
NL	0,22	0,41	1,70	1,79	0,001	0,004	0,09	0,30	0,27	0,51	0,04	-0,81
PL	6,88	0,57	3,65	0,57	0,006	0,004	-4,46	-0,57	2,92	0,65	-6,95	-1,97
PT	0,48	2,30	0,65	2,73	0,004	0,003	0,60	0,32	0,34	0,27	-0,07	-0,43
RO	1,23	-0,12	-0,58	0,25	0,007	0,011	0,63	n/a	0,44	-0,45	-0,59	-0,98
SI	0,62	2,25	0,65	1,91	0,022	0,042	0,41	0,32	1,21	7,87	0,30	-1,05
SK	0,45	1,02	0,68	1,64	0,006	n/a	2,12	0,50	1,17	2,54	0,51	-0,38

(a): Estimates for the period 2015 – 2019

(b): Estimates for the period 2020 - 2021

Estimates on hourly data confirms that:

- The gas price increases the fuel cost of gas fired power plants which increasing the short run marginal costs and as a result the electricity prices. The effect is also determined by the gas share to power generation. The higher the share of gas in total electricity generation the higher the impact of an increase in the natural gas price.
- Carbon price increases electricity price as fossil fuels become more expensive. Effect moderated over time in cases where fossils are substituted (with RES or towards natural gas that has lower carbon intensity).
- The increase in the share of renewables to power generation decreases the price of electricity[254].
- Higher contribution of gas-fired share to power generation increases the electricity price in almost all cases. The effect is even higher in the period 2020-2021 for most cases including Germany, France, Spain, and Netherlands.

9.3.2 Speed of pass-through between wholesale and retail electricity prices.

An ARDL model has been utilized to estimate the speed and the magnitude of pass-through rate of a change in the wholesale electricity price to retail price for industries and households. All estimates have been based on monthly data for EU weighted average price. The estimations are split into two periods (2008-2019 and 2019-2021) to examine the speed of pass-through before and after the energy price surge.

Table 41: Overview of the estimations of the magnitude and speed of pass-through for the electricity price

Period: 2008-2019			Period: 2019-2021		
PTR	Confidence Interval (95%)	Speed	PTR	Confidence Interval (95%)	Speed

254 This effect was noted to be particularly high for Poland, Germany, Belgium and Slovenia

Industry	1.65	[-0.01, 3.32]	4% - (26 months)	0.39	[0.28, 0.50]	46% - (2 months)
Household	-0.03	[-1.75, 1.68]	2% - (50 months)	0.009	[-0.05, 0.06]	33% - (3 months)

Table 41 presents the overview of the results for the speed and the magnitude of the pass-through for the electricity price. Red boxes are characterized by low r-squared and statistically non-significant estimates for the magnitude of the pass-through rate and indicates the complex dynamics that take place in a "canonical period" such as price hedging, contracts etc. On the other hand, green boxes are found with statistically significant estimates for the pass-through rate. The magnitude of the pass-through rate in industries for the period 2019-2021 has been found to be 0.39 and the speed of pass-through is 46%, which means that 39% of the change in the wholesale prices will be pass-through in industries in a time period of 2 months.

ARDL Error Correction Regression
Dependent Variable: D(P_ELE_IND)
Selected Model: ARDL(1, 3)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/09/22 Time: 10:54
Sample: 2008M01 2019M12
Included observations: 141

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.901588	0.372393	5.106396	0.0000
@TREND	0.008327	0.003004	2.771462	0.0064
D(P_ELE_WHS)	0.048061	0.014587	3.294829	0.0013
D(P_ELE_WHS(-1))	-0.033886	0.015532	-2.181644	0.0309
D(P_ELE_WHS(-2))	-0.021772	0.014976	-1.453773	0.1483
CointEq(-1)*	-0.038190	0.007664	-4.982867	0.0000

R-squared	0.178363	Mean dependent var	0.153218
Adjusted R-squared	0.147932	S.D. dependent var	1.154974
S.E. of regression	1.066128	Akaike info criterion	3.007565
Sum squared resid	153.4449	Schwarz criterion	3.133045
Log likelihood	-206.0334	Hannan-Quinn criter.	3.058556
F-statistic	5.861220	Durbin-Watson stat	2.125711
Prob(F-statistic)	0.000062		

Figure 242: ARDL Error Correction Regression for industries (2008-2019, EU27 weighted average) - Electricity price

ARDL Error Correction Regression
Dependent Variable: D(P_ELE_IND)
Selected Model: ARDL(1, 2)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/09/22 Time: 11:01
Sample: 2019M01 2021M12
Included observations: 36

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	22.98827	6.499245	3.537068	0.0013
@TREND	0.196925	0.039085	5.038313	0.0000
D(P_ELE_WHS)	0.060635	0.017265	3.511936	0.0014
D(P_ELE_WHS(-1))	-0.088514	0.034629	-2.556070	0.0159
CointEq(-1)*	-0.460214	0.073082	-6.297264	0.0000

R-squared	0.637074	Mean dependent var	1.244154
Adjusted R-squared	0.590245	S.D. dependent var	2.596303
S.E. of regression	1.661949	Akaike info criterion	3.982105
Sum squared resid	85.62431	Schwarz criterion	4.202038
Log likelihood	-66.67789	Hannan-Quinn criter.	4.058868
F-statistic	13.60420	Durbin-Watson stat	2.001785
Prob(F-statistic)	0.000002		

Figure 243: ARDL Error Correction Regression for industries (2019-2021, EU27 weighted average) - Electricity price

Figure 242 and Figure 243 presents the results of the cointegration equation for industries in the two examined periods. The lag in the ARDL model has been selected by using the Akaike minimum information criterion. The ARDL (1,3) (period 2008-2019) and ARDL (1,2) (period 2019-2021) was selected for industries. The parameter that corresponds to rate of adjustment, the pass through rate, is the coefficient of the variable CointEq(-1).

ARDL Error Correction Regression
Dependent Variable: D(P_ELE_HH)
Selected Model: ARDL(1, 5)
Case 3: Unrestricted Constant and No Trend
Date: 11/09/22 Time: 11:07
Sample: 2008M01 2019M12
Included observations: 139

ECM Regression
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.119144	1.300943	3.166275	0.0019
D(P_ELE_WHS)	0.046515	0.015911	2.923411	0.0041
D(P_ELE_WHS(-1))	0.031542	0.016008	1.970331	0.0509
D(P_ELE_WHS(-2))	0.028399	0.016136	1.759963	0.0807
D(P_ELE_WHS(-3))	0.014117	0.015975	0.883707	0.3785
D(P_ELE_WHS(-4))	-0.034428	0.015836	-2.174001	0.0315
CointEq(-1)*	-0.019426	0.006681	-2.907688	0.0043

R-squared	0.178807	Mean dependent var	0.342870
Adjusted R-squared	0.141481	S.D. dependent var	1.306934
S.E. of regression	1.210957	Akaike info criterion	3.269746
Sum squared resid	193.5670	Schwarz criterion	3.417525
Log likelihood	-220.2474	Hannan-Quinn criter.	3.329800
F-statistic	4.790307	Durbin-Watson stat	1.736113
Prob(F-statistic)	0.000188		

Figure 244: ARDL Error Correction Regression for Households (2008-2019, EU27 weighted average) - Electricity price

ARDL Error Correction Regression
Dependent Variable: D(P_ELE_HH)
Selected Model: ARDL(1, 0)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/09/22 Time: 11:10
Sample: 2019M01 2021M12
Included observations: 36

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	57.29542	19.14897	2.992088	0.0053
@TREND	0.075843	0.023487	3.229203	0.0029
CointEq(-1)*	-0.333832	0.099034	-3.370874	0.0020

R-squared	0.317356	Mean dependent var	0.001611
Adjusted R-squared	0.275984	S.D. dependent var	1.560300
S.E. of regression	1.327645	Akaike info criterion	3.484346
Sum squared resid	58.16718	Schwarz criterion	3.616306
Log likelihood	-59.71823	Hannan-Quinn criter.	3.530404
F-statistic	7.670741	Durbin-Watson stat	1.505138
Prob(F-statistic)	0.001837		

Figure 245: ARDL Error Correction Regression for Households (2019-2021, EU27 weighted average) - Electricity price

Figure 244 and Figure 245 presents the results of the cointegration equation for households in the two examined periods. The lag in the ARDL model has been selected by using the Akaike minimum information criterion. The ARDL (1,5) (period 2008-2019) and ARDL (1,0) (period 2019-2021) was selected for households. The parameter that corresponds to rate of adjustment, the pass through rate, is the coefficient of the variable CointEq(-1). The estimations for households are characterized by low r-squared and non-significant estimates for the magnitude of the pass-through rate.

Figure 246 shows the evolution of wholesale and retail electricity prices from 2008 to 2021. In the period 2008-2019 the variability of the wholesale prices is not followed by retail prices while in the period 2019-2021 the electricity prices in industries follows the lasting increase in the wholesale prices.

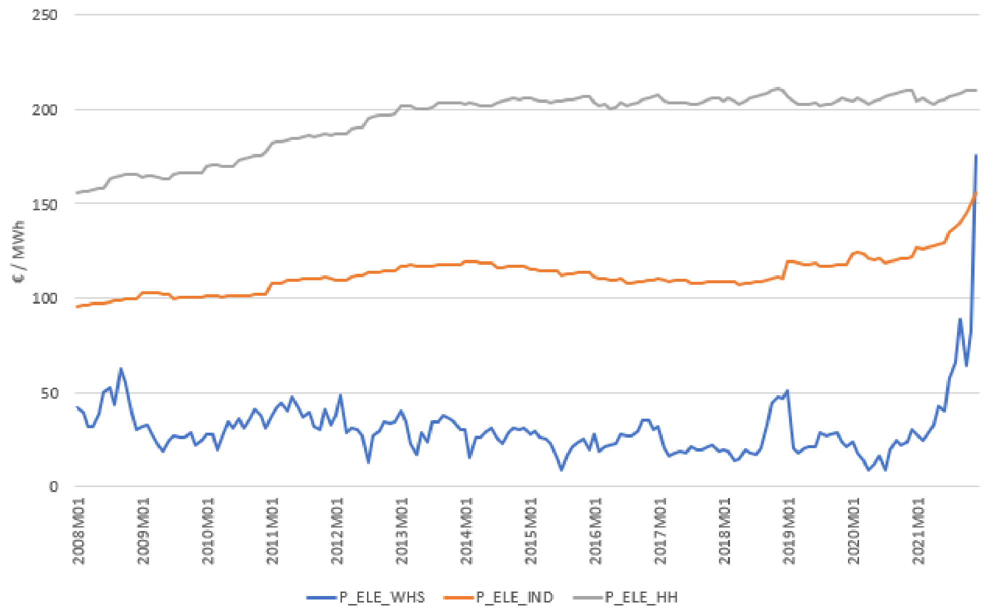

Figure 246: Wholesale and retail electricity prices (in €/MWh)

9.4 Impact on natural gas prices

Key findings

1. Carbon price and the price of crude oil have a positive relationship with the wholesale natural gas price
2. Natural gas storage and the natural gas imports have a negative impact on the wholesale price.
3. For industries the estimations shows that the magnitude of the pass-through rate is 0.62 in 2008-2019 that will be pass-through in a period of 8 months and 0.73 in 2019-2021 that will be pass-through in 1.7 months. For households the magnitude is 1.04 in the period 2008-2019 that will be pass-through in a period of 4 months.

9.4.1 *Wholesale natural gas price estimates.*

Yearly panel data estimates indicates that the carbon price and the price of crude oil have a positive relationship with the wholesale natural gas price whereas the natural gas storage and the natural gas imports have a negative impact on the wholesale price. Based on the results of the OLS panel regression with fixed effects:

$$\log P\_GAS_{t,c} = 0.18 + 0.06 * \log P_{CP_{t,c}} + 1.14 * \log P_{COIL_{t,c}} - 0.28 * \log NGS_{t,c} - 0.16 * \log IMP_{t,c}$$

Estimates are found statistically significant at a 10% level of significance. In particular:

- A 1% increase in carbon price results a 0.06% increase in natural gas price
- A 1% increase in crude oil price results a 1.14% increase in natural gas price
- A 1% increase of natural gas storage results a 0.28% decrease in natural gas price
- A 1% increase in the level of natural gas imports results a 0.16% decrease in natural gas price.

9.4.2 *Speed of pass-through between wholesale and retail natural gas prices.*

An ARDL model has been used to estimate the speed and the magnitude of pass-through rate of a change in the wholesale electricity price to retail price for industries and households. All estimates have been based on monthly data for EU weighted average price. The estimations are split into two periods (2008-2019 and 2019-2021) to examine the speed of pass-through before and after the energy price surge.

Table 42: Overview of the estimations of the magnitude and speed of pass-through for the gas price

	Period: 2008-2019			Period: 2019-2021		
	PTR	Confidence Interval (95%)	Speed	PTR	Confidence Interval (95%)	Speed
Industry	0.62	[0.46, 0.78]	13% - (8 months)	0.73	[0.41, 1.06]	59% - (1,7 months)
Household	1.04	[0.68, 1.40]	26% - (4 months)	-0.32	[-0.53, -0.10]	67% - (1.5 month)

Table 42 presents the overview of the results for the speed and the magnitude of the pass-through for the gas price. Red boxes are characterized by low r-squared and statistically non-significant estimates for the magnitude of the pass-through rate. On the other hand, green boxes are found with statistically significant estimates for the pass-through rate. The magnitude of the pass-through rate in the period 2008-2019 was found to be statistically significant for both industries and households. In period between 2008 and 2019, the magnitude of the pass-through rate is 0.62 for industries with a speed of 13% (8 months) and 1.04 for households with a speed of 26% (4 months). However, the results in the period 2008-2019 have relatively low r-squared (Figure 247 and Figure 249) and it must be considered with caution. In the period between 2019 and 2021, the magnitude of the pass-through rate is 0.73 for industries with a speed of 59% (1.7 months), where for households there are no statically significant estimates.

ARDL Error Correction Regression
Dependent Variable: D(P_NG_IND)
Selected Model: ARDL(1, 3)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/09/22 Time: 11:27
Sample: 2008M01 2019M12
Included observations: 141

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.388610	0.548263	4.356687	0.0000
@TREND	-0.004651	0.001444	-3.220456	0.0016
D(P_NG_WHS)	0.031177	0.028739	1.084828	0.2799
D(P_NG_WHS(-1))	0.058379	0.032697	1.785486	0.0764
D(P_NG_WHS(-2))	0.036132	0.032309	1.118334	0.2654
CointEq(-1)*	-0.131987	0.030145	-4.378490	0.0000

R-squared	0.297160	Mean dependent var	-0.038090
Adjusted R-squared	0.271129	S.D. dependent var	0.628523
S.E. of regression	0.536595	Akaike info criterion	1.634475
Sum squared resid	38.87110	Schwarz criterion	1.759954
Log likelihood	-109.2305	Hannan-Quinn criter.	1.685465
F-statistic	11.41556	Durbin-Watson stat	2.064489
Prob(F-statistic)	0.000000		

Figure 247: ARDL Error Correction Regression for industries (2008-2019, EU27 weighted average)- Natural gas price

ARDL Error Correction Regression
Dependent Variable: D(P_NG_IND)
Selected Model: ARDL(1, 6)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/09/22 Time: 11:30
Sample: 2019M01 2021M12
Included observations: 36

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.40039	7.862384	-1.831555	0.0785
@TREND	0.151217	0.056638	2.669865	0.0129
D(P_NG_WHS)	0.103441	0.084106	1.229879	0.2298
D(P_NG_WHS(-1))	-0.144488	0.120371	-1.200356	0.2408
D(P_NG_WHS(-2))	-0.436352	0.211283	-2.065251	0.0490
D(P_NG_WHS(-3))	-0.246665	0.273854	-0.900719	0.3760
D(P_NG_WHS(-4))	-0.210351	0.240199	-0.875737	0.3892
D(P_NG_WHS(-5))	-0.685792	0.241822	-2.835941	0.0087
CointEq(-1)*	-0.594408	0.155561	-3.821064	0.0007

R-squared	0.479918	Mean dependent var	0.495598
Adjusted R-squared	0.325820	S.D. dependent var	2.514845
S.E. of regression	2.064901	Akaike info criterion	4.500360
Sum squared resid	115.1231	Schwarz criterion	4.896240
Log likelihood	-72.00648	Hannan-Quinn criter.	4.638532
F-statistic	3.114360	Durbin-Watson stat	1.633732
Prob(F-statistic)	0.012620		

Figure 248: ARDL Error Correction Regression for industries (2019-2021, EU27 weighted average)- Natural gas price

Figure 247 and Figure 248 presents the results of the cointegration equation for industries in the two examined periods. The lag in the ARDL model has been selected by using the Akaike minimum information criterion. The ARDL (1,3) (period 2008-2019) and ARDL (1,6) (period 2019-2021) was selected for industries. The parameter that corresponds to rate of adjustment, the pass through rate, is the coefficient of the variable CointEq(-1).

ARDL Error Correction Regression
Dependent Variable: D(P_NG_HH)
Selected Model: ARDL(1, 7)
Case 5: Unrestricted Constant and Unrestricted Trend
Date: 11/09/22 Time: 11:18
Sample: 2008M01 2019M12
Included observations: 137

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.12460	2.128883	4.755826	0.0000
@TREND	0.016925	0.006011	2.815462	0.0057
D(P_NG_WHS)	0.350926	0.123913	2.832026	0.0054
D(P_NG_WHS(-1))	0.011692	0.123052	0.095014	0.9245
D(P_NG_WHS(-2))	-0.058563	0.124950	-0.468692	0.6401
D(P_NG_WHS(-3))	-0.134493	0.128926	-1.043177	0.2989
D(P_NG_WHS(-4))	-0.413093	0.127107	-3.249971	0.0015
D(P_NG_WHS(-5))	-0.038010	0.131617	-0.288791	0.7732
D(P_NG_WHS(-6))	-0.294988	0.128866	-2.289110	0.0237
CointEq(-1)*	-0.259335	0.053949	-4.807054	0.0000

R-squared	0.216578	Mean dependent var	0.027383
Adjusted R-squared	0.161060	S.D. dependent var	2.402850
S.E. of regression	2.200858	Akaike info criterion	4.485763
Sum squared resid	615.1596	Schwarz criterion	4.698901
Log likelihood	-297.2748	Hannan-Quinn criter.	4.572377
F-statistic	3.901044	Durbin-Watson stat	1.775349
Prob(F-statistic)	0.000213		

Figure 249: ARDL Error Correction Regression for Households (2008-2019, EU27 weighted average) - Natural gas price

ARDL Error Correction Regression
Dependent Variable: D(P_NG_HH)
Selected Model: ARDL(1, 3)
Case 3: Unrestricted Constant and No Trend
Date: 11/09/22 Time: 11:22
Sample: 2019M01 2021M12
Included observations: 36

ECM Regression
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	46.77387	9.318046	5.019709	0.0000
D(P_NG_WHS)	0.197892	0.089216	2.218107	0.0343
D(P_NG_WHS(-1))	0.364408	0.118270	3.081164	0.0044
D(P_NG_WHS(-2))	0.600232	0.186544	3.217647	0.0031
CointEq(-1)*	-0.672195	0.133274	-5.043705	0.0000

R-squared	0.462830	Mean dependent var	-0.013711
Adjusted R-squared	0.393518	S.D. dependent var	3.313694
S.E. of regression	2.580604	Akaike info criterion	4.862170
Sum squared resid	206.4451	Schwarz criterion	5.082104
Log likelihood	-82.51907	Hannan-Quinn criter.	4.938933
F-statistic	6.677464	Durbin-Watson stat	1.524442
Prob(F-statistic)	0.000536		

Figure 250: ARDL Error Correction Regression for Households (2019-2021, EU27 weighted average) - Natural gas price

Figure 249 and Figure 250 presents the results of the cointegration equation for households in the two examined periods. The lag in the ARDL model has been selected by using the Akaike minimum information criterion. The ARDL (1,7) (period 2008-2019) and ARDL (1,3) (period 2019-2021) was selected for households. The parameter that corresponds to rate of adjustment, the pass through rate, is the coefficient of the variable CointEq(-1).

Figure 251 shows that in the recent energy crisis the EU27 weighted average wholesale natural gas price decreased from early 2019 to 2020 with sharp increased afterwards and seems that retail prices for industries follow this increase more profoundly than households.

The magnitude of the pass-through rate in the period between 2008 and 2019 was found statistically significant for both industries and households. In period between 2008 and 2019, the magnitude of the pass-through rate is 0.62 for industries with a speed of 13% (8 months) and 1.04 for households with a speed of 26% (4 months). However, the results in the period 2008-2019 have marginally low r-squared (Figure 6 and Figure 8) and it must be considered with caution. In the period between 2019 and 2021, the magnitude of the pass-through rate is 0.73 for industries with a speed of 59% (1.7 months) where for households there are no statically significant estimates.

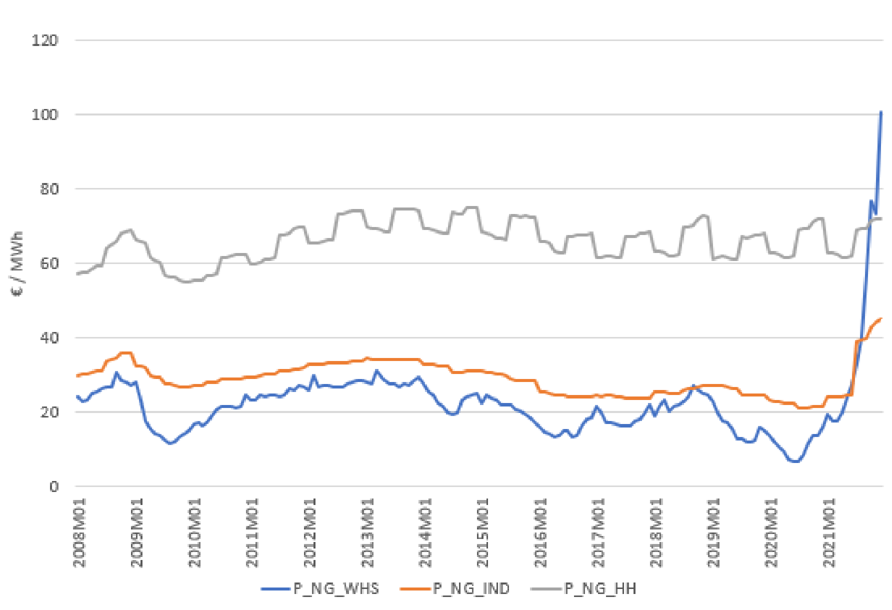

Figure 251: Wholesale and retail natural gas price (in €/MWh)

9.5 Impact on oil prices

Yearly panel data estimates indicates that the natural gas price and the GDP per capita have a positive relationship with the diesel oil price[255] whereas the oil imports have a negative impact on the diesel price. Based on the results of the OLS panel regression with fixed effects:

$$\log P\_OIL_{t,c} = -1.6 + 0 * \log P_{CP_{t,c}} + 0.26 * \log P_{NG_{t,c}} + 0.30 * \log GDPC_{t,c} - 0.11 * \log IMP_{t,c}$$

Most of estimates are found statistically significant at a 1% level of significance. In particular:

- A 1% increase in natural gas price results in a 0.26% increase in diesel oil price
- A 1% increase of GDP per capita results in a 0.30% increase in diesel oil price

255 See also: Nkwantabisa D (2021), *"Determinants of Natural Gas Prices in the United States - A Structural VAR Approach"*, SSRN Electronic Journal. Elsevier BV.

- A 1% increase in the level of oil imports results in a 0.11% decrease in diesel oil price, with a 10% level of significance.

9.6 Conclusion

OLS regression and panel OLS with fixed effects methods were used to analyse the impact of various factor on the electricity, natural gas and oil price. The estimation by using hourly data found to be superior in terms of statistical significance due to the better explanation of the electricity price variability as peak and base load demand differ by hour.

For the wholesale electricity price, it is found that an increase in the natural gas price increases electricity costs since the gas-fired power plants can cover peak load demand and have increased their penetration in the power mix in the period examined in most EU member states. Hence, the role of gas price as an electricity price determinant has been intensified over the period 2020 -2021. The carbon price is positively correlated with the electricity price. The effect is moderated over time in cases of fossils being substituted by renewable energy or other fossil fuels that have a lower carbon intensity. The increase in the share of renewables to power generation decreases the price of electricity.

By examining how quickly a change in the wholesale electricity price is passed through the retail electricity price we found that a sudden change in the wholesale electricity price would take 2 months to pass through to the retail electricity price in industries were the magnitude of the pass-through rate is 0.39 in the period 2019-2021. For the wholesale natural gas prices in industries the estimations shows that the magnitude of the pass-through rate is 0.62 in 2008-2019 that will be pass-through in a period of 8 months and 0.73 in 2019-2021 that will be pass-through in 1.7 months. For households the magnitude is 1.04 in the period 2008-2019 that will be pass-through in a period of 4 months.

Natural gas and diesel oil prices were analysed by using yearly panel data across for the EU countries. In both cases, there is a positive correlation of the price with the change in other energy prices considered in the estimated equation and a negative correlation with their respective imports. Natural gas storage levels negatively impact (e.g. lower) the natural gas price.

10 Impact of price developments on low-carbon emission technologies

In this Chapter, we take a closer look at how the current energy prices impact the financial attractiveness of renewable energy alternatives and energy saving measures for households. To do this, we analyse two of the key measures that households can take to lower their energy use and emissions:

a) switching from gas to electric heating with a heat pump and
b) switching to an electric vehicle (EV).

The analysis focuses on the financial attractiveness of these investments and on how the recent price increases influenced the business case for these two key measures.

10.1 Case study 1: Heat pumps vs. gas boilers

In the first case study, we analyse the Total Cost of Ownership (TCO) of full-electric heat pumps in comparison with conventional gas boilers — currently the most used heating source for households in the EU. The European Commission see (full electric) heat pumps as one of the main technologies that could deliver significant energy and emission reductions in the built environment and households, and potentially save costs as well.

Methodology

For this analysis, we selected four representative heating profiles: households in cold (e.g. Poland) and moderate (e.g. Netherlands) climate zones with average or good insulation[256]. The analysis is based on a common four-person household occupying a 110m^2 house, as in Table 43. These four profiles give a simplified but good basis for the analysis on the financial viability of heat pumps in the EU. Most input parameters were based on a study of the Coolproducts initiative of the European Environmental Bureau.[257] Table 44 shows all parameters and inputs that were taken into account to assess full lifetime costs.[258]

Heat pump viability and cost differences in the EU

This analysis is inevitably a simplification of reality, which gives a rough estimate of the impact of higher energy prices on heating technologies throughout the EU, based on average EU27 costs. Among others, in this analysis we use EU27 tax levels, average EU heat pumps costs and efficiency, average EU emission intensity. Also, the calculation is based on forecasts for wholesale spot prices and the retail energy price can differ significantly.

Individual cases can show (significantly) different results as a result of variations in among others:

- **Operational costs:** depends on the household's energy contract (electricity and/or gas), which (especially in 2021-2022) can lead to large differences in energy prices; national tax levels.

[256] All values are in EUR2021 prices.
[257] European Environmental Bureau (2021). Analysis of the affordability of switching to renewable heating for a standardized middle-income family in the EU.
258 The model is inevitably a simplification of reality, used to compare the impact of higher energy prices on heating technologies. Absolute estimates of payback times, operational costs etc. should be interpreted with caution. Individual cases may show (significantly) different results, depending on the price of the heat pump, the energy price paid by households under their contract, insulation level, geographical location, additional measures needed in (old) houses, etc. This is especially the case given the use of EU27 averages when available (average EU27 taxes, average EU27 heat pump cost and efficiency, average EU27 emission intensity). Also, the calculation is based on forecasts for wholesale spot prices and the retail energy price can differ significantly. All values are in EUR2021 prices.

- **Investment costs**: depends on the necessary adjustments to the existing heating system; high labour costs increase installation costs.
- **Heating demand**: specific heating demand of the house depending on insulation level; heat pump efficiency (depending on house type, heat pump type and insulation level).

Table 43: Characteristics of reference household type in different climates and with different insulation levels. Reference household is 110 m2 with a four-person family. Unit: kWh heating need per year.

Climate zone	Moderate		Cold	
Insulation level	Average	High	Average	High
Heat demand (kWh)				
Space heating demand	9,595	6,716	17,271	12,089
Water heating demand (4 persons)	3,778	3,778	3,778	3,778
Total heat demand	13,373	10,494	21,048	15,867

Heating profiles based on 944 kWh water heating demand per person. Average space heating demand in moderate climate based on average heating demand in the Netherlands in 2019 of 87 kWh/m2; for cold climate average space heating of Poland is used of 157 kWh/m2. For high insulation a 30% reduction of heating demand is assumed.
Source: Odyssee-Mure (2022). Heating consumption per m2 and dwelling.

In addition, in this analysis, houses in warm climates are not included, as (air-to-source) heat pumps are rarely the most viable decarbonisation route in warm climates with limited heating needs. Cheaper air-to-air heat pumps that can both heat and cool in combination with solar boilers are expected to be more cost-efficient options.
Poor insulation dwellings are not included as well, as they can require large additional investments in insulation measures first to reduce their heating demand before heat pumps become viable. In this situation, the relative saving compared to gas is lower, but the reduction of absolute energy consumption (and bills) is likely the highest.

Table 44: Main assumptions used in simplified analysis of heat pump financials.

Category	Indicator	Unit	Standard boiler	High-Efficiency boiler	Air-to-source heat pump	Ground source heat pump	Source
Characteristics	Efficiency	Heat output/heat input (%)	75%	90%	360%	460%	Ecoboiler-Review[259]
	Lifetime	years	12	12	20	20	
Costs[260]	Purchase +installation cost	EUR2021	1701	2430	10000	16000	
	Operational + repair + maintenance	EUR2021/year	270	270	49	52	
Emissions	Refrigerant emissions	kg CO2 annually	0	0	140	140	Coolproducts (2021)[261]
	Gas	kg CO2/MWh	204				IPCC[262]
	Electricity (EU average 2022-2030)	kg CO2/MWh	190				EEA (2022)[263]

[259] Ecoboiler-review (2019).Review study: Environment & economics
[260] In the case of existing houses, additional investments could be necessary in order to make the house suitable for heat pump heating. This includes insulation measures, but could also mean a switch replacing existing radiators to larger models or a switch to floor heating or forced-air systems. These costs can make up 35% of total investment costs (incl. installation). Source: IEA (2022).The future of heat pumps.
[261] Coolproducts (2021). Analysis of the affordability of switching to renewable heating
[262] IPCC data via RVO (2020). List of energy carriers and emission factors.
[263] EEA (2022). Greenhouse gas emission intensity of electricity generation in Europe

Insights and results

Table 45 shows some key indicators of the cost savings for households when switching to heat pumps. The results are shown for four possible gas and electricity price scenarios[264]:

- *Current price forecast 2022-2030 (Elec 250 EUR/MWh; gas 100 EUR/MWh):* This provides an up-to-date price forecast for the next 8 years. Therefore, taking into account the current very high prices but also lower prices towards 2030.
- *Pre-price increase forecast 2022-2030 (Elec 150 EUR/MWh; gas 49 EUR/MWh):* This shows the expected price forecast made mid-2021, so before the current very high price increases. The difference between these first scenarios shows the impact of the recent price increase.
- *Continuing current price levels (Elec 380 EUR/MWh; gas 168 EUR/MWh):* In this scenario, we assume that the current extremely high price level will continue. While this scenario could be considered as extreme, it gives a good insight on the impact of the current situation on heat pumps.

Below we present some of the main results of the analysis in which we compare the costs of an (air-to-source) heat pump with a (high-efficiency) gas boiler.

- **The current very high price levels and forecasted long-term prices will likely make heat pumps over their lifetime cheaper than fossil gas boilers.** When assessing total lifetime costs, before recent price increases heat pumps without any subsidy showed similar lifetime costs to gas boilers. However, because of the current high energy prices and its likely impact on the overall price level in the coming 10 years, heat pumps will be cheaper (or 'less expensive') compared to gas boilers and **saving around €300-€700** per year and lowering heating energy bills **by 20-25%** compared to gas. The main reason heat pumps are relatively more favourable now is that the ratio between electricity and gas prices has decreased, while staying lower than the efficiency ratio between boilers and heat pumps (Figure 252). Nevertheless, in case of continuing high electricity prices, energy bills will stay high; also with a heat pump still higher than the heating costs pre price-increase. The estimated payback time for heat pumps (additional investment compared with gas) in this scenario is 6-9 years. Also, it is estimated that investment costs for heat pumps could further reduce with 20% towards 2030, both through heat pump cost reductions as well as more efficient installation methods (though labour shortages might on the other hand drive up costs).[265]

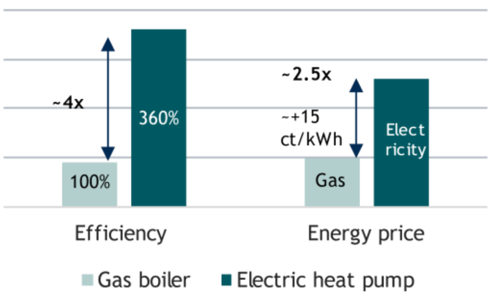

Figure 252: Difference between efficiencies and energy price for gas boilers and electric heat pumps. A higher efficiency difference and lower energy price difference, results in heat pumps being relatively more financially attractive.

[264] All above 4 total costs include a network + tax costs of **28 EUR**/MWh for natural gas and **113 EUR**/MWh for electricity, in line with the 2021 EU27 average.
[265] IEA (2022). The future of heat pumps.

- **Even more so, if current price levels continue, energy bill savings from a heat pump can pay back the high initial investment (compared to gas) in 2 to 4 years.** Though it is worthwhile to note that this is based on current day-ahead wholesale prices, which may not translate into the same level of retail prices. As an example, the current average retail price for electricity is, at 250 EUR/MWh, significantly lower than recent peaks in wholesale prices, which have risen as high as 500 EUR/MWh.
- **Current price developments still lead to very high energy bills, independent from the heating technology**. This creates an undesirable situation that puts stress on (low-income) household budgets. For example, in the 'current price forecast' scenario total lifetime costs for gas boiler heating increase by **65%-90% (**energy bill increases from €1429 to €2403 per year) compared to the pre-price increase situation. For heat pumps, the increase is lower but still **20%-40** (€1360 to €1849). It should be noted that these scenarios are based on energy price scenarios for a ten-year period and already take into account a reduction of energy prices in coming years compared with 2022 levels (Figure 253 and Figure 254).
- **Switching from gas heating to heat pumps can save 1200-2400 m3 of gas per year for an average household.** To put this into perspective, gas savings from 1 million heat pumps in households are equal to ~1% of the Russian gas supply in 2021 to the EU. Gas used for generating the additional electricity accounts to less than 10% of the gas saving (100 m3/y), when assuming the 2019 average of a 20% share of gas in the electricity generation mix.
- **Heat pumps can reduce heating emissions for households by around 70%.** The use of heat pumps leads to emission reductions both through energy savings and in many grid cases a cleaner fuel (electricity). With increasing low-carbon electricity penetration, emissions could be reduced up to 100% instead of ~70%. Besides energy-related emissions however, heat pumps also lead to a limited amount of refrigerant emissions, which still have potential to be further reduced in the future. Heat pumps mainly lead to energy savings through its very high efficiency of up to 360% to 460% (heat output compared to energy input; lower heating value) compared to the 80-90% for gas boilers. Other electrical alternatives, such as electric heaters can only reach an efficiency of up to 100% and are therefore significantly less efficient than heat pumps. In addition, switching to heat pumps from other polluting fuel heating systems such as coal or oil boilers — still widely used in some Member States — can also significantly improve air quality and thus lead to additional health benefits.
- **The results are comparable for other heating technology types.** Ground-to-source heat pumps under current prices will lead to more lifetime savings for households with high energy use (larger houses) but have higher initial purchase costs, which forms a barrier to high uptake. Also, standard gas boilers, which are still installed in many homes in the EU, have higher lifetime costs than high-efficiency boilers and thus switching to a heat pump will lead to more relative savings for households with a standard gas boiler (if a house has sufficient insulation to take full advantage of a heat pump).

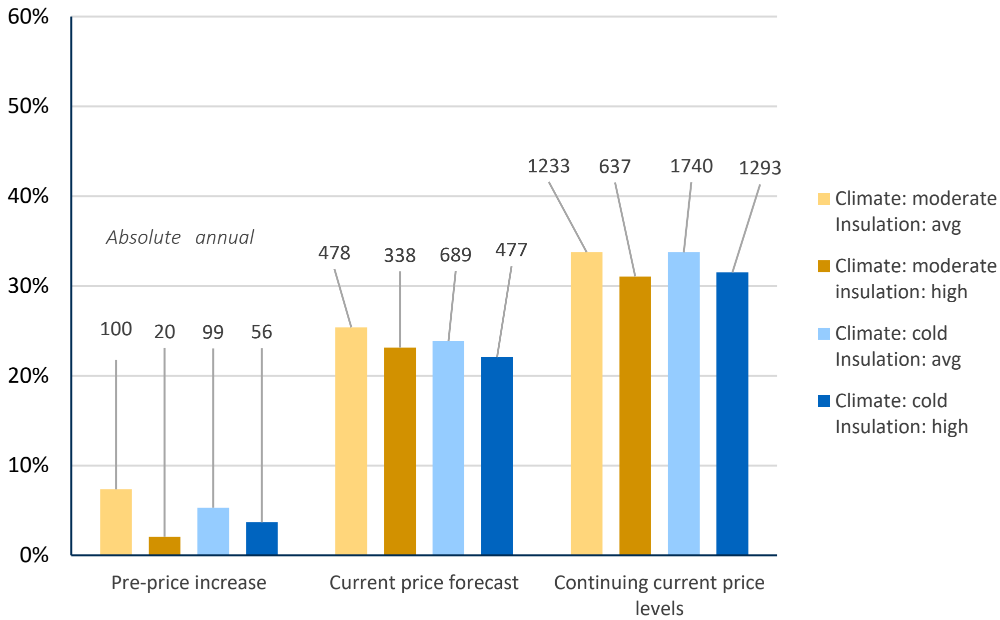

Figure 253: Reduction of energy bill as a result of switching from a gas boiler to an all-electric heat pump. The bars show the percentage reduction (%) of the energy bill. The amounts indicate the absolute cost saving in the scenarios for an average household.

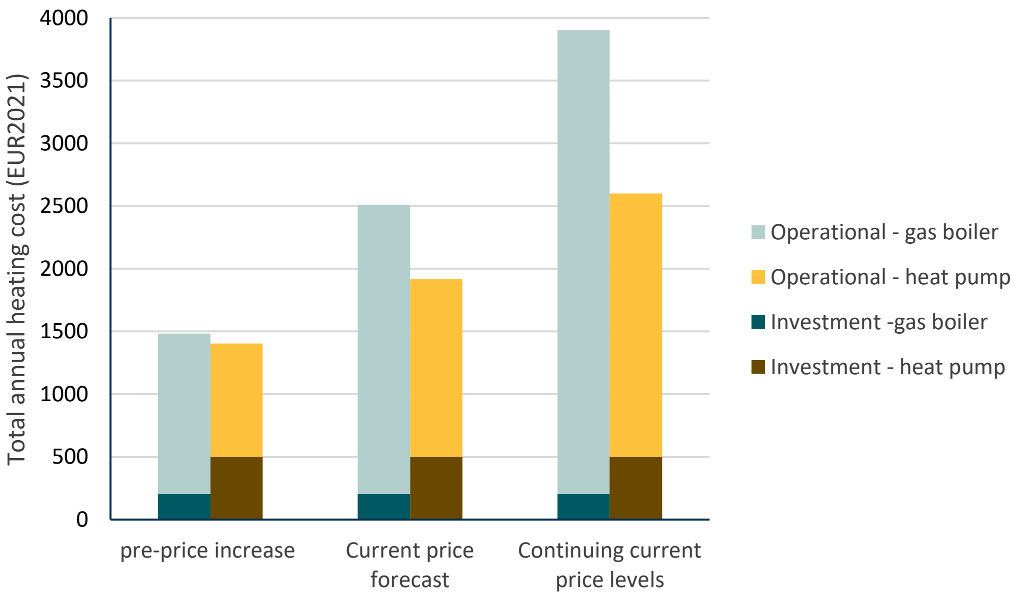

Figure 254: Total annual heating costs per heating technology in 3 different energy price scenarios in EUR2021, split into investment costs and operational costs (fuel + maintenance).

Table 45: Overview of financial benefits of (air-to-source) heat pumps compared to natural gas boilers.

			Household type			
		Climate zone	Moderate		Cold	
		Insulation level	Average	High	Average	High
Price scenario	**Indicator**	**Unit**				
Business case heat pumps for different price scenario's						
pre-price increase forecast 2022-2030	Cost savings per year	EUR2021	-100	-20	-99	-56
	% reduction of energy costs	%	-7%	-2%	-5%	-4%

		Climate zone	Household type: Moderate		Cold	
		Insulation level	Average	High	Average	High
Price scenario	**Indicator**	**Unit**				
	Payback time	Years	15	19	15	17
Current price forecast 2022-2030	Cost savings per year	EUR2021	-478	-338	-689	-477
	% reduction of energy costs	%	-25%	-23%	-24%	-22%
	Payback time	Years	8	9	6	8
Continuing current price levels (Sept 2022)	Cost savings per year	EUR2021	-1714	-1329	-2411	-1799
	% reduction of energy costs	%	-38%	-36%	-35%	-34%
	Payback time	Years	3	4	2	3
Impact of high energy prices						
All scenario's	Additional savings per year	EUR2021	-482	-303	-691	-436
	Impact higher energy prices on business case heat pump	% Additional energy bill reduction	-19%	-19%	-20%	-19%
	Reduction of payback time	%	-55%	-52%	-64%	-60%
Climate benefits						
All scenario's	Gas saving	X 1000 m3/year	1.5	1.2	2.4	1.8
	Additional electricity	MWh/year	3.7	2.9	6.4	4.8
	Net energy saving	MWh/year	11.1	8.7	17.0	12.8
	Emission saving (Forecast emission intensity 2021-2030)	t CO_2/year	2.3	1.8	3.6	2.7
		% decrease of heating emission	-72%	-71%	-73%	-71%

Policy implications

- **The significant initial investment costs of heat pumps might still require support schemes for lower-income households to help overcome the initial investment hurdle.** While our analysis shows that in many cases heat pumps can be cheaper than fossil fuel alternatives, many lower-income households do not have the means for financing a large one-time investment. Given that heat pumps eventually will pay this investment cost back, such support do not necessarily have to be subsidies, but could also be financing schemes that help spread out the initial investment. Nevertheless, the societal benefit of reduced emissions may justify public spending.
- **Policies that decrease the cost of electricity compared to natural gas or other heating fuels improve the business case for heat pumps**. The profitability of installing heat pumps depends on the price differential between the current heating fuel (mainly natural gas) and electricity. Thus, policies that reduce the price of electricity compared to natural gas will make switching to heat pumps more financially attractive. The main instrument for governments to steer this price differential is via tax policy. As an example, several Member States such as the Netherlands have implemented tax reforms in which the energy tax for households is increased on gas while lowered on electricity. Additionally, smart heating technology, which enables heating during hours with lower electricity prices, can further improve the business case for heat pumps.

10.2 Case study 2: Electric vehicles vs. Gasoline internal combustion engine

In this case study, we analysed how the costs of a full battery electric vehicle (BEV) compared to a vehicle with a gasoline internal combustion engine (ICE) and how the energy price increases have influenced the costs difference. For a complete comparison, we take a Total Cost of Ownership (TCO) perspective, which means that all costs during the full vehicle lifetime are taken into account.

Methodology

Cost components

The costs components taken into account in this analysis are the following:

- Purchase price premium of the BEV (compared to the ICE), taking into account:
  - battery and home charger cost[266] (positive purchase price premium);
  - Powertrain cost (negative purchase price premium).[267]
- Fuel (gasoline or electricity) expenditures over the vehicle lifetime;
- Maintenance costs over the vehicle lifetime.

The approach taken to estimate the above-mentioned various costs components is further detailed below. The results can be very sensitive to a number of these assumptions; therefore the latter should always be borne in mind when interpreting the results.

Vehicle lifetime

The vehicle lifetime mileage is based on an annual mileage of 10 000 km (considered broadly representative of an average EU gasoline car) and a vehicle lifetime of 15 years (also broadly representative of an average EU car), i.e. 150 000 km.[268] The TCO analysis is performed over this overall distance, for the vehicle lifetime. Therefore it does not reflect first-owner perspective only (as is sometimes done in other vehicle TCO analyses), and does not consider any residual value for the car at the end of its lifetime.

Charging costs

As mentioned above, the analysis includes the purchase and installation cost of a home charger (estimated to EUR 1 000[269]) and does not account for operational home charging expenditures other than the retail electricity price. It is assumed that the vehicle will run 80% of its lifetime mileage on electricity from (slow) home charging, and 20% on electricity from fast charging along the road (e.g. on highways). The cost of fast charging is assumed to have a price premium of 50% compared to the electricity retail price for home charging. This therefore reflects a BEV usage mainly based on home charging (usually the main charging solution for BEV owners), with instances of fast charging for longer trips.

Battery costs

The battery price applied to BEV batteries in this analysis is EUR 140/kWh and is considered to be representative of a BEV battery pack price in Europe in 2021.[270] Rapidly falling battery prices over the past decade (which is expected to continue throughout this decade in particular through technology

[266] See assumptions on battery and home charger costs in the corresponding paragraphs below.
[267] The assumption of the difference in powertrain costs between the BEV and the ICE is EUR 2,000 in favour of the BEV. A BEV powertrain is cheaper than an ICE powertrain among others due to simpler architecture and fewer moving parts. In the future, more stringent pollutant and GHG emissions requirements on ICEs will tend to further increase the ICE powertrain cost, while with larger-scale manufacturing BEV powertrain costs may experience a further decreasing trend. Combining these different purchase price premium components (battery, home charger and powertrain), the purchase price premium is positive for BEVs (i.e. the BEV purchase price is higher than the ICE), driven by the battery costs.
[268] Many battery electric vehicle warranties are for eight years and 160 000 km (Car magazine, 2022), which should represent a minimum battery durability. However, many early adopters report longer battery durability. It is therefore assumed in this analysis that no battery replacement is necessary during the vehicle's lifetime.
[269] All used prices are in real EUR2021 and use simple prices (no discounting).
[270] Estimated from BNEF, 2021.

learning and scale-up), but also rising raw material prices and supply bottlenecks (i.e. lithium costs, see chapter 4) make this assumption subject to possible variations (e.g. depending on geography and in time), and therefore variations in TCO analyses results.

Maintenance costs

Maintenance costs are generally understood to be lower for BEVs than for ICEs due to simpler vehicle architecture, fewer moving parts and brake energy recovery[271]. These have been estimated to amount to around 1.3 €ct/km for a BEV, and 40% more for an ICE (i.e. around 1.8 €ct/km). Insurance costs have not been accounted for in this analysis, as they are estimated to generally be independent of powertrain.[272]

Other vehicle characteristics

The analysis is carried-out for a medium-size car consuming 6.5 litres of gasoline per 100 km for the ICE version. A similar, medium-size BEV is considered, which, depending on its range (2 ranges are considered – 200 km and 400 km), consumes 0.185 kWh/km and 0.19 kWh/km, respectively. This difference in consumption accounts for additional electricity use in moving the 400 km range BEV, due to a heavier battery. Battery size, and therefore battery purchase costs, are calculated from the BEV range and electricity consumption per km, with a 5% penalty in order to account the avoidance of a completely full charge or discharge of the battery.

Gasoline price

The TCO analysis results are provided for three gasoline price cases (Figure 255):

- The “central” case has a gasoline price of EUR 1.83/L and reflects the EU average gasoline price (inclusive of taxes) on 17 October 2022.[273]
- The “low” case accounts for a gasoline price 0.50 EUR *lower* than in the central case, i.e. EUR 1.33/L.
- The “high” case accounts for a gasoline price 0.50 EUR *higher* than in the central case, i.e. EUR 2.33/L.

For each case, these gasoline prices are fixed for all fuel expenditures over the vehicle lifetime.

Electricity price

The TCO analysis results are provided for the same three electricity price scenarios as in the heat pump case study (see footnote 264 and Table 46):

- The "Pre-price increase forecast" scenario has an electricity price of 0.15 EUR/kWh.
- The "Current price forecast" scenario has an electricity price of 0.25 EUR/kWh.
- The "Continuing current price levels" scenario has an electricity price of 0.50 EUR/kWh.

For each scenario, these electricity prices are fixed but they represent an average price forecast over the whole vehicle lifetime (except ‘continuing current price levels’ in which current very high prices simply continue). All electricity expenditures over the vehicle lifetime, are inclusive of current tax levels.

Results

Figure 255 shows that the cost-competitiveness of BEVs over ICEs is highly dependent on electricity and gasoline prices, as well as on BEV range and therefore battery size and price. The cheaper the electricity

[271] Brake energy recovery allows for longer brake durability and thus reduced brake replacement costs over the vehicle lifetime.
[272] Element Energy (2021). Electric Cars: Calculating the Total Cost of Ownership for Consumers
[273] European Commission (2022). Weekly oil bulletin, 17th of October 2022.

price, or, on the other hand, the higher the gasoline price, the more cost-competitive the BEV is. Conversely, the current rapid increase in electricity prices reduces the cost-competitiveness of BEVs. Table 46 presents this difference in total cost of ownership under 18 specific combinations of BEV range, electricity price and gasoline price.

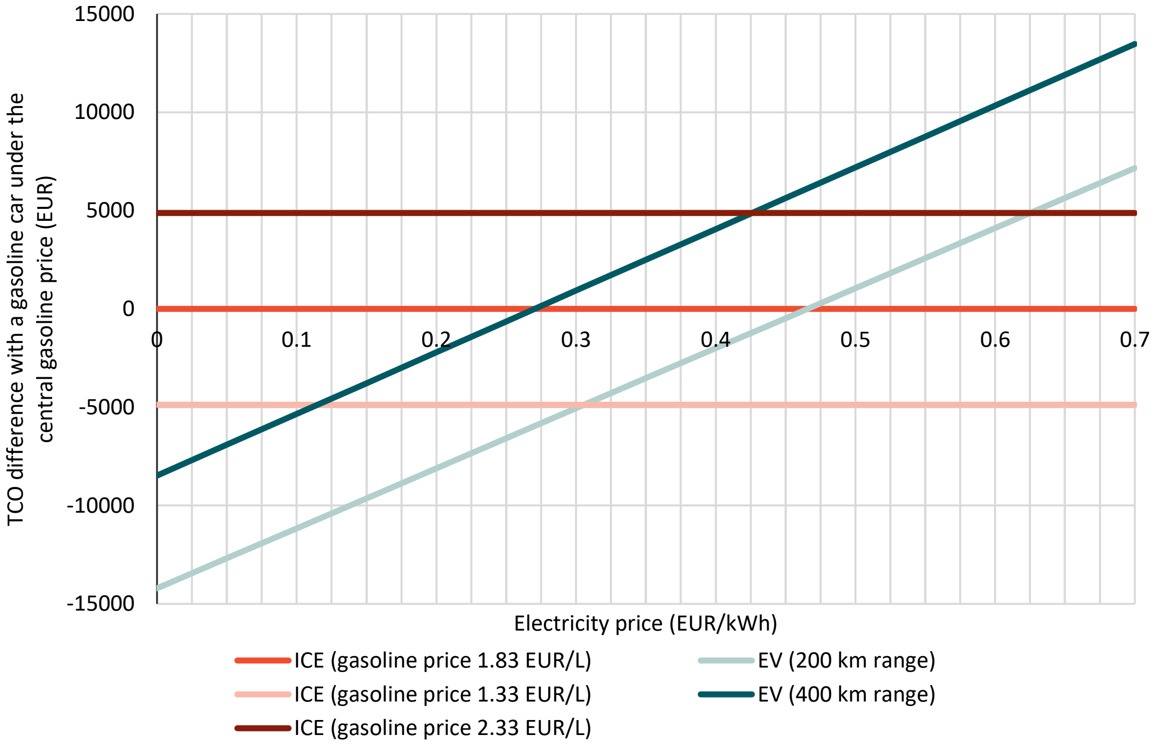

Figure 255: Difference in TCO between a medium-size car under 4 cases (BEV with 200 km range, BEV with 400 km range, ICE associated to a high gasoline price and ICE associated to a low gasoline price) and a medium-size gasoline ICE car associated to a central gasoline price, over the vehicle lifetime, in function of electricity price.

Notes: A negative TCO difference means that the alternative (e.g. the BEV) is cheaper than the ICE associated to a central gasoline price. For assumptions, refer to the above "Methodology" section.

Table 46: Difference in TCO between a medium-size BEV and a medium-size ICE under various BEV range, electricity price and gasoline price assumptions

		Gasoline					
		'Low' gasoline price (1.33 EUR/L)		'Central' gasoline price (1.83 EUR/L)		'High' gasoline price (2.33 EUR/L)	
		200 km range	400 km range	200 km range	400 km range	200 km range	400 km range
Electricity	'Pre-increase' electricity price scenario (0.15 EUR/kWh)	-4,756	1,101	-9,631	-3,774	-14,506	-8,649
	'Current market conditions' electricity price scenario (0.25 EUR/kWh)	-1,703	4,236	-6,578	-639	-11,453	-5,514
	'Continuing current levels' electricity price scenario (0.4 EUR/kWh)	2,875	8,938	-2,000	4,063	-6,875	-812

Notes: Negative TCO difference means that the BEV is cheaper than the ICE, emphasized by the green colour. For assumptions, refer to the above "Methodology" section.

With the used assumptions, a recently-purchased BEV with a 200 km range is cost-competitive with an ICE car for electricity prices lower than EUR 0.47/kWh, and the same vehicle with a 400 km range is cost-competitive for electricity prices below EUR 0.27/kWh. Only under the “Pre-increase” electricity price scenario are both types of BEVs clearly cheaper on a TCO basis than their ICE counterpart (Figure 255). The currently observed electricity price increases challenge the cost-competitiveness of BEVs (without any subsidies), in particular for long-range models.[274]

Under the “Current market conditions” electricity price scenario, only the short-range BEV (200 km) is clearly cost-competitive (around EUR 6 500 cheaper over the vehicle lifetime - Table 46) with the gasoline car under the central gasoline price scenario.

Under the “Continuing current levels” of electricity prices, the 400 km range BEV has a higher TCO than the ICE car. On the other hand, the 200 km range BEV is only EUR 2 000 cheaper than the ICE car over its lifetime, unless gasoline prices significantly increase: with a gasoline price of 2.33 EUR/L (high gasoline price case), both BEVs are cost-competitive with the ICE regardless of the electricity price scenario.

With increasing electricity prices, lifetime electricity expenditures for a BEV come at par with and even surpass the vehicle’s battery purchase costs. While battery purchase is an upfront expenditure, and therefore may remain a stronger barrier to BEV purchase than electricity price (electricity expenditures are spread across the lifetime of the vehicle), this shows that high electricity prices can possibly significantly affect the overall cost structure of owning a BEV. However, lifetime gasoline expenditures of the ICE remain higher than lifetime electricity expenditures of both BEV types, whichever the electricity scenario and gasoline price case[275].

Table 46 shows that under most combinations of BEV range, electricity price and gasoline price the BEV has a lower TCO than the ICE (in 13 cases out of 18). Under these favourable cases for BEVs, cost differentials range from around EUR 14 500[276] to below EUR 1 000[277] over the vehicle lifetime.

When considering the 400 km range BEV only, it does not reach cost-competitiveness with the ICE under any of the electricity price scenarios when the gasoline price is “low” (1.33 EUR/L), nor does it do so significantly under any of the gasoline price scenarios when the electricity price remains similar to current levels (“Continuing current levels” scenario). Under this electricity price scenario, the 400 km range BEV reaches TCO competitiveness under the ‘high’ gasoline price case, in which the TCO difference is around EUR 800 in favour of the BEV, which however does not constitute a clear cost-competitiveness case. Indeed, too low TCO savings over the vehicle lifetime may not suffice to trigger the decision for a consumer to buy a BEV given its higher purchase cost than an ICE car (the purchase premium for a 400 km range medium-size BEV is around EUR 10 000)[278].

[274] This analysis focuses on costs and does not discuss any other aspects that may motivate EV adoption besides cost-competitiveness, such as pollution, climate, and noise-related aspects.
[275] This difference between lifetime gasoline and electricity expenditures is as low as around EUR 450-750 when considering a BEV under the highest electricity price scenario (EUR 0.4/kWh) and an ICE under the ‘low’ gasoline price case (EUR 1.33/L). It can be as large as around EUR 18 000 when considering a BEV under the lowest electricity price scenario (EUR 0.15/kWh) and an ICE under the ‘high’ gasoline price case (EUR 2.33/L).
[276] For a 200 km range BEV under “Pre-increase” electricity prices (0.15 EUR/kWh) and the high gasoline price (EUR 2.33/L) cases.
[277] For a 400 km range BEV under “Current market conditions” of electricity prices (0.25 EUR/kWh) and the ‘central’ gasoline price (EUR 1.83/L) cases; and for a 400 km range BEV under “Continuing current levels” electricity prices (0.4 EUR/kWh) and the ‘high’ gasoline price (EUR 2.33/L) cases.

Policy implications

Although the TCO-competitiveness of BEVs vs ICE cars is favourable to BEV in most cases shown in Table 46, continuous policy support in favour of BEVs still seems necessary for the time being and particularly in the current context of increasing electricity prices. Such support can take various forms, notably policies having an effect on the relative fuel expenditures of EVs vs ICEs, such as an increase of gasoline taxes to reflect its externalities adequately. Moreover, temporary tax reductions on gasoline and diesel, which are currently implemented in many Member States, reduce the relative competitiveness of BEVs.

For BEV buyers, the purchase cost premium due to the battery cost remains a major barrier, which purchase subsidies or differentiated purchase taxes can continue to alleviate. This also shows the important role that further battery cost reductions can play in stimulating BEV attractiveness and how any supply bottlenecks (for raw materials or battery components) should be anticipated.

In addition, mechanisms to encourage BEV charging at off-peak times or coupled with home-based renewable generation (e.g. PV), would allow BEV owners to enjoy cheaper-than-average electricity and may significantly reduce the electricity expenditures of BEV owners and positively affect the cost-competitiveness of BEVs, even in cases of high average electricity prices. However, there are still major regulatory barriers limiting the incentives for off-peak charging. Among others, dynamic pricing (with hourly variable rates) is not used by consumers on a large scale yet. Smart charging (and pricing) could not only have a positive impact on EV costs but can also enable more efficient and flexible use of the electricity grid, which becomes ever more important in an electricity system relying on variable electricity sources (solar, wind).

Finally, in a first vehicle owner perspective, policies that increase market confidence in the future of BEVs (e.g. EV deployment targets, charging infrastructure deployment, ICE bans) will increase the residual value of BEVs and/or decrease that of ICEs after the first owner time period and therefore affect the residual value gap between BEVs and ICEs in favour of BEVs. This will benefit the TCO competitiveness of BEVs for first owners.

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