European Commission

Final report

Study on energy prices and costs - evaluating impacts on households and industry's costs – 2024 edition

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Final Report

Trinomics

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Study on energy prices and costs - evaluating impacts on households and industry's costs – 2024 edition

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Study on energy prices and costs - evaluating impacts on households and industry's costs – 2024 edition

In association with:

Abstract

English

This report provides an objective and detailed assessment of energy prices. It has a focus on the period since 2014 to the present day; the EU, its Member States and also main global trading partners; and electricity, gas, oil, coal and various alternative fuels. Prices were analysed to understand their key components and drivers, with a focus on developments since 2021-2022 when the previous edition of the report was written. The report provides across its 10 chapters a detailed analysis of: energy price movements for electricity, gas and other fuels; the impact on industrial energy costs; the impact on household energy expenditures; the EU energy import bill; EU energy taxes and levies; an econometric analysis of price drivers and cost pass through; and the role of renewable energy in electricity market price formation. In doing so the report provides a comprehensive overview of EU energy prices and costs to inform EC decision making.

Français

Ce rapport fournit une évaluation objective et détaillée des prix de l'énergie. Il se concentre sur la période allant de 2014 à aujourd'hui, sur l'UE, ses États membres et ses principaux partenaires commerciaux mondiaux, ainsi que sur l'électricité, le gaz, le pétrole, le charbon et divers combustibles alternatifs. Les prix ont été analysés afin de comprendre leurs principales composantes et leurs moteurs, en mettant l'accent sur les évolutions depuis 2021-2022, date à laquelle la précédente édition du rapport a été rédigée. Le rapport présente dans ses 10 chapitres une analyse détaillée des éléments suivants : l'évolution des prix de l'électricité, du gaz et des autres combustibles ; l'impact sur les coûts énergétiques industriels ; l'impact sur les dépenses énergétiques des ménages ; la facture des importations d'énergie de l'UE ; les taxes et prélèvements sur l'énergie de l'UE ; une analyse économétrique des facteurs de prix et de la répercussion des coûts ; et le rôle des énergies renouvelables dans la formation des prix sur le marché de l'électricité. Ce faisant, le rapport fournit une vue d'ensemble des prix et des coûts de l'énergie dans l'UE afin d'éclairer la prise de décision de la CE.

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Executive summary

This 2024 edition of the energy prices and costs report follows a period of exceptional turbulence on global and European energy markets since 2020. The sustained period of high energy prices has had, and despite prices returning towards pre-crisis levels, continues to have, serious implications for European households, industry, the broader economy and public finances. The purpose of this report is to objectively analyse energy price, cost and other data to provide a clear understanding of the changes in prices and their drivers, and the impact of these changes on energy costs for EU industry and households, EU energy imports and energy taxes.

Energy prices

Electricity prices

Wholesale prices

- **Wholesale electricity market prices have stabilised since the energy crisis of 2021-2022.** The prices on day-ahead markets as of 2024 (85 EUR2023/MWh average in Q3 and Q4 2023) have settled at a level higher than their historical averages (56 EUR2023/MWh average in 2008-2020 period). It appears unlikely that prices will reduce to pre-crisis levels in the coming years. Prices on forward markets have in 2023 also stabilised to lower levels, albeit above their historical average.
- **The electricity mix of the EU hit a new record of renewable electricity generation in 2023, at 43% of total production.** The share of nuclear has rebounded since a low in 2022 with the re-activation of French plants (23% of total production). Natural gas use in the electricity mix has also trended downward, from 19% in 2021 to 17% in 2023.
- **The EU's wholesale electricity prices continue to be slightly elevated compared to trading partners.** Japanese market prices (81 EUR/MWh in 2023) have recently dropped below those of the EU (103 EUR/MWh in 2023), while the US maintains its low prices (59 EUR/MWh in 2023). The UK is the exception here, where wholesale electricity prices (115 EUR/MWh in 2023) are now generally above EU-27 averages.

Retail prices

- **Average household retail electricity prices have increased in 2022 and 2023**. This followed significant increases in wholesale electricity prices, which were passed on to consumers with a time delay. Early indications from Q1 2024 indicate that prices across the EU-27 have largely continued at similar levels to 2023 prices.
- **Household retail prices continue to differ significantly across the EU-27 in 2023**, with some MS having very high (Netherlands: 401 EUR/MWh) and other quite low (Bulgaria: 116 EUR/MWh) prices. Member States also differed greatly in the composition of their prices.
- **The EU continues to have high household electricity prices compared to the rest of the world**. Internationally, prices in Japan, Australia, and Brazil are 20% to 50% lower, while those in the US and other countries can be over 50% lower. Only in the UK are prices similar to the EU average.
- **Industrial electricity prices have also increase in the EU-27 across 2022-2023** – with less delay following wholesale electricity price increases. For the ID consumption band for example, prices in 2023 were 97% above their 2014-2020 average.
- **Industrial end user prices have diverged significantly across the EU-27 in the 2022-2023 period**. Different price interventions were activated at different times by different countries, leading to a larger range of prices across the EU in early 2024, for both the ID and the IF consumption band.

- **Industrial end user prices in the EU are relatively high in the global comparison**, affecting the competitiveness of EU industry. Prices in the UK have substantially increased (304 EUR_{2023}/MWh) and remain above EU levels (149 EUR_{2023}/MWh in Jan 2024), while those of Japan are at comparable levels (134 EUR_{2023}/MWh). For the US, Canada, and Türkiye, prices are much lower (74.3, 92.4, and 76.4 EUR_{2023}/MWh, respectively).

Gas prices

Wholesale prices

- **The Russian invasion of Ukraine and subsequent uncertainty and sanctions led to exceptionally high wholesale gas spot prices**, staying above 100 EUR2023/MWh for large parts of 2021-2022, increasing to an all-time high peak spot price in August 2022 of 231 EUR2023/MWh. Starting in September 2022, gas spot prices decreased quickly from the 231 EUR2023/MWh peak in August 2022 to 42 EUR2023/MWh in April 2023. This happened due to several reasons – among others, storage levels were very high at the beginning of the winter, there was reduced uncertainty about Russian pipeline supply, given its role became marginal with positive signs that LNG import capacity would be sufficient to cover demand. In addition, gas demand in the EU was quite low due to the mild winter.
- **In 2023 and 2024, a new 'price equilibrium' has emerged at around ~30-40 EUR2023/MWh (still relatively high compared to 20 per EUR2023/MWh pre-crisis level).** Due to the phasing out of Russian pipeline gas and reduced domestic production in the EU, the market has shifted mainly from cheap pipeline supply to a higher reliance on more expensive LNG imports, which is reflected in the new price 'equilibrium'.
- **Due to the gas supply crisis, LNG has become a more important factor in the European gas system.** The share of Russian pipeline supply in gas imports shrunk from 40% in 2021 to about 8% in 2023. Simultaneously, the LNG import share increased from 22% (75 bcm) in 2021 to 39% (115 bcm) in 2023. The largest increase in LNG shipments came from the US (51 bcm), which has become in 2023 the largest LNG import source of the EU, followed by Qatar and Russia.
- **Wholesale gas prices in the EU – as well as in other, LNG-dependent countries such as Japan and South Korea –were substantially higher during the energy crisis than in other trading partner markets.** Although they increased in all markets, gas prices in major gas producers such as the US and Canada remained at below 87 EUR2023/MWh levels. In China prices increased considerably, but not to the same extent as in the EU.

Retail prices

- **In parallel with the large increase in wholesale prices, EU average gas retail prices for households started to increase** from their earlier level of around 70-80 EUR2023/MWh in 2021 to a price level of 125 EUR2023/MWh in August 2022. Prices have since slowl declined and have been stabilizing since Q3 2023 in all Member States, although at levels almost twice as high as pre-crisis (100 EUR2023/MWh instead of ~60 EUR2023/MWh).
- **The energy crisis resulted in significant differences in household gas prices both between and within Member States.** Retail prices in 2023 were highest in Sweden and the Netherlands (~205 EUR2023/MWh) and lowest in Romania, Croatia and Hungary (all lower than 55 EUR2023/MWh).
- **Notably, most Member States implemented far-reaching temporary measures aimed at preventing very high price levels for (certain) households.** This had a significant mitigating impact on retail price levels throughout the EU, albeit at a large financial cost for governments. As examples, some MS froze retail prices at low levels (e.g. Hungary), while other MS implemented price ceilings (e.g. the Netherlands) or lowered the VAT rate (e.g. Belgium, Germany). Gradually in 2023 most of these temporary relief measures have been removed, thereby creating upward price pressure at a time that wholesale prices decreased.
- **Compared with other global regions, EU retail gas prices have historically been relatively high** (though different per MS), also due to relatively high network costs and taxes in the EU

and large subsidies in other regions. This was not different during the energy crisis, although household prices also significantly increased in many other regions, such as the US.

- **During the energy crisis, EU average industrial gas prices for the I3 consumption band almost doubled from 40 EUR_{2023}/MWh in 2016-2019 to 74 EUR_{2023}/MWh in 2022 and 76 EUR_{2023}/MWh in 2023.** For the I5 band, prices surged from 39 EUR2023 /MWh in 2021 to 87 EUR_{2023}/MWh in 2022 but reduced more quickly to 59 EUR_{2023}/MWh in 2023.
- **Compared with households, relief measures were not implemented on the same scale for industry.** This contributed to larger average price increases for industry compared to households, see the following section for more on the impact on industry.

Oil, coal and alternative fuel prices

- **Since 2020 crude oil prices have been notably volatile, mainly due to two major global events: the global Covid-19 pandemic in 2020 and the invasion of Ukraine by Russia in 2022**, prices peaked at very high levels at more than 130 USD/bbl in March 2022, after which prices reduced stabilising since January 2023 at around 80 USD/bbl.
- **In 2022, coal demand and hence import prices increased to more than 250 EUR/tonne until Q3 2022. Demand growth was mainly driven by gas-to-coal switching for power generation in Europe.** As of 2023, coal use for power generation was comparable with pre-crisis (2019) levels, and subsequently prices have also reduced as well, but similar to other fuels remain at structurally higher levels than pre-crisis.
- High crude oil prices resulted in high **oil product prices,** such as **diesel**, **gasoline** and **heating oil**, in 2022 and 2023. In these years, prices have been at the highest level since at least 2008, averaging in the EU-27 a pump price of 1.79 EUR/litre for gasoline and 1.75 EUR/litre for diesel.
- **Alternative fuels including biofuels such as bioethanol and biodiesel and LPG generally follow similar price movements to diesel and gasoline prices,** since they can be used (to a certain extent) interchangeably or are produced from crude oil (LPG).
- **EV charging prices in 2023 in the EU-27 can diverge significantly per location/MS and time**. On average prices are estimated at between 150-350 EUR_{2023}/MWh for home charging. Public AC charging prices are generally higher at 400-600 EUR_{2023}/MWh. Fast DC charging is most expensive at 500-700 EUR_{2023}/MWh. Compared to 2021, in general charging prices have increased, although it heavily depends on the time of charging, given that dynamic and off-peak tariffs are available in most EU Member States
- **Battery storage technology costs continue to decline -after a brief plateauing in 2022 -, driven by decreasing raw material prices and by a growing penetration of lower-cost LFP cathode chemistries**, thus making battery storage solutions competitive for more applications in more circumstances. Reductions in battery costs also continue to make electric vehicles (EVs) more affordable. China leads in most stages of the supply chain of batteries and EVs. Behind-the-meter storage also benefits strongly from this cost reduction but remains concentrated mainly in Germany and Italy
- **Green Hydrogen produced with grid or renewable-powered electrolysis continues to be in an early development stage** and is very uncompetitive with grey hydrogen (using Steam Methane Reforming). Grey hydrogen production costs have surged though due to increasing natural gas prices since the energy crisis, from lower than 2 EUR_{2023}/kg in 2019 to 6 EUR_{2023}/kg in 2022. However, these values were still lower than green hydrogen production costs that are estimated at above 10 EUR_{2023}/kg in most Member States.

Industrial energy costs

The energy price crisis has challenged the competitiveness of EU industry compared to competitors elsewhere in the world. However, at the time of this work (July 2024), the latest complete and reliable energy prices and costs data for EU industry is only available up to 2021, while only partial data is available for 2022 and 2023. Direct data collection was undertaken through surveys with energy-intensive industries (EIIs) and was used to provide more up-to-date and deeper insights into the role of energy prices and costs for the European industries.

The competitiveness of EU industries in the new EU energy era

- **In 2023, whilst the average electricity and natural gas prices decreased from 2022 levels, EU average prices in 2023 were still significantly higher than those from pre-COVID and pre-crisis levels.** Based on data obtained from 81 plants across 10 industrial sectors (Cf Chapter 2–3).
- **Electricity prices in 2023 are around double compared to 2019 across the industrial sectors surveyed** (*Mining*, *Secondary aluminium, Refineries*, *Flat glass* and *Ferro-alloys and Silicon, Primary aluminium, Pulp and paper* and *Downstream aluminium).*
- **Natural gas prices were 2–4 times in every industrial sector surveyed in 2022 compared to 2019**. In 2023, average natural gas prices for the surveyed sectors started a decreasing trend with significant variances between sectors.
- **The increases in prices for electricity and natural gas led to an increase in the share of energy costs in the total production costs for almost all surveyed sectors** and particularly for *Primary aluminium* (38%), *Ferro-alloys and silicon* (29%) and *Flat glass* (25%).
- **Almost all surveyed sectors also experienced a decrease in production since their energy costs increased**. Production output trends showed an average production output decreased by 43% and 18% for *Ferro-alloys and Silicon* and *Flat glass* sectors between 2019 and 2023.
- **Soaring energy prices in 2022 and 2023 have made energy costs a more decisive factor in the competitiveness of the surveyed industrial sectors**. Whilst other costs e.g. raw materials, labour; and international markets and other factors play important roles energy prices have increased in importance. While some sectors like *Downstream Aluminium* and *Flat Glass* have been able to pass on some of their costs to customers, they have still faced reduced competitiveness due to increased energy costs. In sectors *Primary Aluminium*, *Flat Glass* and *Ferro-alloys and silicon*, surveyed plants have listed the increase in energy prices and costs as one of the main factors influencing curtailments and plant closures in the EU.
- **Key non-EU competitors in China, United States, Brazil, India and Türkiye, are estimated to have energy costs at least 20% lower than in the EU**, and total production costs at least 10% lower. In the case of *Flat glass* and *Pulp and paper*, some plants estimate this difference to be larger than 30%. However, the energy intensity of EU manufacturing industry tends to be lower than international competitors in most sectors.
- **The average profitability of the EU industry also tend to be lower than those of the EU's main trading partners.** Gross operating surplus (GOS) shares (as a proxy for profitability) of the EU industry ranges between 10% and 15% in the time period 2014 to 2021, whilst that of most other G20 countries ranged between 15% and 25%. The relatively low GOS means that the EU industry has limited room to absorb cost increases such as energy cost increases experienced in 2022 and 2023.
- **Power Purchasing Agreements (PPAs) are one of the key hedging strategies available to the industry against energy price volatility**. The European PPA market has grown annually by 37% per year in the period 2018–2023 with Spain, Germany and Sweden amongst the leaders in adoption.

Household energy expenditures

Household expenditures on energy in both the residential and transport sector were analysed across all EU Member States and for various income groups (see chapter 6). Amongst the key findings

Based on the available data for 2022, the households within the lowest income decile in the EU spent an average of EUR 1250 on energy products[1]. This is around 7.5% of their total expenditure.

[1] *This includes electricity, gas, liquid and solid fuels, and heating.*

This average is based on data from the following Member States (MS): Belgium, Bulgaria, Denmark, Finland, Croatia, Italy, Luxemburg, and Portugal. The average is weighted based on the number of households reported by the MS.

The share of energy expenditures in total expenditures has decreased between 2010 and 2022, most notably for low-income households by 2.5 percentage points. In comparison to 2020 the share increased very slightly for low and low middle-income groups, but not for middle-income groups.

Table 1: Share of energy and transport exenditure (in total household expenditure) for different income groups by year

	2010	2020	2022	2010-2022	2020-2022
Share of expenditure on energy					
Low-income households	9.9%	7.3%	7.5%	-2.4%	0.2%
Low middle-income households	7.6%	6.4%	6.9%	-0.7%	0.6%
Middle-income households	6.9%	6.4%	6.4%	-0.5%	0.0%
Share of expenditure on transport energy					
Low-income households	2.2%	2.4%	3.2%	1.0%	0.8%
Low middle-income households	3.6%	3.6%	4.3%	0.7%	0.6%
Middle-income households	4.1%	3.8%	4.3%	0.1%	0.5%

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

Sensitivity analysis to estimate the effects of high energy prices in 2022 and 2023 on different income groups shows that:

- **The share of energy expenditure (including and excluding transport) in total consumption expenditure has substantially increased compared to pre-crisis years** (i.e. pre-2022), linked to the fact that energy prices substantially increased.
- **For countries with recent data for 2022/2023: Comparing 2024 energy expenditure share to 2022/2023 values shows a significant decline in energy cost burden**. However, only a few countries so far have reported data for 2022 or 2023.
- **Comparing the harmonized price index for 2024 to 2020 values shows that the increase of inflation is mainly driven by an increase in the prices of natural gas, liquid fuels and in some instances electricity**. Which of the energy carriers mainly drive inflation varies by Member State, as does the extent of the price increase. Austria, Czechia, Germany, Italy and Latvia experienced a nearly doubling in natural gas prices between May 2020 and May 2024. Liquid fuels showed the highest price increases in 13 Member States and increased by more than eighty percent in 6 Member States, and increased more than twice in 7 Member states.
- **For energy expenditure *excluding* transport fuels, higher prices present a substantially higher burden for households with low income,** i.e. they lead to more negative distribution effects 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.

EU Energy bill

The EU energy import bill was analysed for oil, gas and coal to estimate the total and to analyse the key drivers including volumes, prices and exchange rates. The import bill total was calculated by summing the 3 most significant components, crude oil, natural gas and coal, these are shown in Figure 1.

The EU energy bill totalled almost EUR 550 billion in 2022 at the peak of the energy crisis, but has now declined to EUR 377 billion. With the decline driven by price decreases and decreased import volumes of gas and coal. However, the 2023 bill remains significantly higher than the EUR 150-300 billion range for 2014-2021.

Oil remains the main component of the EU energy bill. It represented over 80% of the total energy bill from 2014 to 2020. Oil bill variations were the main driver of the total energy bill before 2021.

The natural gas import bill surged in 2021 to more than EUR 220 billion (24% of the total), before declining to EUR 118 billion in 2022 (40% of the total). Prior to this it remained relatively stable between 2014 and 2019 at around EUR 25 – 40 billion per year, or around 10-15% of the total.

Despite a sharp decrease compared to 2022, the energy import bill in 2023 is 44% higher than the 2014-2022 average. The decrease was driven by significant reductions in every driving factor except for oil import volume (which increased 6%). Between 2022 and 2023 import prices of oil, gas and coal decreased by 20%, 34% and 54% respectively. Import volumes of gas and coal decreased by 18% and 24% respectively.

Amongst main trading partners Japan and Korea have higher import bills as a percentage of GDP, whilst China has comparable levels. The United Kingdom has proportionally lower bills and the United States has since 2020 been a net energy exporter.

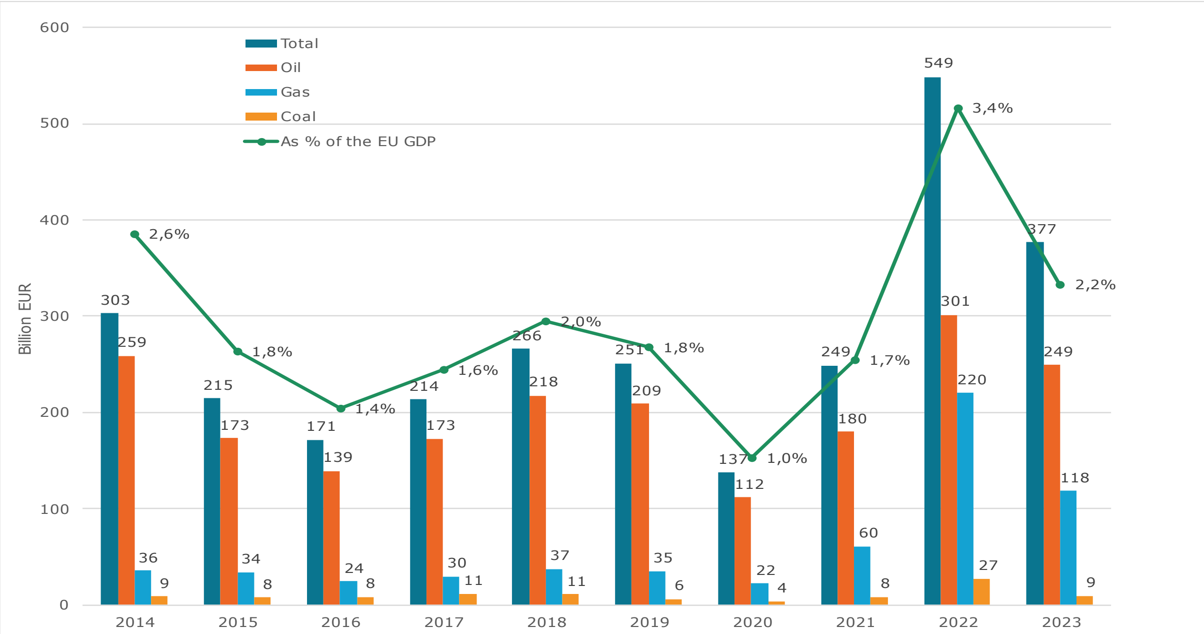

Figure 1: EU import bill up to 2023

Energy taxes and levies

Analysis of energy taxes and levies was also carried out and showed that:

On the EU-27 scale:

- **Despite an increase rise in final energy prices in the EU-27 since 2020, the proportion of taxes and levies in these prices decreased across all energies and end users**. These shares were offset by higher raw energy costs and the adoption of national measures set to contain prices.
- **In 2022, energy taxes collected in the EU-27 amounted to EUR_{2022} 248bn (i.e. 1.6% of EU GDP, or 3.8% of total revenues from taxes).** Revenues decreased since 2019 (-12%), due to the COVID-19 pandemic & energy prices increase.
- **The main contributor to energy tax revenues in 2022 are households**; they paid 39% of total energy taxes (a decrease compared to 50% in 2008).

On the MSs scale:

- **The role of energy taxes in government revenues varies between MSs** in 2022: in Bulgaria, energy taxes accounted for 14.4% of total revenues from taxes & social contribution while it represented 2.4% in Ireland. On EU27 average they accounted for 3.8% of MSs revenues from taxes & social contributions.
- **In 2021, 76% of revenues from energy taxes and levies in the EU-27 came from excise taxes, and 21% from mechanisms implemented to support the development of renewables**.

Crisis responses in excise duties and VAT rates

- **Substantial profits (windfall profits) emerged from high energy prices since 2021** in the energy sector. As a response to those, both at the EU and Member States levels, **taxes on those profits were introduced, in 2022 these totalled EUR 17.6 billion**.
- **Excise duties revenues reached EUR_{2022} 230 billion in 2021 and reduced by 8% in 2022 to EUR_{2022} 211 billion as countries reduced rates to compensate end-users for high energy prices.** 18 countries reduced their excise tax rate on gasoline, gasoil, electricity and/or natural gas between 2022-2023. Most countries prioritised on the reduction of excise taxes on gasoil (18 countries) and gasoline (14), followed by electricity (9) and natural gas (8). However, excise duty rates are starting to rebound since July 2023-January 2024 for all energies.
- **5 countries took measures to reduce VAT rates to fight rising energy prices** (regardless of the energy). Those countries were: BE, IE, LU, NL and PL. Rates are now returning to 2022 levels as temporary measures are ended.

Other observations

- **EU MSs are more dependent on energy tax revenues to balance their budgets compared to selected international trading partners**. International VAT rates on electricity and natural gas are quite heterogeneous, but in the same range as the different EU-27 countries. European countries tend to tax petroleum fuels at the highest level globally. Excise taxes are approximately 5 times higher in Europe than the US for gasoline and 4 times higher for gasoil.
- **Energy taxes have been declining whilst energy subsidies have been increasing.** Between 2015 and 2021, we estimate that energy-related revenues have fallen by EUR 12.6 bn in the EU-27, while in the meantime energy-related subsidies increased by EUR 32.1 bn.

Résumé

Cette édition 2024 du rapport sur les prix et les coûts de l'énergie fait suite à une période de turbulences exceptionnelles sur les marchés mondiaux et européens de l'énergie depuis 2020. La période prolongée de prix élevés de l'énergie a eu et continue d'avoir, et ce malgré le retour des prix aux niveaux d'avant la crise, de graves conséquences pour les ménages européens, l'industrie, l'économie au sens large et les finances publiques. L'objectif de ce rapport est d'analyser objectivement les données relatives aux prix et aux coûts de l'énergie, ainsi que d'autres données, afin de permettre une vue claire de l'évolution des prix et de leurs facteurs, ainsi que de l'impact de ces changements sur les coûts de l'énergie pour l'industrie et les ménages de l'UE, sur les importations d'énergie de l'UE et sur les taxes sur l'énergie.

Prix de l'énergie

Prix de l'électricité

Prix de gros

- **Les prix du marché de gros de l'électricité se sont stabilisés depuis la crise énergétique de 2021-2022.** Les prix sur les marchés 'day-ahead' à partir de 2024 (85 EUR$_{2023}$/MWh en moyenne aux troisième et quatrième trimestres 2023) se sont établis à un niveau supérieur à leurs moyennes historiques (56 EUR$_{2023}$/MWh en moyenne au cours de la période 2008-2020). Il semble peu probable que les prix reviennent aux niveaux d'avant la crise dans les années à venir. Les prix sur les marchés à terme se sont également stabilisés en 2023 à des niveaux plus bas, bien que supérieurs à leur moyenne historique.
- **Le bouquet électrique de l'UE a atteint un nouveau record de production d'électricité renouvelable en 2023, avec 43 % de la production totale.** La part du nucléaire a rebondi depuis le creux de 2022, avec la réactivation des centrales françaises (23 % de la production totale). L'utilisation du gaz naturel dans le mix électrique a également eu tendance à diminuer, passant de 19 % en 2021 à 17 % en 2023.
- **Les prix de gros de l'électricité dans l'UE restent légèrement élevés par rapport à ses partenaires commerciaux.** Les prix du marché japonais (81 EUR/MWh en 2023) sont récemment tombés en dessous de ceux de l'UE (103 EUR/MWh en 2023), tandis que les États-Unis maintiennent leurs prix bas (59 EUR/MWh en 2023). Le Royaume-Uni fait figure d'exception, puisque les prix de gros de l'électricité (115 EUR/MWh en 2023) y sont désormais généralement supérieurs aux moyennes de l'UE-27.

Prix de détail

- **Les prix de détail moyens de l'électricité pour les ménages ont augmenté en 2022 et 2023**. Cette hausse fait suite à des augmentations significatives des prix de gros de l'électricité, qui ont été répercutées sur les consommateurs avec un certain décalage dans le temps. Les premières indications du premier trimestre 2024 montrent que les prix dans l'UE-27 se sont maintenus à des niveaux similaires à ceux de 2023.
- **Les prix de détail pour les ménages ont continué de varier considérablement dans l'UE-27 en 2023**, certains États membres ayant des prix très élevés (Pays-Bas : 401 EUR/MWh) et d'autres des prix assez bas (Bulgarie : 116 EUR/MWh). Les États membres diffèrent également beaucoup dans la composition de leurs prix.
- **Les prix de l'électricité domestique restent élevés dans l'UE par rapport au reste du monde**. Au niveau international, les prix au Japon, en Australie et au Brésil sont inférieurs de 20 à 50 %, tandis que les prix aux États-Unis et dans d'autres pays peuvent être inférieurs de plus de 50 %. Il n'y a qu'au Royaume-Uni que les prix sont similaires à la moyenne de l'UE.
- **Les prix de l'électricité industrielle ont également augmenté dans l'UE-27 au cours de la période 2022-2023** - avec moins de retard par rapport aux augmentations des prix de gros

de l'électricité. Pour la tranche de consommation ID, par exemple, les prix en 2023 étaient supérieurs de 97 % à leur moyenne 2014-2020.

- **Les prix pour l'utilisateur final industriel ont considérablement divergé dans l'UE-27 au cours de la période 2022-2023**. Différentes interventions sur les prix ont été activées à différents moments par différents pays, ce qui a conduit à une plus grande variété de prix dans l'UE au début de l'année 2024, à la fois pour la tranche de consommation ID et IF.
- **Les prix pour l'utilisateur final industriel dans l'UE sont relativement élevés par rapport au reste du monde**, ce qui affecte la compétitivité de l'industrie de l'UE. Les prix au Royaume-Uni ont considérablement augmenté (304 EUR_{2023} /MWh) et restent supérieurs aux niveaux de l'UE (149 EUR_{2023} /MWh en janvier 2024), tandis que ceux du Japon sont à des niveaux comparables (134 EUR_{2023} /MWh). Pour les États-Unis, le Canada et la Turquie, les prix sont beaucoup plus bas (74,3, 92,4 et 76,4 EUR_{2023} /MWh, respectivement).

Prix du gaz

Prix de gros

- **L'invasion de l'Ukraine par la Russie et l'incertitude et les sanctions qui en ont découlé ont entraîné des prix de gros au comptant du gaz exceptionnellement élevés**, qui sont restés supérieurs à 100 EUR_{2023}/MWh pendant une grande partie de la période 2021-2022 et ont atteint un pic historique en août 2022, à 231 EUR_{2023}/MWh. À partir de septembre 2022, les prix spot du gaz ont rapidement diminué, passant du pic de 231 EUR_{2023}/MWh en août 2022 à 42 EUR_{2023}/MWh en avril 2023. Cette évolution s'explique par plusieurs raisons : les niveaux de stockage étaient très élevés au début de l'hiver, l'incertitude concernant l'approvisionnement par gazoduc russe a diminué, son rôle étant devenu marginal et des signes positifs indiquant que la capacité d'importation de GNL serait suffisante pour couvrir la demande. En outre, la demande de gaz dans l'UE a été assez faible en raison de la douceur de l'hiver.
- **En 2023 et 2024, un nouvel "équilibre des prix" est apparu à environ 30-40 EUR_{2023}/MWh (encore relativement élevé par rapport aux 20 EUR_{2023}/MWh d'avant la crise).** En raison de l'abandon progressif du gazoduc russe et de la réduction de la production intérieure dans l'UE, le marché est passé principalement d'un approvisionnement par gazoduc bon marché à une plus grande dépendance à l'égard des importations de GNL plus coûteuses, ce qui se reflète dans le nouvel "équilibre" des prix.
- **En raison de la crise de l'approvisionnement en gaz, le GNL est devenu un facteur plus important dans le système gazier européen.** La part de l'approvisionnement par gazoduc russe dans les importations de gaz a diminué, passant de 40 % en 2021 à environ 8 % en 2023. Simultanément, la part des importations de GNL est passée de 22 % (75 milliards de m3) en 2021 à 39 % (115 milliards de m3) en 2023. La plus forte augmentation des expéditions de GNL est venue des États-Unis (51 milliards de m3), qui sont devenus en 2023 la plus grande source d'importation de GNL de l'UE, suivis par le Qatar et la Russie.
- **Les prix de gros du gaz dans l'UE - ainsi que dans d'autres pays tributaires du GNL comme le Japon et la Corée du Sud - ont été nettement plus élevés pendant la crise énergétique que sur les marchés d'autres partenaires commerciaux.** Bien qu'ils aient augmenté sur tous les marchés, les prix du gaz dans les principaux pays producteurs, tels que les États-Unis et le Canada, sont restés inférieurs à 87 EUR_{2023}/MWh. En Chine, les prix ont considérablement augmenté, mais pas dans la même mesure que dans l'UE.

Prix de détail

- **Parallèlement à la forte augmentation des prix de gros, les prix de détail moyens du gaz dans l'UE pour les ménages ont commencé à augmenter**, passant de leur niveau antérieur d'environ 70-80 EUR_{2023}/MWh en 2021 à un niveau de prix de 125 EUR_{2023}/MWh en août 2022. Depuis, les prix ont lentement diminué et se sont stabilisés depuis le troisième trimestre 2023 dans tous les États membres, bien qu'à des niveaux presque deux fois plus élevés qu'avant la crise (100 EUR_{2023}/MWh au lieu de ~60 EUR_{2023}/MWh).

- **La crise énergétique a entraîné des différences significatives dans les prix du gaz domestique, tant entre les États membres qu'à l'intérieur de ceux-ci.** Les prix de détail en 2023 étaient les plus élevés en Suède et aux Pays-Bas (~205 EUR_{2023}/MWh) et les plus bas en Roumanie, en Croatie et en Hongrie (tous inférieurs à 55 EUR_{2023}/MWh).
- **En particulier, la plupart des États membres ont mis en œuvre des mesures temporaires de grande envergure visant à prévenir des niveaux de prix très élevés pour (certains) ménages.** Ces mesures ont eu un impact significatif sur les niveaux des prix de détail dans l'ensemble de l'UE, bien qu'elles aient représenté un coût financier important pour les gouvernements. À titre d'exemple, certains États membres ont gelé les prix de détail à des niveaux peu élevés (par exemple, la Hongrie), tandis que d'autres États membres ont mis en place des plafonds de prix (par exemple, les Pays-Bas) ou ont abaissé le taux de TVA (par exemple, la Belgique et l'Allemagne). Progressivement, en 2023, la plupart de ces mesures d'allègement temporaires ont été supprimées, créant ainsi une pression à la hausse sur les prix à un moment où les prix de gros diminuaient.
- **Par rapport à d'autres régions du monde, les prix de détail du gaz dans l'UE ont toujours été relativement élevés** (bien qu'ils varient d'un État membre à l'autre), notamment en raison des coûts de réseau et des taxes relativement élevés dans l'UE, et des subventions importantes dans d'autres régions. Cette situation n'a pas changé pendant la crise énergétique, bien que les prix pour les ménages aient également augmenté de manière significative dans de nombreuses autres régions, telles que les États-Unis.
- **Pendant la crise énergétique, les prix moyens du gaz industriel dans l'UE pour la tranche de consommation I3 ont presque doublé, passant de 40 EUR_{2023} /MWh en 2016-2019 à 74 EUR_{2023} /MWh en 2022 et 76 EUR_{2023} /MWh en 2023.** Pour la tranche I5, les prix ont bondi de 39 EUR_{2023} /MWh en 2021 à 87 EUR_{2023} /MWh en 2022, mais ont diminué plus rapidement pour atteindre 59 EUR_{2023} /MWh en 2023.
- **Par rapport aux ménages, les mesures d'allégement n'ont pas été mises en œuvre à la même échelle pour l'industrie.** Cela a contribué à des augmentations de prix moyennes plus importantes pour l'industrie que pour les ménages (voir la section suivante pour plus d'informations sur l'impact sur l'industrie).

Prix du pétrole, du charbon et des combustibles de substitution

- **Depuis 2020, les prix du pétrole brut ont été particulièrement volatils, principalement en raison de deux événements mondiaux majeurs : la pandémie mondiale de Covid-19 en 2020 et l'invasion de l'Ukraine par la Russie en 2022**. Les prix ont culminé à des niveaux très élevés, à plus de 130 USD/b en mars 2022, après quoi ils ont baissé pour se stabiliser depuis janvier 2023 à environ 80 USD/b.
- **En 2022, la demande de charbon et donc les prix à l'importation ont augmenté pour atteindre plus de 250 euros/tonne jusqu'au troisième trimestre 2022. La croissance de la demande est principalement due au passage du gaz au charbon pour la production d'électricité en Europe.** En 2023, l'utilisation du charbon pour la production d'électricité était comparable aux niveaux d'avant la crise (2019) et, par conséquent, les prix ont également diminué. Cependant, comme pour les autres combustibles, ils restent à des niveaux structurellement plus élevés qu'avant la crise.
- Les prix élevés du pétrole brut ont entraîné une hausse des **prix des produits pétroliers** en 2022 et 2023, tels que le **diesel**, **l'essence** et le **fioul domestique**. Au cours de ces années, les prix ont atteint leur niveau le plus élevé depuis au moins 2008, avec en moyenne dans l'UE-27 un prix à la pompe de 1,79 EUR/litre pour l'essence et de 1,75 EUR/litre pour le gazole.
- **Les carburants alternatifs, y compris les biocarburants tels que le bioéthanol et le biodiesel, ainsi que le GPL, suivent généralement des mouvements de prix similaires à ceux du diesel et de l'essence** car ils peuvent être utilisés (dans une certaine mesure) de manière interchangeable ou sont produits à partir de pétrole brut (GPL).

- **Chargement des VE : Les prix en 2023 dans l'UE-27 peuvent varier considérablement en fonction du lieu/MS et de l'heure**. En moyenne, les prix sont estimés entre 150 et 350 EUR_{2023} /MWh pour la recharge à domicile. Les prix de la recharge publique en courant alternatif sont généralement plus élevés, de 400 à 600 EUR_{2023} /MWh. La recharge rapide en courant continu est la plus chère, à 500-700 EUR_{2023} /MWh. Par rapport à 2021, les prix de la recharge ont généralement augmenté, bien que cela dépende fortement de l'heure de la recharge, étant donné que des tarifs dynamiques et hors pointe sont disponibles dans la plupart des États membres de l'UE.
- **Les coûts des technologies de stockage par batterie continuent de diminuer - après un bref plafonnement en 2022 - grâce à la baisse des prix des matières premières et à la pénétration croissante de cathodes LFP moins coûteuses**, ce qui rend les solutions de stockage par batterie compétitives pour un plus grand nombre d'applications dans un plus grand nombre de circonstances. La réduction des coûts des batteries continue également à rendre les véhicules électriques (VE) plus abordables. La Chine est leader dans la plupart des étapes de la chaîne d'approvisionnement des batteries et des véhicules électriques. Le stockage derrière le compteur bénéficie aussi fortement de cette réduction des coûts, mais reste concentré principalement en Allemagne et en Italie.
- **L'hydrogène vert produit à l'aide d'un réseau ou d'une électrolyse alimentée par des sources d'énergie renouvelables n'en est qu'à ses débuts** et n'est pas du tout compétitif par rapport à l'hydrogène gris (reformage du méthane à la vapeur). Les coûts de production de l'hydrogène gris ont cependant augmenté en raison de la hausse des prix du gaz naturel depuis la crise énergétique, passant de moins de 2 EUR_{2023} /kg en 2019 à 6 EUR_{2023} /kg en 2022. Toutefois, ces valeurs restent inférieures aux coûts de production de l'hydrogène vert qui sont estimés à plus de 10 EUR_{2023} /kg dans la plupart des États membres.

Coûts énergétiques industriels

La crise des prix de l'énergie a remis en question la compétitivité de l'industrie de l'UE par rapport à ses concurrents du reste du monde. Toutefois, au moment où ce travail est réalisé (juillet 2024), les dernières données complètes et fiables sur les prix et les coûts de l'énergie pour l'industrie de l'UE ne sont disponibles que jusqu'en 2021, tandis que seules des données partielles sont disponibles pour 2022 et 2023. La collecte de données directes a été entreprise par le biais d'enquêtes auprès des industries à forte intensité énergétique (IEI) et a été utilisée pour fournir des informations plus récentes et plus approfondies sur le rôle des prix et des coûts de l'énergie pour les industries européennes.

La compétitivité des industries de l'UE dans la nouvelle ère énergétique de l'UE

- **En 2023, bien que les prix moyens de l'électricité et du gaz naturel aient diminué par rapport aux niveaux de 2022, les prix moyens de l'UE en 2023 étaient encore nettement plus élevés que les niveaux d'avant la directive COVID et d'avant la crise.** Ce constat est basé sur des données obtenues auprès de 81 usines réparties dans 10 secteurs industriels (voir chapitre 2-3).
- **Les prix de l'électricité en 2023 sont environ deux fois plus élevés qu'en 2019 dans les secteurs industriels étudiés** (*mines*, *aluminium secondaire, raffineries*, *verre plat*, *ferro-alliages et silicium, aluminium primaire, pâte à papier* et *aluminium en aval)*.
- **Les prix du gaz naturel ont été multipliés par 2 à 4 dans tous les secteurs industriels étudiés en 2022 par rapport à 2019**. En 2023, les prix moyens du gaz naturel pour les secteurs étudiés ont entamé une tendance à la baisse avec des écarts importants entre les secteurs.
- **Les hausses des prix de l'électricité et du gaz naturel ont entraîné une augmentation de la part des coûts énergétiques dans les coûts de production totaux pour presque tous les secteurs étudiés** et en particulier pour l'*aluminium primaire* (38 %), les *ferro-alliages et le silicium* (29 %) et le *verre plat* (25 %).

- **Presque tous les secteurs étudiés ont également connu une baisse de leur production en raison de l'augmentation de leurs coûts énergétiques**. Les tendances de la production ont montré une baisse moyenne de la production de 43 % et 18 % pour les secteurs des *ferro-alliages, du silicium* et du *verre plat* entre 2019 et 2023.
- **La flambée des prix de l'énergie en 2022 et 2023 a fait du coût de l'énergie un facteur plus décisif pour la compétitivité des secteurs industriels étudiés**. Alors que d'autres coûts, tels que les matières premières, la main-d'œuvre, les marchés internationaux et d'autres facteurs jouent un rôle important, les prix de l'énergie ont gagné en importance. Si certains secteurs comme l'*aval de l'aluminium* et le *verre plat* ont pu répercuter une partie de leurs coûts sur les clients, ils ont tout de même dû faire face à une baisse de compétitivité due à l'augmentation des coûts de l'énergie. Dans les secteurs de l'*aluminium primaire*, du *verre plat*, des *ferro-alliages et du silicium*, les usines interrogées ont cité l'augmentation des prix et des coûts de l'énergie comme l'un des principaux facteurs influençant les réductions et les fermetures d'usines dans l'UE.
- **Les principaux concurrents extracommunautaires, à savoir la Chine, les États-Unis, le Brésil, l'Inde et la Turquie, ont des coûts énergétiques inférieurs d'au moins 20 % à ceux de l'UE** et des coûts de production totaux inférieurs d'au moins 10 %. Dans le cas du *verre plat* et de la *pâte à papier*, certaines usines estiment que cette différence est supérieure à 30 %. Toutefois, l'intensité énergétique de l'industrie manufacturière de l'UE tend à être inférieure à celle des concurrents internationaux dans la plupart des secteurs.
- **La rentabilité moyenne de l'industrie de l'UE tend également à être inférieure à celle des principaux partenaires commerciaux de l'UE.** La part de l'excédent brut d'exploitation (EBE) (indicateur indirect de la rentabilité) de l'industrie de l'UE se situe entre 10 % et 15 % pour la période 2014-2021, alors que celle de la plupart des autres pays du G20 se situe entre 15 % et 25 %. Le niveau relativement faible de l'excédent brut d'exploitation signifie que l'industrie de l'UE dispose d'une marge de manœuvre limitée pour absorber les augmentations de coûts, telles que les augmentations des coûts de l'énergie qui se produiront en 2022 et 2023.
- **Les contrats d'achat d'électricité (CAE) sont l'une des principales stratégies de couverture dont dispose l'industrie contre la volatilité des prix de l'énergie**. Le marché européen des AAE a connu une croissance annuelle de 37 % pour la période 2018-2023, l'Espagne, l'Allemagne et la Suède étant parmi les leaders en matière d'adoption.

Dépenses énergétiques des ménages

Les dépenses énergétiques des ménages dans le secteur résidentiel et dans celui des transports ont été analysées dans tous les États membres de l'UE et pour différentes catégories de revenus (voir chapitre 6). Parmi les principales conclusions :

Sur la base des données disponibles pour 2022, les ménages du décile de revenu le plus bas de l'UE ont dépensé en moyenne 1 250 euros en produits énergétiques[2]. Cela représente environ 7,5 % de leurs dépenses totales. Cette moyenne est basée sur les données des États membres suivants : Belgique, Bulgarie, Danemark, Finlande, Croatie, Italie, Luxembourg et Portugal. La moyenne est pondérée en fonction du nombre de ménages déclarés par les États membres.

La part des dépenses énergétiques dans les dépenses totales a diminué entre 2010 et 2022, surtout pour les ménages à faible revenu, de 2,5 points de pourcentage. Par rapport à 2020, la part a très légèrement augmenté pour les groupes à faible revenu et à faible revenu intermédiaire, mais pas pour les groupes à revenu intermédiaire.

[2] *Il s'agit de l'électricité, du gaz, des combustibles liquides et solides et du chauffage.*

Table 2: Part des dépenses d'énergie et de transport (dans les dépenses totales des ménages) pour différents groupes de revenus, par année

	2010	2020	2022	2010-2022	2020-2022
Part des dépenses énergétiques					
Ménages à faible revenu	9.9%	7.3%	7.5%	-2.4%	0.2%
Ménages à revenus faibles et moyens	7.6%	6.4%	6.9%	-0.7%	0.6%
Ménages à revenus moyens	6.9%	6.4%	6.4%	-0.5%	0.0%
Part des dépenses consacrées à l'énergie dans les transports					
Ménages à faible revenu	2.2%	2.4%	3.2%	1.0%	0.8%
Ménages à revenus faibles et moyens	3.6%	3.6%	4.3%	0.7%	0.6%
Ménages à revenus moyens	4.1%	3.8%	4.3%	0.1%	0.5%

Source : DG ENER : Collecte de données ad hoc de la DG ENER sur les dépenses de consommation des ménages

L'analyse de sensibilité visant à estimer les effets des prix élevés de l'énergie en 2022 et 2023 sur les différentes catégories de revenus montre que :

- **La part des dépenses énergétiques (y compris et hors transport) dans les dépenses totales de consommation a considérablement augmenté par rapport aux années précédant la crise** (c'est-à-dire avant 2022), ce qui s'explique par le fait que les prix de l'énergie ont fortement augmenté.
- **Pour les pays disposant de données récentes pour 2022/2023 : La comparaison de la part des dépenses énergétiques de 2024 avec les valeurs de 2022/2023 montre une baisse significative de la charge des coûts énergétiques**. Toutefois, seuls quelques pays ont jusqu'à présent communiqué des données pour 2022 ou 2023.
- **La comparaison de l'indice des prix harmonisé pour 2024 avec les valeurs de 2020 montre que la hausse de l'inflation est principalement due à une augmentation des prix du gaz naturel, des combustibles liquides et, dans certains cas, de l'électricité**. Le choix des vecteurs énergétiques qui alimentent principalement l'inflation varie d'un État membre à l'autre, de même que l'ampleur de l'augmentation des prix. L'Autriche, la République tchèque, l'Allemagne, l'Italie et la Lettonie ont vu les prix du gaz naturel presque doubler entre mai 2020 et mai 2024. Les carburants liquides ont connu les plus fortes augmentations de prix dans 13 États membres : plus de 80 % dans 6 États membres et plus du double dans 7 États membres.
- **Pour les dépenses énergétiques *hors* carburants, les prix plus élevés représentent une charge nettement plus lourde pour les ménages à faible revenu,** c'est-à-dire qu'ils entraînent des effets de répartition plus négatifs de la charge des dépenses.
- **En ce qui concerne les dépenses en énergie, *y compris les* carburants pour le transport, la charge supplémentaire est la plus élevée pour les groupes à revenus élevés**, car ils possèdent plus souvent une voiture et conduisent davantage.

Facture énergétique de l'UE

La facture des importations d'énergie de l'UE a été analysée pour le pétrole, le gaz et le charbon afin d'estimer le total et d'analyser les principaux facteurs, notamment les volumes, les prix et les taux de change. Le total de la facture d'importation a été calculé en additionnant les trois composantes les plus importantes, à savoir le pétrole brut, le gaz naturel et le charbon (Figure 2).

La facture énergétique de l'UE s'élevait à près de 550 milliards d'euros en 2022, au plus fort de la crise énergétique, mais elle est aujourd'hui retombée à 377 milliards d'euros. Ce recul s'explique par la baisse des prix et des volumes d'importation de gaz et de charbon. Toutefois, la facture de 2023 reste nettement plus élevée que la fourchette de 150 à 300 milliards d'euros pour la période 2014-2021.

Le pétrole reste la principale composante de la facture énergétique de l'UE. Il a représenté plus de 80 % de la facture énergétique totale entre 2014 et 2020. Les variations de la facture pétrolière ont été le principal facteur de la facture énergétique totale avant 2021.

La facture des importations de gaz naturel a bondi en 2021 pour atteindre plus de 220 milliards d'euros (24 % du total), avant de redescendre à 118 milliards d'euros en 2022 (40 % du total). Auparavant, elle était restée relativement stable entre 2014 et 2019, aux alentours de 25 à 40 milliards d'euros par an, soit environ 10 à 15 % du total**.**

Malgré une forte diminution par rapport à 2022, la facture des importations d'énergie en 2023 est supérieure de 44 % à la moyenne 2014-2022. Cette baisse est due à des réductions significatives de tous les facteurs déterminants, à l'exception du volume des importations de pétrole (qui a augmenté de 6 %). Entre 2022 et 2023, les prix à l'importation du pétrole, du gaz et du charbon ont diminué respectivement de 20 %, 34 % et 54 %. Les volumes d'importation de gaz et de charbon ont diminué de 18 % et 24 % respectivement.

Parmi les principaux partenaires commerciaux, le Japon et la Corée ont des factures d'importation plus élevées en pourcentage du PIB, tandis que la Chine a des niveaux comparables. Le Royaume-Uni a des factures proportionnellement moins élevées et les États-Unis sont, depuis 2020, un exportateur net d'énergie.

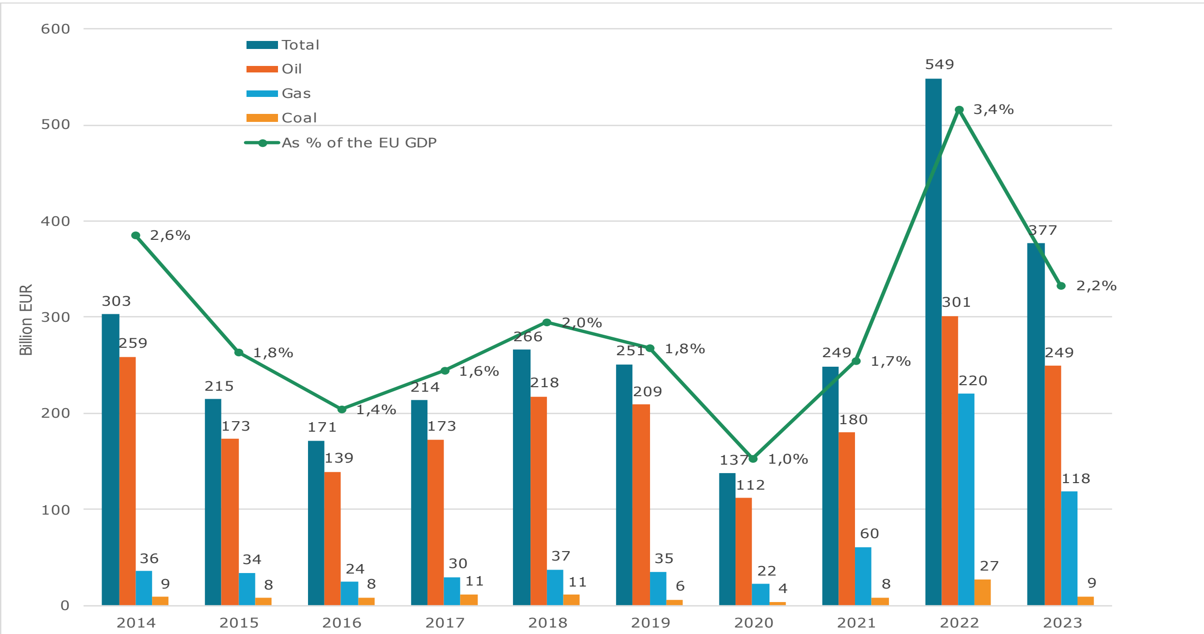

Figure 2: Facture d'importation de l'UE jusqu'en 2023

Taxes et prélèvements sur l'énergie

L'analyse des taxes et des prélèvements sur l'énergie a également été effectuée et a montré que :

À l'échelle de l'UE-27.

- **Malgré une augmentation des prix de l'énergie finale dans l'UE-27 depuis 2020, la part des taxes et prélèvements dans ces prix a diminué pour toutes les énergies et tous les**

utilisateurs finaux. Ces parts ont été compensées par la hausse des coûts de l'énergie brute et l'adoption de mesures nationales destinées à contenir les prix.

- **En 2022, les taxes sur l'énergie perçues dans l'UE-27 s'élevaient à 248 milliards d'EUR$_{2022}$ (soit 1,6 % du PIB de l'UE ou 3,8 % des recettes fiscales totales).** Les recettes ont diminué depuis 2019 (-12 %), en raison de la pandémie de COVID-19 et de l'augmentation des prix de l'énergie.
- **Les ménages sont les principaux contributeurs aux recettes des taxes sur l'énergie dans 2022** ; ils ont payé 39 % du total des taxes sur l'énergie (une baisse par rapport aux 50 % de 2008).

A l'échelle des EM.

- **Le rôle des taxes sur l'énergie dans les recettes publiques varie selon les États membres** en 2022 : en Bulgarie, les taxes sur l'énergie représentaient 14,4 % des recettes totales provenant des impôts et des cotisations sociales, tandis qu'elles représentaient 2,4 % en Irlande. En moyenne dans l'UE27, elles représentaient 3,8 % des recettes fiscales et sociales des États membres.
- **En 2021, 76 % des recettes provenant des taxes et prélèvements sur l'énergie dans l'UE-27 provenaient des droits d'accises, et 21 % des mécanismes mis en œuvre pour soutenir le développement des énergies renouvelables**.

Réactions à la crise en matière de droits d'accises et de taux de TVA

- **Depuis 2021, le secteur de l'énergie a réalisé d'importants bénéfices (bénéfices exceptionnels) grâce aux prix élevés de l'énergie**. En réponse à ces **bénéfices**, tant au niveau de l'UE que des États membres, des **taxes sur ces bénéfices ont été introduites. En 2022, ces taxes s'élevaient au total à 17,6 milliards d'euros**.
- **Les recettes des droits d'accises ont atteint 230 milliards d'euros$_{2022}$ en 2021 et ont diminué de 8 % en 2022 pour atteindre 211 milliards d'euros$_{2022}$, les pays ayant réduit les taux pour compenser les utilisateurs finaux en raison des prix élevés de l'énergie.** 18 pays ont réduit leur taux d'accise sur l'essence, le gasoil, l'électricité et/ou le gaz naturel entre 2022 et 2023. La plupart des pays ont donné la priorité à la réduction des droits d'accises sur le gasoil (18 pays) et l'essence (14), suivis par l'électricité (9) et le gaz naturel (8). Cependant, les taux d'accises commencent à remonter depuis juillet 2023-janvier 2024 pour toutes les énergies.
- **5 pays ont pris des mesures pour réduire les taux de TVA afin de lutter contre la hausse des prix de l'énergie** (quelle que soit l'énergie). Il s'agit des pays suivants : BE, IE, LU, NL et PL. Les taux reviennent maintenant aux niveaux de 2022, les mesures temporaires ayant pris fin.

Autres observations

- **Les États membres de l'UE sont plus dépendants des recettes fiscales liées à l'énergie pour équilibrer leur budget que certains partenaires commerciaux internationaux**. Les taux de TVA internationaux sur l'électricité et le gaz naturel sont assez hétérogènes, mais se situent dans la même fourchette que les différents pays de l'UE-27. Les pays européens ont tendance à taxer les carburants pétroliers au niveau le plus élevé au monde. Les droits d'accises sont environ 5 fois plus élevés en Europe qu'aux États-Unis pour l'essence et 4 fois plus élevés pour le gasoil.
- **Les taxes sur l'énergie ont diminué tandis que les subventions à l'énergie ont augmenté.** Entre 2015 et 2021, nous estimons que les recettes liées à l'énergie ont diminué de 12,6 milliards d'euros dans l'UE-27, alors que dans le même temps les subventions liées à l'énergie ont augmenté de 32,1 milliards d'euros.

1. Introduction

This 2024 edition of the energy prices and costs report follows a period of exceptional turbulence on global and European energy markets since 2020. The sustained period of high energy prices has had, and despite prices returning towards pre-crisis levels, continues to have serious implications for European households, industry, the broader economy and public finances.

The energy markets first experienced upheavals in 2020 as a result of the COVID-19 pandemic and lockdowns, which first led to a sharp decrease in energy demand and prices due to declining activity in the industry and service sector. This was later followed by an equally sharp energy demand increase thanks to rapid economic recovery.[3]

The energy price crisis began in summer-autumn 2021 driven by a gas supply crisis, together with the 2022 invasion of Ukraine, both driven by Russia, and which created unprecedented uncertainties and price peaks on the European energy markets. This led to a strong political will in Europe to move away from Russian fossil fuel sources, endorsed in the REPowerEU plan, presented in May 2022. In this plan, the EC proposed to achieve energy independence from the Russian Federation via the diversification of its fossil fuel imports, increased energy efficiency measures and an accelerated uptake of renewable energy sources.

At the same time and in preparation for the first winter without sufficient Russian gas supplies in 2022/23, the EU and its Member States took immediate and ultimately successful steps to prevent energy (gas and electricity) supply disruptions. Member States reached an agreement on gas storage filling targets at 80% of the available technical capacity[4], with some going above this target[5]. In the short-term, intra-EU competition to secure gas to fill storages led to sharp price increases – but in the longer-term, together with an unusually mild winter[6], the coordinated action helped the EU to prepare for winter 2022/23 and to bring down energy prices closer to their 2021 level by March 2023, where they have further declined and stabilized in the past year.

Other factors also remained important, with the ongoing energy transition having a profound impact on European energy markets and prices, for example providing an estimated 0.6% reduction of wholesale spot electricity price for every percentage point increase in renewable energy share in the electricity mix[7]. At the same time, large renewable shares have other consequences, for example the number of hours of negative wholesale electricity prices has significantly increased, with implications for energy markets and suppliers. The objective of this 2024 edition of the energy prices and costs report is to put the energy crisis, subsequent energy price dynamics and other market forces into context, and to help understand the impact on the costs and the competitiveness of the EU, based on official data and statistics. The report provides analysis across the following sections:

- The report provides the regular review of **price developments on wholesale and retail markets 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 network costs, 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.

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[3] *https://www.iea.org/reports/covid-19-impact-on-electricity*

[4] *https://www.iea.org/reports/how-to-avoid-gas-shortages-in-the-european-union-in-2023/the-need-for-action*

[5] *https://www.bmwk-energiewende.de/EWD/Redaktion/EN/Newsletter/2023/02/Meldung/topthema.html*

[6] *https://www.iea.org/reports/how-to-avoid-gas-shortages-in-the-european-union-in-2023/baseline-european-union-gas-demand-and-supply-in-2023*

[7] *https://www.imf.org/-/media/Files/Publications/WP/2022/English/wpiea2022220-print-pdf.ashx*

- **Chapter 4** provides the analysis of price developments for **oil, coal, alternative fuels and other key technologies** such as storage and hydrogen.
- **Chapter 5** addresses the impact of increasing **energy costs for European industry**. The assessment of energy-related costs has a focus on energy intensive industries and manufacturing, but some analyses are also provided for the agriculture and services sectors (more than 40 economic sectors in total). The chapter provides analysis of these sectors' energy costs shares, energy intensities and energy prices and, where available, comparisons with international partners.
- **Chapter 6** looks at the **evolution of households' energy expenditure**, the drivers behind these changes, including consumption, and the impact on households' budgets across income levels and energy poverty.
- **Chapter 7** addresses the **EU's energy import bill** (Chapter 7), whilst **Chapter 8** looks in detail at the **taxes imposed on energy products** and assesses their importance for government budgets and their impact on the prices of these products.
- **Chapter 9** provides an **econometric analysis of the energy price surge**, covering the period of the energy crisis, and examining its drivers and impacts, with a specific focus on how wholesale price changes are passed through to retail prices.
- **Chapter 10** provides an analysis of the **impact of increased renewable energy generation on electricity price formation**, including analysis of short term and long-term effects, and negative prices.

The report also has a supplementary Annex A which provides more detailed information and assessments of industry energy costs.

2. Electricity prices

Methodology

This section presents an overview of the methodological choices made in the energy prices analysis in **Chapters 2, 3 and 4**. *Note that the below described assumptions apply only to these specific chapters, and other methodological choices are made in other chapters of this report.* Unless specified otherwise, below methodology is applied in Chapters 2, 3 and 4.

Consumption band selection

- For energy retail prices Eurostat data is used in most cases. Eurostat presents retail price data for different consumption bands**.** Consumption bands refer to the range of yearly energy (gas/electricity/oil product) consumption levels for which the average retail price is estimated by Eurostat. Eurostat prices are based on actually invoiced prices that are paid by end-users. In Table 3 the consumption bands used in the data are shown in. More information about what type of industries generally speaking fall in the consumption bands can be found in chapter 5 on industry costs.

Table 3: Overview of Eurostat consumption bands used.

Energy carrier	Retail segment	Consumption bands	Previous edition (2023)
Electricity	Households	**DD:** 5 000-15 000 kWh. *Also 1 figure for most representative band per MS.*	DC: 2500-5000 kWh
	Industry	**ID:** 2 000-20 000 MWh (small industrial) **IF:** 70 000- 150 000 MWh (large industrial)	Same bands used. Most representative band *per* MS for MS-specific figures instead of same band for all MS.
Gas	Households	**D2:** 20-199 GJ (568 m3-5680 m3)	
	Industry	**I3:** 10-100 TJ (0.28-2.8 million m3) **I5:** 1000-4000 TJ (28.4 – 114 million m3).	

These consumption bands are selected for the following reasons:

- **General:**
  - In Chapters 2 to 4 figures both show EU-averages and Member State-specific data: if not mentioned otherwise, all EU-average figures show consumption-weighted average prices.
  - Also, for both MS-specific and EU average figures a single consumption band is used. This is a change compared to the previous edition where the most representative band *per* MS was used to show more representative data. The switch to a single consumption band was made to make data more comparable between MS, although it does slightly lower the representativeness of the data.
  - For the international comparison the same bands are used for non-EU countries if data is available; for industry, the comparison is only shown for the largest consumption bands (IF and I5).
  - Further details about the consumption falling within consumption bands per MS can be found on Eurostat and per industry in chapter 5 on industrial energy costs.[8]
- **Electricity for households:** The DD band has since recent years become the consumption band with the highest share of total household consumption in the EU: 32%.[9] In the previous edition the lower DC band (2500-5000 kWh) was used, but among others due to further electrification of household heating, the DD band share has overtaken the DC share as the most common band. This means the data shows the retail price for households with relatively large electricity consumption though. For figures comparing Member States, the DD band is used for all MS, regardless of the largest consumption band in this Member State. In addition, to show a more complete analysis also the comparison is given for the most representative band. More details on this can be found Box B.
- **Electricity for industry:** the report presents average prices for two consumption bands for non-household users. The ID band is representative for small industrial companies and on average 24% of the total non-household electricity consumption in EU Member States falls in this band. Since electricity prices (and more notably taxes and network costs) can be quite different for smaller industrial and large energy-intensive businesses, the IF band (70 000-150 000 MWh) is also shown, representing large energy-intensive businesses. The highest IG band (>150 000 MWh) has higher relative consumption (up to 40% of total non-household consumption for some MS) levels in several Member States with significant industry. However, data for IG is missing for many Member States due to limited industry and subsequently there is a lack of sufficient (anonymized) data available. Hence the IG band is chosen to allow comparison between more Member States. Due to the lower relative consumption in the IG band however (<15% of total non-household consumption in most MS), it leads to less representative price levels for large industry. It is worthwhile to note for industry (both gas and electricity) that the data sample can be relatively small as a result of a limited number of businesses in a consumption band. As a result, individual differences in network costs or the type or timing of energy contracts of businesses can have an influence on the national prices shown. More details about industrial consumption bands and how they relate to industrial sectors can be found in Chapter 5 on industrial energy costs.

[8] *Eurostat (2024). nrg_pc_203_v to nrg_pc_206_v*

[9] *Eurostat (2024). household consumption volumes of electricity by consumption bands (nrg_pc_205_v)*

- **Gas for households:** The D2 band was selected for households with a similar logic as described above for electricity. The majority of household gas consumption falls in the D2 band: 76%, making it an easy choice to select the D2 band.[10] No additional figure therefore for the most representative band is needed.
- **Gas for industry:** similar to electricity, two bands were selected: the I3 band (10-100 TJ) to represent small – though still energy-intensive – industry and I5 (1000-4000 TJ) for large, energy-intensive industry. Consumption in the I3 band is significant in most MS: 20-40% is of total non-household consumption is common. For the I5 band, the consumption represents between 0-20% of non-household consumption with relatively large differences between MS, similar to the electricity consumption by large industry. Unfortunately, also for the I5 band, data is missing for some MS, due to no consumption or very concentrated consumption in this band (if there are only few consumers in a band, data is not shown to prevent traceability of individual consumer data). However, the data for the I5 band is still representative for large industry while for the I6 band data is missing for even more countries.

Other methodological choices made within Chapters 2-4 are:

- All household prices are presented *including* taxes such as VAT. Industrial (business) prices are displayed excluding VAT since the majority of businesses can recover VAT.

Deflators

Depending on the main objective of the chapters, different types of deflators are used to allow for a fair and insightful data comparison. In this section a short rationale is given for the chosen deflator.

In general, the used approach for internationally traded commodities (the majority of commodities discussed in this report) is to first use the currency conversion rate from foreign currencies (such as US dollar) to euro's, using the exchange rate at a given time (daily exchange rates available for daily prices, or annual/monthly exchange rate averages if using monthly/annual data; source: Eurostat). For traded commodities, a single deflator is used, typically the Eurozone deflator. For commodities traded on a more local level, the approach is different: then the local inflation rate (or another deflator) is applied first which is then converted to euros using the exchange rate in a reference year. The choice of the sequencing of exchange rate conversion and deflation has some influence on the converted price outputs, however, typically most prices are quoted in either EUR or USD, for which deflators are relatively similar.

On deflator selection, Table 4 general guidelines used, but it is possible certain figures deviate from the below approach.

Table 4: Overview of used deflator types.

Price types	Type	Deflator	Rationale
Wholesale		GDP (Gross Domestic Product) deflator	GDP deflator is the most logical deflator for which data is available for the time period studied. Suitable for global comparison between years. For other options such as GVA (Gross Value Added) data was not available for the entire period studied.
Retail	Households	HICP (Harmonized Index of Consumer	For households the HICP (2023=100) is used to compensate for changes in

[10] *Eurostat (2024). Household consumption volumes of gas by consumption bands*

Price types	Type	Deflator	Rationale
		Prices) deflator or nominal prices	consumer price level during years. This index best represents the inflationary environment observed by households.
	Industry	GDP deflator	GDP is the deflator which best represents the economic environment experienced by industry, and for which data was available throughout the studied time period.
International comparison gas and electricity	Retail	National/regional deflators based on consumer price indexes	In the Eurozone, this is the annual HICP.
Wholesale		National/regional deflators based on GDP	
Globally traded commodities (oil, biofuels, LPG, coal)		Nominal prices	For globally traded commodities (often traded in a single currency, such as dollars for oil) it is most relevant to compare how prices in export regions compare *within* a year, for which nominal prices give a good representation.

Data collection methods

Numerous data provided in this section come from Enerdata's online databases. Energy and price data are collected from numerous sources, of which national statistical offices (NSO), ministries, energy agencies, energy regulators, central banks, companies... At Enerdata, particular attention is being paid to ensuring that the data provided is harmonised and allows for meaningful comparisons. In some cases, particularly where price data is concerned, it is difficult to compare because of the specific characteristics of each country (e.g. #1, the calorific value of coal differs from one country to another, so the prices indicated are specific to each energy product covered; e.g. #2, the features of prices to end-users vary from one country to another: some use specific consumption bands, others provide data aggregated by consumer type, others are regulated prices, and finally some are prices modelled according to certain consumption profiles). Therefore the metadata for each series is provided so that readers can make informed analyses and comparisons.

In terms of process, quantity-weighted averages are preferred to arithmetic averages, which are the second-best option. For wholesale electricity and gas prices in Europe, monthly prices are the arithmetic average of hourly (electricity) or daily (gas) assessments on the market places.

For figures with monthly household and industry end user prices (such as Figure 20), these prices are estimated by Enerdata by using the Harmonised Index of Consumer Prices (HICP) and the Producer Price Index (PPI) respectively to convert annual Eurostat data to monthly figures.

2.1. Wholesale prices

Main findings

- **Wholesale electricity market prices have stabilised** since the energy crisis of 2021-2022. Rebounding economic activity after the coronavirus pandemic boosted electricity demand, while fossil fuel supply changes following the Russian invasion of Ukraine reduced supply, leading to significantly higher prices. Production and import diversification and mild winters have tempered prices. The prices on day-ahead markets as of 2024 (85 EUR_{2023}/MWh average in Q3 and Q4 2023) have settled at a level higher than their historical averages (56 EUR_{2023}/MWh average in 2008-2020 period). It appears unlikely that prices will reduce to pre-crisis levels in the coming years.
- **The EU's various bidding zones remain somewhat fragmented**. Price convergence in the CWE, Northern Europe, and British Isles regions dropped considerably during the energy crisis and has not fully recovered. In the CEE, SEE, and Apennine Peninsula regions, price convergence improved. The Iberian Peninsula maintains almost full price convergence (i.e. over 90% of hours have <1 EUR/MWh price difference).
- **Prices on forward markets have in 2023 also stabilised to lower levels, albeit above their historical average**. Forward product prices previously were somewhat similar to day-ahead market prices for electricity, reflecting little value gained from hedging price risks. The premium on forward products versus day-ahead market prices due to this hedging of risk has however increased since pre-crisis levels.
- **The electricity mix of the EU hit a new record of renewable electricity generation in 2023**, at 43% of total production. The share of nuclear has rebounded since a low in 2022 with the re-activation of French plants (23% of total production). Natural gas use in the electricity mix has also trended downward, from 19% in 2021 to 17% in 2023.
- **The CWE region has recovered as the main electricity exporter in the EU-27** with over 7 TWh exported in December 2023. This is primarily resulting from the re-activation of nuclear assets in France. Italy remains the main importing country (4.6 TWh imported in December 2023), while the Northern Europe region has transformed into a net-positive region in terms of inflows and outflows (29 TWh exported over 2023). Other regions remain close to their historical neutral position.
- **The EU's wholesale electricity prices continue to be slightly elevated compared to trading partners**. Japanese market prices (81 EUR/MWh in 2023) have recently dropped below those of the EU (103 EUR/MWh in 2023), while the US maintains its low prices (59 EUR/MWh in 2023). The UK is the exception here, where wholesale electricity prices (115 EUR/MWh in 2023) are now generally above EU-27 averages. Historically, the EU has maintained slightly higher prices, with averages over the 2014-2020 period of 49 EUR_{2023}/MWh versus 43 EUR_{2023}/MWh for the US.

2.1.1. Evolution of day-ahead wholesale electricity prices

Figure 3 shows the evolution of the European Power Benchmark (EPB) with the range between minimum and maximum monthly wholesale electricity spot prices and the relative standard deviation, for the past decade – from the beginning of 2014 to the end of 2023. Between 2014 and 2018 prices were relatively stable averaging in the EUR 29 and EUR 36 per MWh range. The year 2018 brought a significant increase in the average price (EUR 44 per MWh), followed by a lasting decrease again in 2019. Spot prices averaged the lowest in 2020 within this 10-year period, at EUR 26 per MWh. The first half of 2021 brought a steep increase already, and by the end of 2021 the electricity prices averaged 3-4 times the average price a year before – at around EUR 94 per MWh. In 2021 and the first half of 2022 the average electricity price doubled every 6 months. This tendency broke only by the end of 2022, which still brought a significant increase, but the EPB yearly average eventually plateaued at EUR 218 per MWh in 2022. The year 2023 saw the cooling of the market, and the return of the yearly average to the 2021 level at EUR 94 per MWh.

As can be seen below, the stable wholesale electricity price level between 2014 and 2018 (with an uptick at the end of 2016 and 2018) started to fall (from an already higher base set by the 2018 increase) at the beginning of 2019 and to follow a downward trajectory (EUR 36 per MWh EPB average in 2019) until the end of Q1 in 2020. The compound effects of a slowing economy, falling fuel costs, soaring GHG emission allowance prices, and already rising renewable electricity penetration, together with the short-term effects of the COVID-19 lockdowns (and reduced power demand) first imposed in Europe in March 2020 helped to drive electricity prices down and increase the share of renewables in the energy mix.[11] As a result, average European wholesale prices on the spot market reached their lowest levels in April 2020 (at EUR 15 per MWh), when slow recovery began, and eventually the EPB benchmark averaged EUR 26 per MWh again in 2020.

Prices started to gradually increase again in 2021, to reach very high levels, reaching local maximums in December 2021 (EUR 214 per MWh), and then again in March 2022 (EUR 246 per MWh). In the first half of 2021, the price increase was mainly caused by rising import prices for fossil fuels[12], unusually cold weather, soaring equipment prices and carbon costs[13]. In Q2 and the second half of 2021, these factors (mainly the still high fuel and carbon costs) were exacerbated by the post-pandemic easing of lockdown measures and the subsequent rapid economic recovery.[14, 15] During the summer of 2021, electricity prices reached 20-year highs and continued increasing. This outcome was mainly due to geopolitical tension between the EU and its historical main gas supplier, Russia, in the build-up to and following the Russian invasion of Ukraine, with Russia using gas deliveries as a political tool to pressure the EU. Gas supply did not match the post-pandemic global economic recovery and the increasing demand, which led to increasing competition and import costs in Europe – by that time already low also on storage.[16] Other supply-side factors also impacted market prices, including the low availability of French nuclear power plants, and low hydroelectric generation capacities caused by droughts (reportedly Europe's worst in centuries).[17, 18] Q3 of 2022 brought an all-time high of the EPB at EUR 383 per MWh due to continued market uncertainty about future gas deliveries from Russia, with Russia gradually reducing gas flows via Nord Stream 1 and other pipelines. Notably, the price peak could be seen before the Nord Stream explosions in September. The price impact of the explosion was limited, showing prices already incorporated the expectation that Russian gas supply would structurally be minimal).[19] More details about gas price developments can be found in chapter 3. Q4 of 2022 already brought significant easement on the wholesale electricity market with the improved outlook of the gas supply (due to LNG deliveries), mild weather, and energy efficiency measures.[20]

The tendency continued throughout all of 2023 for similar reasons (mild weather leading to lower heating demand, higher than expected gas storage levels, improving certainty regarding gas supply, and energy efficiency measures), aided also by increased renewable and nuclear generation availability, stabilizing the electricity prices (although on 3-4 times higher compared to pre-crisis levels).[21]

The standard deviation of prices between the different market regions showed a decreasing tendency (with great fluctuations within the 9% and 40% range) in the period 2014-2018. The year 2019 proved to turning point. This was mainly due to the fact that prices in the CWE and CEE regions cleared on a much lower level than in southern EU markets, especially Greece. Prices in other

[11] *IEA (2020) Electricity Market Report*
[12] *European Council (2024). Energy price rise since 2021*
[13] *European Commission (2021). Quarterly report on European electricity markets Q1 2021*
[14] *European Commission (2021). Quarterly report on European electricity markets Q2 2021*
[15] *European Commission (2022). Quarterly report on European electricity markets Q3 2021*
[16] *European Commission (2022). Quarterly report on European electricity markets Q4 2021*
[17] *European Commission (2022). Quarterly report on European electricity markets Q2 2022*
[18] *IEA (2023). Electricity Market Report 2023*
[19] *European Commission (2023). Quarterly report on European electricity markets Q3 2022*
[20] *European Commission (2023). Quarterly report on European electricity markets Q4 2022*
[21] *European Commission (2023). Quarterly report on European electricity markets Q1 2023*

Southern regions, such as in Italy, the Balkans and on the Iberian Peninsula were affected by weak hydro generation.[22] 2020 especially showed great divergence in prices across the regions owing to the fact that the decrease in prices in countries and regions that traditionally form the lower part of the spectrum – i.e. the Nordic countries and the CWE region – was greater than in Southern Europe, where wholesale prices are typically higher. As a result, the relative standard deviation in wholesale market prices reached its highest level since 2015.[23] This tendency persisted in the following years, with Q2 of 2023 again showing higher deviation than Q1 because of the summer months[24], and standard deviation trending generally higher in the 4-year period between 2020 and 2024 (in the range of 15-40%) than in the previous 4-year period.

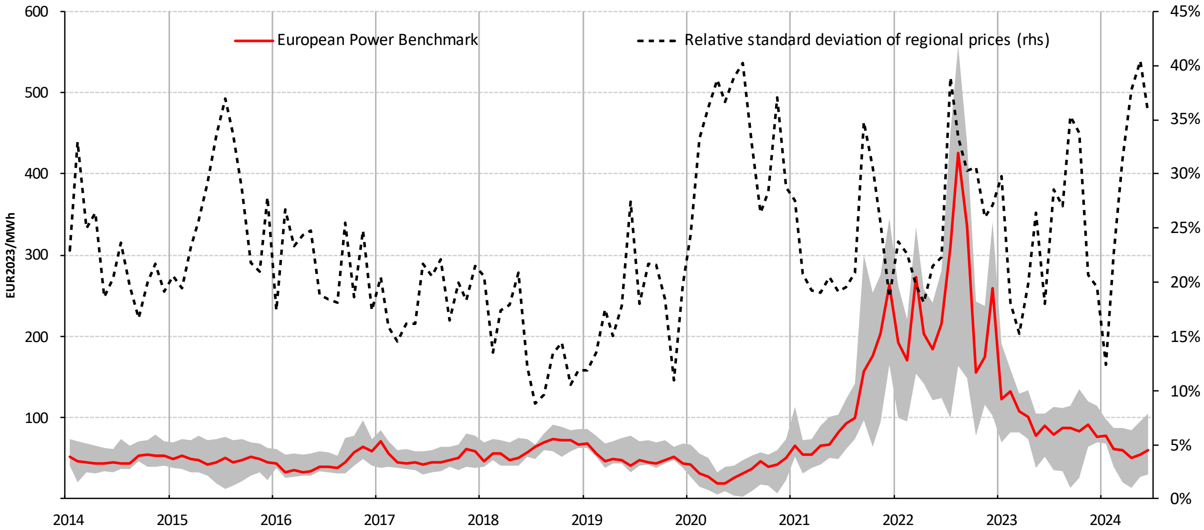

Figure 3: Evolution of monthly average wholesale day-ahead baseload electricity prices in Europe in EUR2023/MWh, showing the European Power Benchmark and the range of minimum and maximum prices across the main EU markets.

Source: S&P Platts, ENTSO-E

Price convergence

European electricity markets showed mixed developments in terms of price convergence over the five-year period between 2017 and 2021, with some markets converging and others diverging. Price convergence peaked in the period 2018-2020 in different/most regions (with the notable exception of the CEE electricity market, which got coupled into the MRC in 2021 only) and got on a decreasing trend after. The Iberian electricity market (MIBEL) showed the most stability, with an almost identical price development in Portugal and Spain, and the Greek-Italian markets showed a significant convergence within this period as well. 2023 (post energy crisis) proved to be a turning point in almost all investigated markets, that put prices on a converging trend again between the bidding zones. Overall, market coupling seems to have supported day-ahead price convergence in Europe – however, the energy crisis that unfolded in 2022 shed some light on certain structural disparities between these markets as well, resulting in the aforementioned decline in full price convergence due to insufficient available interconnection capacities (although they proved to be successful in shaving the most severe price peaks at least)[25]. While the diverging trend seems to have passed with 2023,

[22] *European Commission (2019). Quarterly report on European electricity markets Q1 2019*
[23] *European Commission (2020). Quarterly report on European electricity markets Q1 2020*
[24] *European Commission (2023). Quarterly report on European electricity markets Q2 2023*
[25] *European Commission (2023). Quarterly report on European electricity markets Q4 2022*

European electricity price convergence level remains well below the one that could be observed in the 2018-2020 period.

Figure 4 illustrates the degree of price convergence in day-ahead markets within selected European regions[26] expressed in percentages of hours in a given year in the period between 2017 and 2024 (with the most recent available datapoint). In theory, price convergence is an indication of the level and efficiency of market integration between different (national) bidding zones. The price convergence is driven by market-coupling initiatives, such as the expansion of interconnection capacities.[27] Short-term price divergences, however, can occur regardless of the level of integration, and can be a result of one-time events. These one-time events can be due to technical issues, changes in generation mix, consumption patterns, or the amount of cross-zonal capacities designated by the TSOs for commercial purposes.[28] A recent example is a technical issue with the EPEX Spot trading system, which led to a partial decoupling of German-French markets on 26 June.[29]

- In the **Central Western European Region** (CWE) the share of hours with nearly full price convergence and moderate price convergence peaked in 2020 at 17% and 72% respectively, only to enter into a steep decline in 2021, and reach bottom levels in 2022 at 3% and 19%. This decrease can be attributed to the combined effect of the unavailability of French nuclear power plants, and a depressed hydro power generation due to unfavourable weather conditions, which turned France from a net exporter to an importer – pushing the French electricity prices up and on a diverging pattern compared to the rest of the region. In comparison, Germany was able to somewhat mitigate the price spikes, brought on by the natural gas crisis in 2021 and then again in 2022, thanks to its dynamically increasing renewable electricity generation, as well as the coal-fired power generation capacity.[30] Since the energy crisis in 2021 and 2022, the price convergence also entered into an increasing pattern again within the region in 2023.
- The significant convergence of the electricity prices observed in the **Central Eastern European** (CEE) region in 2021 and 2022 – due to the successful coupling of the 4M MC market (CZ, SK, HU, RO) and the Multi-Regional Coupling (MRC) mid-2021[31] – continued (and even accelerated after a small disruption in the 2022 crisis) in 2023, reaching its highest levels in the investigated time period. The share of hours with a full price convergence stood at 15% in 2023, with 35% of the hours achieving moderate price convergence too.
- The **South-East European** (SEE) electricity market shows the least level of convergence in the European electricity markets – but is on a converging pattern. In the absence of cross-border infrastructure, the region's energy market has historically been isolated. The emerging convergence within the region can be attributed to the finalisation of several key infrastructure projects, financed by the CEF (Connecting Europe Facility) and entered into operation recently – e.g., the Bulgarian-Greek electricity interconnector.[32]
- The **Northern European** electricity market seems to be ahead of the more general European trend, reaching its peak convergence in 2018 already, and entering a steep decline right after. This trend is driven by growing trade imbalances between the Scandinavian countries and Finland.[33] During the energy crisis – unlike the Baltics – the Scandinavian countries (Norway and Sweden specifically) had large hydro power reserves to fall back on[34,35], therefore they developed the lowest dependence on natural gas in the region, and often observed the

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[26] *The CWE region comprises of AT, DE/LU, BE, NL, FR and CH. The CEE region includes CZ, SK, HU, RO, PL and SI bidding zones. The SEE region includes BG, GR, HR and RS. The Northern European bidding zone consists of DK, EE, FI, LV, LT, SE, NO. The British Isles region includes the UK and IE, Iberia consists of ES and PT, and the Apennine Peninsula bidding zone consists of IT and MT.*

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

[28] *European Commission (2023). Quarterly report on European electricity markets Q4 2022*

[29] *Independent Commodity Intelligence Services (2024). Day-ahead power price spreads soar as markets decouple on technical issue*

[30] *European Commission (2023). Quarterly report on European electricity markets Q4 2022*

[31] *HUPX (2021). Press release 17 June 2021 - DE-AT-PL-4M MC (Interim Coupling) project goes live*

[32] *European Commission (2022). Infrastructure Fact Sheet: Projects of Common Interest in energy infrastructure in the Central and South-Eastern region*

[33] *European Commission (2023). Quarterly report on European electricity markets Q4 2022*

[34] *IEA (n.d.). Countries - Norway*

[35] *IEA (n.d.). Countries - Sweden*

lowest electricity prices in Europe throughout 2022. The Baltic states – which generally show a much more significant price convergence compared to the rest of the Nordic electricity market[36] – also experienced a hard stop of inflow of both electricity and natural gas in their energy system previously coupled to the Russian grid rather than to the rest of Europe. The often congested interconnection capacities of the region could also be a contributing factor in the complete detachment of electricity prices throughout the region with a diverse energy mix.[37]

- Price convergence on the **British Isles** has increased between 2017 and 2020 (mainly resulting from market coupling). On 31 January 2020, the UK officially left the EU, and after the transition period provided until the end of 2020, the GB electricity market (not including Northern Ireland) decoupled from the EU market frameworks.[38] The implicit coupling system between Ireland and the UK was replaced by an explicit trading system – as a result, British day-ahead order books are no longer coupled with EU markets. Price convergence numbers also reflect that the British Isles region's price convergence numbers have not in 2022 or 2023 returned to their prior levels.
- The **Iberian Peninsula** (Portugal and Spain) shows a consistently high price convergence, peaking in 2021 and entering a somewhat declining phase after. Apart from the successful market coupling in 2007 that created the Iberian Electricity Market (MIBEL), the very similar production and consumption patterns of the two countries also aided this convergence.[39] The electricity prices on the day-ahead market reached peak convergence levels between Spain and France in 2020, when both full and moderate price convergence started to decline steeply to reach its minimum around the height of the energy crisis induced by the Russian invasion of Ukraine in 2022. This decline can be explained by the same trend as observed on the CWE market – the simultaneous unavailability of the French nuclear fleet and hydropower capacities putting the market under stress, while the Spanish market benefitted from its access to large LNG import infrastructure. The interconnection capacity between the two countries remains limited and highly congested (no day recorded without congestion in 2022, 73.4% of the days congested for more than 12 hours on the day-ahead horizon[40]). A moderately increasing tendency of price convergence can be observed between the two countries since then, all throughout 2023.
- An additional analysis focuses on **the CORE Region** (which includes Austria, Belgium, Croatia, the Czech Republic, France, Germany, Hungary, Luxemburg, the Netherlands, Poland, Romania, Slovakia and Slovenia). Poland is generally excluded from these analyses on price convergence, due to allocational constraints impacting the possibility for Core CCR trade. This region has seen growing price convergence in recent years, with almost 30% of all timeslots experiencing full price convergence in 2023. Excluding Poland, price convergence rates between different borders in the CORE region are also rather close to each other, while HR-SI and HU-SK are the borders with the best price convergence in 2023. Since the core DA coupling, clearing prices in all markets (excluding Poland) have become closer to the mean CORE price in 2023.[41]

[36] European Commission (2023). Quarterly report on European electricity markets Q4 2022
[37] ERR (2023). Electricity price differential between Estonia and Nordics arose in 2020
[38] European Commission (n.d.). United Kingdom - Post-Brexit relations on energy fall under the EU-UK Trade Cooperation Agreement and the Euratom-UK Agreement
[39] Macedo et al (2022). The role of electricity flows and renewable electricity production in the behaviour of electricity prices in Spain
[40] Red electrica (2023). France
[41] Consultancy.eu (2023). Analysis: Core Flow-Based Market Coupling 18 months since go-live

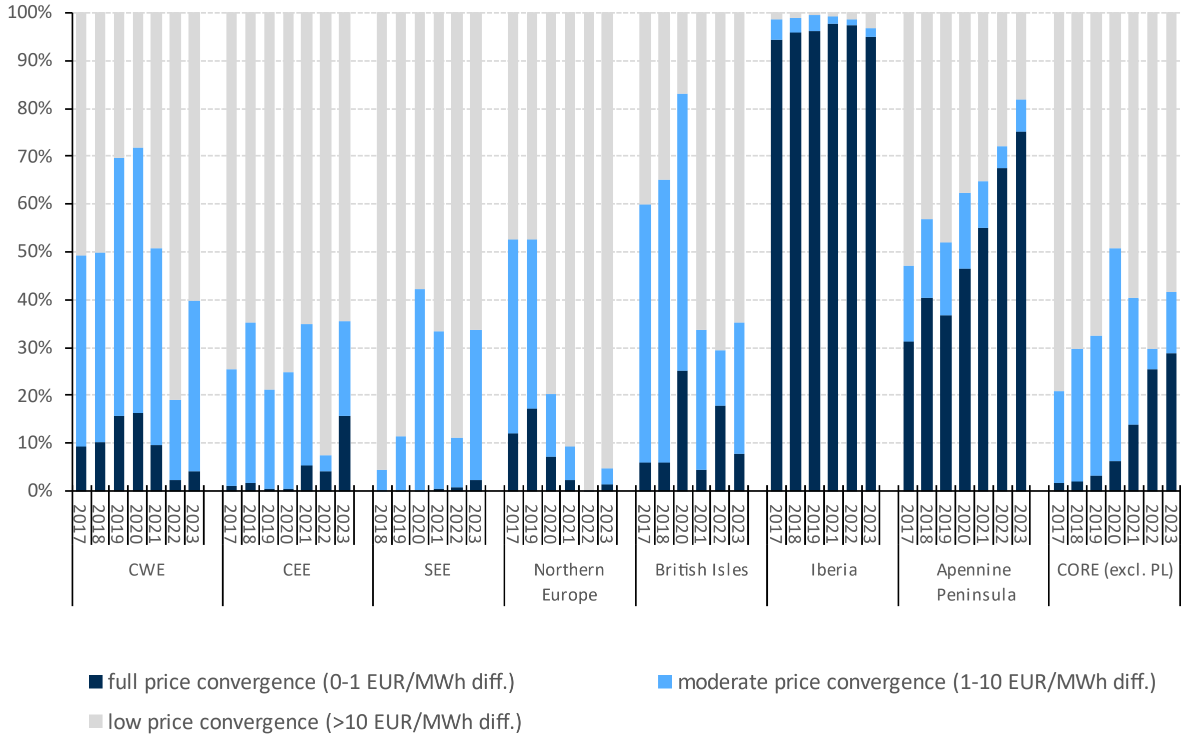

Figure 4: Price convergence on day-ahead markets in selected regions as percentage of hours in a given year.

Source: ENTSO-E, S&P Platts

The mixed trends in price convergence levels underline the importance of further investment in strengthening (cross-border) network capacities between Member States (keeping in mind that full convergence is not a policy goal by itself, as it would require excessive investment). Similar trends (leading to the same conclusions) could be observed within specific Member States with more than one bidding zone (i.e. in Sweden), where regional electricity prices decoupled from each other completely because of insufficient transmission capacities connecting these regions and the differing electricity generation mixes (i.e. the availability or lack of hydropower and nuclear capacities).[42]

Spot and forward wholesale electricity price trends

Figure 5 gives an indication of the relationship between market participants' expectations regarding the development of future wholesale electricity prices and the actual price development over the years between 2017 and 2024 (until the last available data point). To achieve this, a consumption-weighted baseload benchmark of the five most advanced markets was created (EP5), with a three-year visibility into the future. These markets are Germany, France, Spain, the Netherlands, and Nord Pool.

From 2017 to early 2019, spot electricity prices were comparable, somewhat higher than forward electricity prices – anticipating a decrease as a result of higher renewable energy penetration and a less tight market situation. In Q2 of 2019 the spot and forward prices started to diverge more significantly, the observed spot prices trending below the forward prices. This tendency lasted until the end of 2020 and can be explained by the ongoing COVID-19 lockdowns and the anticipated recovery after the measures being lifted. In 2021 the quick economic recovery and (especially later the same year) the start of the gas crisis and scarcity in Europe induced a significant divergence

[42] Riksbank (n.d.). *What effect can measures to dampen the electricity price have on inflation?*

between the EP5 spot price index and the forward price indexes – this time the observed spot prices being significantly higher than the forward prices. Figure 5 showcases the TTF gas price index development, as well as the already mentioned spot and forward electricity prices, and the clearly visible correlation between them.

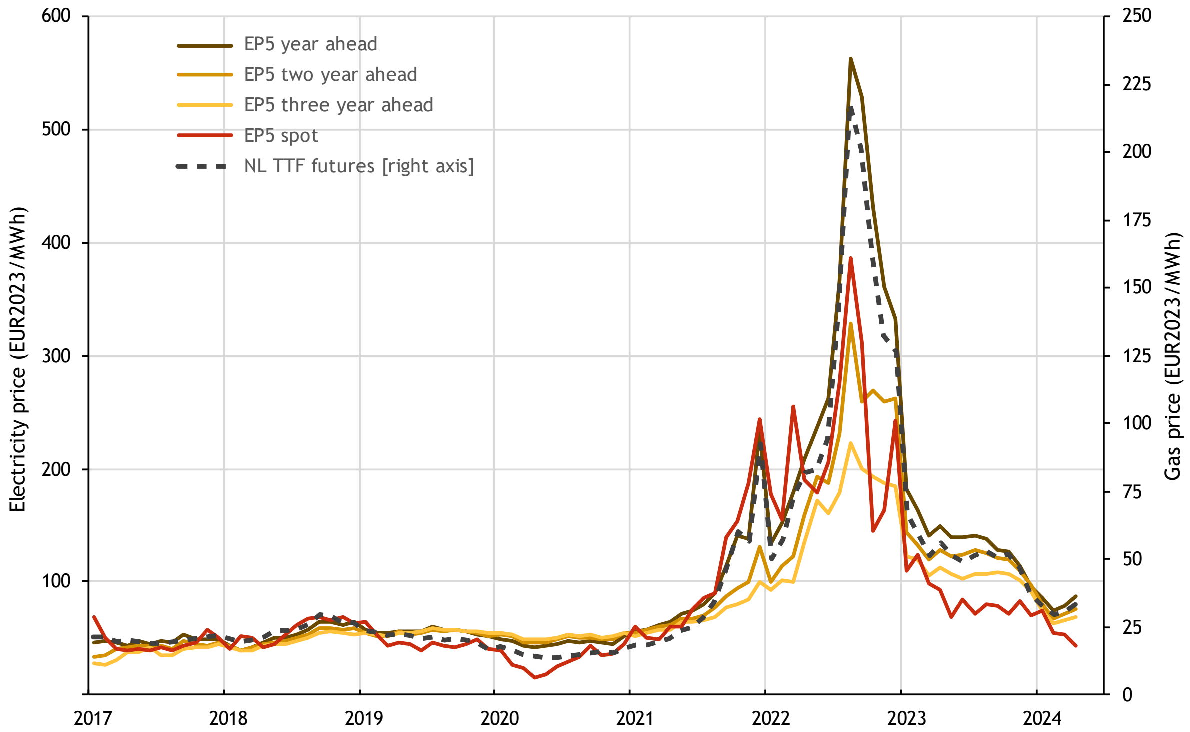

Figure 5: Monthly evolution of spot and forward wholesale electricity prices in Europe since 2017 in EUR2023/MWh. The right axis shows gas TTF future prices.

Source: S&P Platts

Electricity (and natural gas) wholesale prices have shown a significant increase all throughout 2021 and in the first half of 2022, after which (in August 2022) they reached their peak. This tendency was true for both the spot and forward markets for year(s)-ahead contracts, as spot prices went from EUR 54 per MWh in January 2021 to EUR 169 per MWh in January 2022. The three-year ahead prices followed from EUR 47 per MWh to EUR 89 per MWh within the same timeframe. By August 2022, the spot price stood at EUR 368 per MWh, with the three-year ahead price at EUR 211 per MWh, to enter a steep decline for the rest of the year. By March 2024 the spot prices returned to the pre-crisis levels they stood at in January 2021, at EUR 53 per MWh. Throughout 2023 and the beginning of 2024 EP5 spot prices were significantly lower than the forward prices in all timeframes – five-year ahead prices stood at 204%, three-year ahead prices at 159%, and two-year ahead prices at 178% of the spot prices in April 2024. This can be explained by the high market volatility and the increased supplier risk experienced during the energy crisis, and may necessitate risk-hedging solutions to break down the electricity prices and long-term energy related costs for households and industry.[43]

Regional trends in wholesale electricity prices

Figure 6 below show the **regional wholesale electricity prices** in the Northwestern Europe (NWE) market coupling area, including CWE, British Isles, Northern Europe, and Iberia.

[43] ACER (2024). Key developments in EU electricity wholesale markets - 2024 Market Monitoring Report

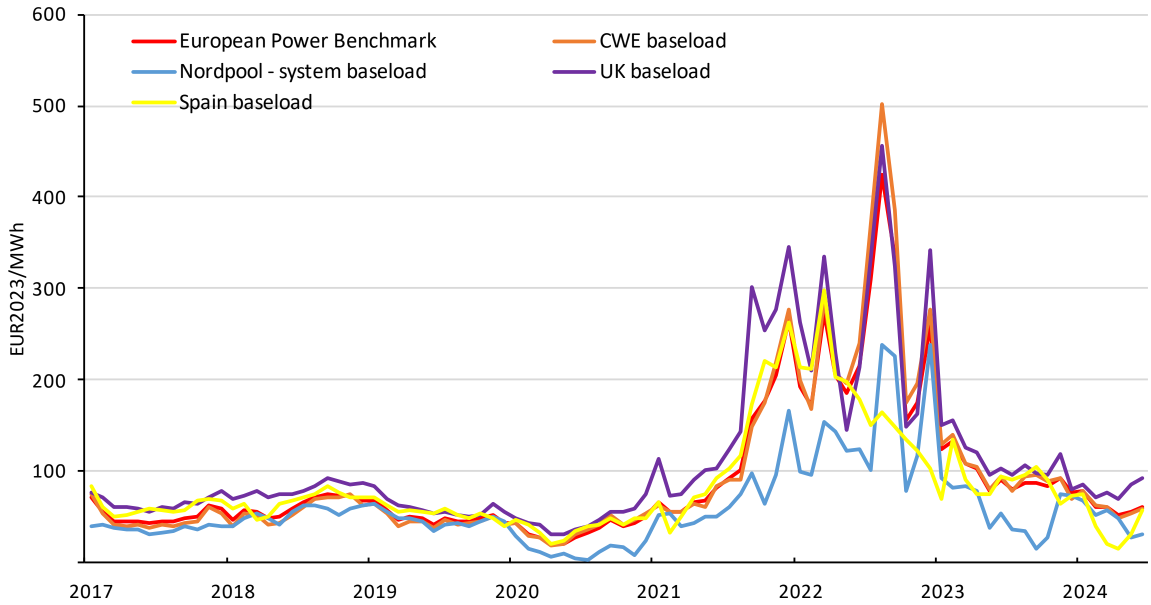

Figure 6: Regional average monthly day-ahead wholesale prices in the North-Western Europe coupled area in EUR2023/MWh.

Source: S&P Platts, ENTSO-E

Wholesale prices for baseload electricity between 2017 and 2020 varied in the EUR 41.5-73.4 per MWh range on the EPB. The UK experienced a significantly higher electricity price-base in the same period, between EUR 47.2 and EUR 113.7 per MWh, whereas the Nordpool market displayed a consistently lower price in the EUR 27.9-63.5 per MWh range. The Iberian market price trended the closest to the EPB, staying in the EUR 38.5-84.2 per MWh price range within the same timeframe. In 2020, all markets went into a decreasing price trend due to the COVID-19 restrictions and the slowdown of economic activity during the lockdowns, which led to substantially lower demand. In this period, the Nordpool spot prices especially were nearing 0 in large parts of the year, while prices in some CWE countries went even below 0 in some hours. The gas supply crisis in 2021 and the following energy crisis in 2022 hit all European markets rather hard.

This figure clearly shows the prices were on the rise between early 2021 and Q1 of 2022 in all markets, with baseload prices sharply increasing in all regions. The turning point was August 2022, when the prices peaked between EUR160-500 per MWh, with the Iberian market displaying the lowest, and the CWE market displaying the highest electricity prices. The Iberian market peaked about 6 months earlier, in March 2022, at EUR299 per MWh. The unusual market trend of reaching peak energy prices in the summer rather than in winter months can be attributed to the effort made by the EU Member States to fill the gas storage capacities in anticipation of the coming winter and further deterioration of relations between the bloc and the Russian Federation. The set mandatory filling goal (80% of technical capacity[44]) was reached successfully in August 2022, and additionally, 90% filling of the technical capacity was reached in October the same year[45]. While this effort provided much needed and strategic security of supply throughout the winter, it also resulted in additional demand and (intra-EU) competition for natural gas, and therefore, momentarily increased gas and also electricity prices in European markets – though it is hard to assess to what extent.[46] This obligation is not scheduled to be lifted before 31 December 2025, and thus expected to remain a factor in electricity

[44] *European Council (n.d.).* *How much gas have the EU countries stored?*

[45] *European Council (n.d.).* *How much gas have the EU countries stored?*

[46] *ACER (2023). (Study on the impact of the measures included in the EU and National Gas Storage Regulations for the European Union Agency for the Cooperation of Energy Regulators*

price formation for at least the coming year.[47] Member States with high gas storage capacities (particularly Austria, Hungary, Latvia and the Netherlands[48]) expressed concerns of being affected disproportionately by the measure, which distorts the market and expects them (the 18 EU-Member States with storage capacity) to buy natural gas in large quantities at peak prices, only to be forced and sell the stored gas to Member States without storage capacities (1/3 of the EU-27) later, potentially at a lower price. In response, the EU introduced a burden-sharing mechanism prescribing the contribution Member States without own storage facilities have to make.[49, 50]

The Nordpool market showed the most resilience in the face of the 2022 energy crisis, displaying the lowest average electricity price, and staying (mostly) below every other index. This is due to the high penetration of renewable electricity generation capacities and hydropower storage in the energy mix, and therefore, least reliance on natural gas.[51] The tendency continued in 2023 as well, when all other price indexes stabilized between EUR90-120 per MWh, whereas Nordpool continued to decline as low as EUR 13.6 per MWh. In the second half of 2023, all markets showed slowly but steadily declining electricity prices. By the end of 2023 and in the beginning of 2024 Nordpool joined the rest of the indexes in the EUR 72-75 per MWh range.

Up until 2021, wholesale electricity prices in the Iberian market slightly exceeded the EPB benchmark. However, in June 2022 the EC approved the Spanish and Portuguese governments' proposal for intervention, and a natural gas price cap was implemented to reduce the volatility on the MIBEL market. This price cap maximized the price of natural gas in the EUR 55-65 per MWh range (which constitutes a 90% price reduction at the peak, compared to the TTF prices, as shown on the graph above).[52] This measure was originally set for 1 year, and scheduled to expire in May 2023 but the Spanish and Portuguese governments extended it until December 2023. This measure shaved the August 2022 peak off on the Iberian market via government intervention. The proposal foresaw an EUR 8.4 billion combined cost of this measure for Spain and Portugal.[53] The Spanish government estimates that the measure saved EUR 5 billion directly for Spanish consumers, with some additional benefits on slowing down inflation.[54] However, the intervention caused some market distortion, which resulted in some unintentional subsidisation, i.e. via increased export of (cheaper) natural gas and electricity from Spain to France.[55]

Figure 7 shows the development of the average day-ahead wholesale electricity price on the CEE regional market (Poland, Czechia, Slovakia, Hungary, Romania, Croatia and Slovenia), compared to the EPB. In the period between 2017 and 2021, CEE electricity prices were already consistently above the EPB levels – but especially in 2019 and 2020, when higher carbon emission prices were imposed (average carbon emission price went up EUR 9/tonne year-on-year in the EU ETS, and reached EUR 25/tonne in 2019[56]), affecting the more coal-heavy energy mixes of Poland[57] and Czechia[58], and pushing the gap between the two indexes to average 30% (EUR 10 per MWh). The 2021 coupling of the 4M MC (Czechia, Slovakia, Hungary and Romania) to the Multi-Regional Coupling (MRC) brought price convergence, and in 2021 and the first half of 2022, the CEE prices and the EPB equalized. However, while the energy crisis hit the whole continent hard, and the prices clearly moved together with the EPB, the peak was significantly higher in the CEE market than the recorded peak of the EPB

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[47] *European Council (2022). Council adopts regulation on gas storage*
[48] *Reuters. (2022). EU countries seek 'solidarity' fix to urgently fill gas storage*
[49] *European Commission (n.d.). Gas storage*
[50] *Gas Infrastructure Europe (2022). Get ready for the winter: A toolkit to master the basics of underground gas storage*
[51] *Riksbank (n.d.). What effect can measures to dampen the electricity price have on inflation?*
[52] *European Commission (2023). State aid: Commission approves prolonged and amended Spanish and Potuguese measure to lower electricity prices amid energy crisis*
[53] *European Commission (2022). State Aid SA. 102454 (2022/N)*
[54] *Center on Global Energy Policy (2023). The Iberian exception and its impact*
[55] *The Oxford Institute for Energy Studies (2023). The Iberian Exception: An overview of its effects over its first 100 days*
[56] *S&P Global (2020). Global carbon markets grow 34% in 2019, led by Europe: Refinitiv.*
[57] *IEA (n.d.). Countries - Poland*
[58] *IEA (n.d.). Countries - Czechia*

(EUR 490 vs. EUR 377 per MWh). The primary reason for this price divergence was the energy crisis which led to scarcity- and competition-driven price hikes of natural gas. Subsequently, electricity generated with natural gas experienced similar price hikes, while the economies relying on coal-based electricity generation (i.e. Poland, that were hit harder in 2019 by the ETS price hikes) experienced somewhat lower electricity prices. However, the overall tendency of the CEE to clear at higher prices than the EPB remained all throughout 2023, when the CEE prices averaged about 12% above the EPB.

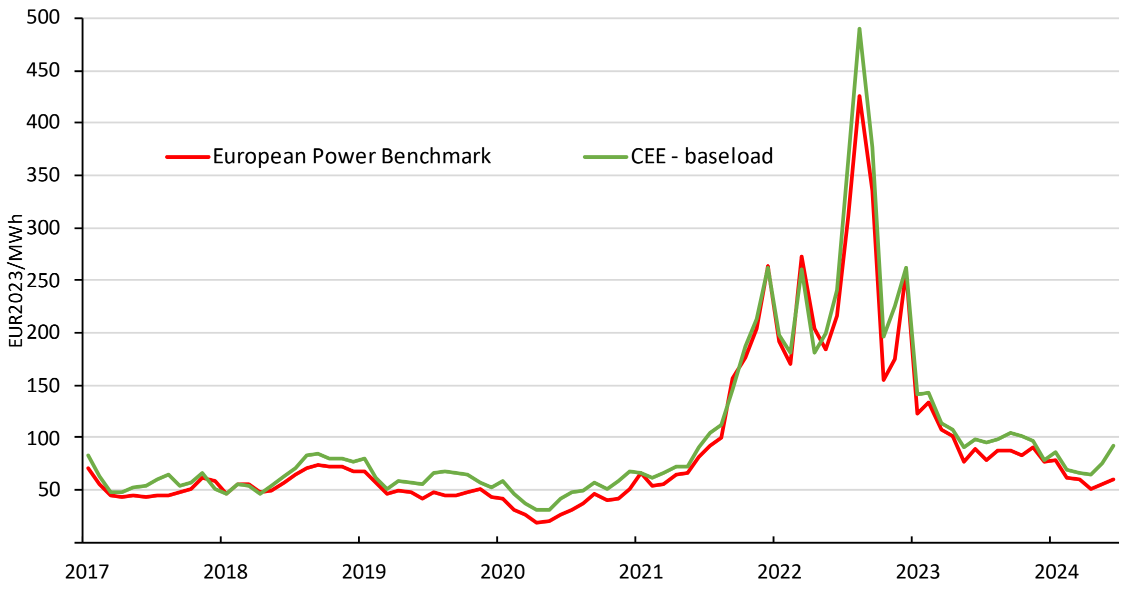

Figure 7: The Central Eastern Europe average day-ahead monthly wholesale price in EUR2023/MWh and the EPB benchmark.

Source: ENTSO-E

Figure 8 shows the wholesale electricity spot prices in Italy, Greece and Bulgaria, in relation to the EPB. While the prices clearly move together, Italy and Greece traditionally display higher wholesale electricity prices compared to the EPB due to their heavy reliance on imported fossil fuels – particularly (Russian) natural gas – in their electricity generation mix. In both countries almost all natural gas is imported, approximately 40% of which from Russia specifically (until 2022).[59, 60] Natural gas is the largest source of energy for electricity generation (by some margin), with hydropower coming distant second in Italy, and only third in Greece. In 2022 the drought, in combination with the gas supply crisis resulted in Italy getting hit harder than the rest of the region, somewhat decoupling the wholesale electricity market prices not just from the EPB and Bulgaria but also from Greece. This can be explained by the larger share of natural gas in the electricity generation mix (48% in Italy vs. 38% in Greece), and the lower share of solar and wind power generation (17% in Italy vs. 35.9% in Greece), the availability of which has a general lowering effect on electricity prices.[61] Consequently, the Italian wholesale market price reached as high as EUR 520 per MWh in August 2022, followed by a sharp decline, just like in the rest of European markets, with a temporary uptick again at the end of the year. 2023 was then characterized by more stable wholesale electricity prices somewhat above the EPB levels (by 20-60%), and still significantly above the pre-crisis prices (by 100-150% compared to pre-energy crisis and pre-COVID-19 levels).

[59] *Friedrich Ebert Stiftung (2023). Energy Without Russia - The consequences of the Ukraine war and the EU Sanctions on the energy sector in Europe - Country Report Italy*

[60] *Friedrich Ebert Stiftung (2023). Energy Without Russia - The consequences of the Ukraine war and the EU Sanctions on the energy sector in Europe - Country Report Italy*

[61] *European Commission (2023). Quarterly report on European electricity markets Q4 2022*

The coupling of the Bulgarian and Romanian markets in October 2021 brought an increased competition and price convergence with the rest of the zone, and – in contrast with the period between 2017-2019) since the beginning of 2023 the Bulgarian wholesale electricity prices are consistently higher than the EPB – although still lower than the Italian and Greek market prices. This is due to the increase in carbon emission costs – the Bulgarian electricity sector still being heavily reliant on coal.[62]

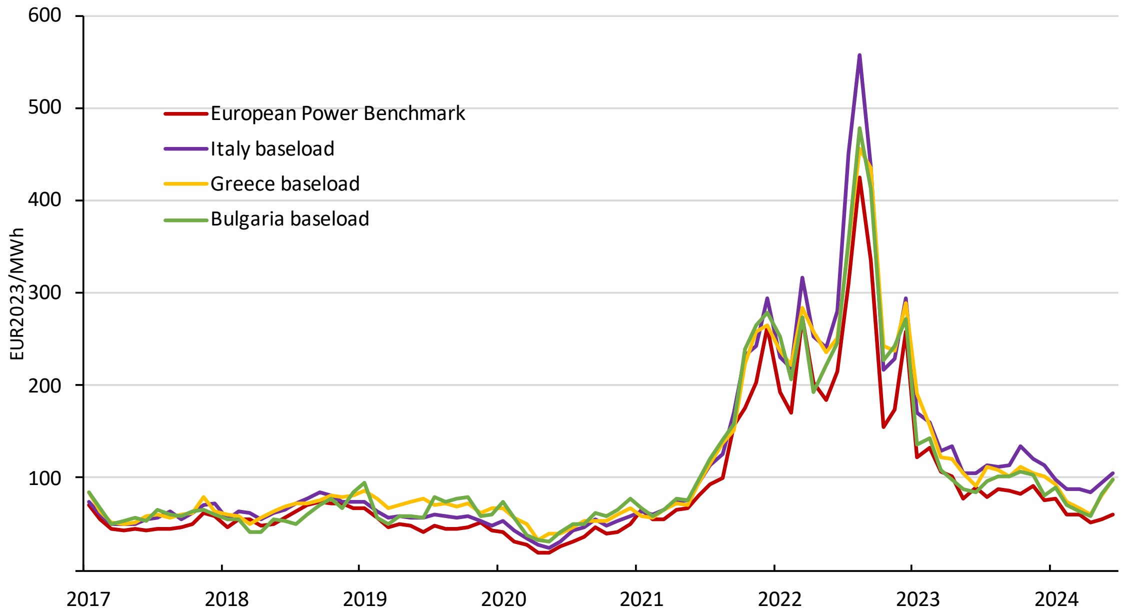

Figure 8: Regional day-ahead spot market prices in Italy and South Eastern Europe in EUR2023/MWh.

Source: ENTSO-E

In the liberalised European energy markets, the wholesale spot price of electricity is set by the merit order mechanism. This means that electricity demand is met by the generators' bids ranked in ascending order, based on their variable production cost. In this model, European electricity prices are in most markets still often set by fossil fuel- (mostly natural gas) based power plants. The EU's decarbonisation effort made natural gas – as a transition fuel from the more polluting coal and oil – the main price setting fuel on the electricity spot markets.[63]

Figure 9 shows the day-ahead natural gas prices on the NL TTF, the main European natural gas trading hub, with the day-ahead electricity prices on the EPB, and how the energy component of household retail prices developed on average in the period between 2020 and 2024. The figure shows the strong correlation between the natural gas and electricity prices on the EPB - when the natural gas supply shortage resulted in the gas price increase in 2021, and then again in 2022, the electricity prices followed the trend immediately. The natural gas prices were partially driven by EU Member States' efforts to meet the new EC 80% storage filling obligation. When in 2023, the European gas demand was met by new LNG contracts, prices started to stabilise at a rate higher than their historical average, together with the EPB electricity price index.

Similarly, the energy component of household electricity prices followed the trend, and reached its maximum in 2022, after which it started to decline slowly, and in 2023 normalised on a significantly

[62] *IEA (n.d.). Countries - Bulgaria*

[63] *58% in Zakeri et al. (2023). The role of natural gas in setting electricity prices in Europe 86% in JRC (2023). The Merit Order and Price-Setting Dynamics in European Electricity Markets*

higher than the pre-COVID-19 and pre-energy crisis level, and stood at 190% of the 2019 average. Relative price fluctuations for households are lower and more gradual though, due to large tax components and pass-through not being immediate for most retail contracts. In absolute price increases, the impact on household retail prices was still very significant. Chapter 3.2.1. on household energy expenditure provides more details on the impact on households.

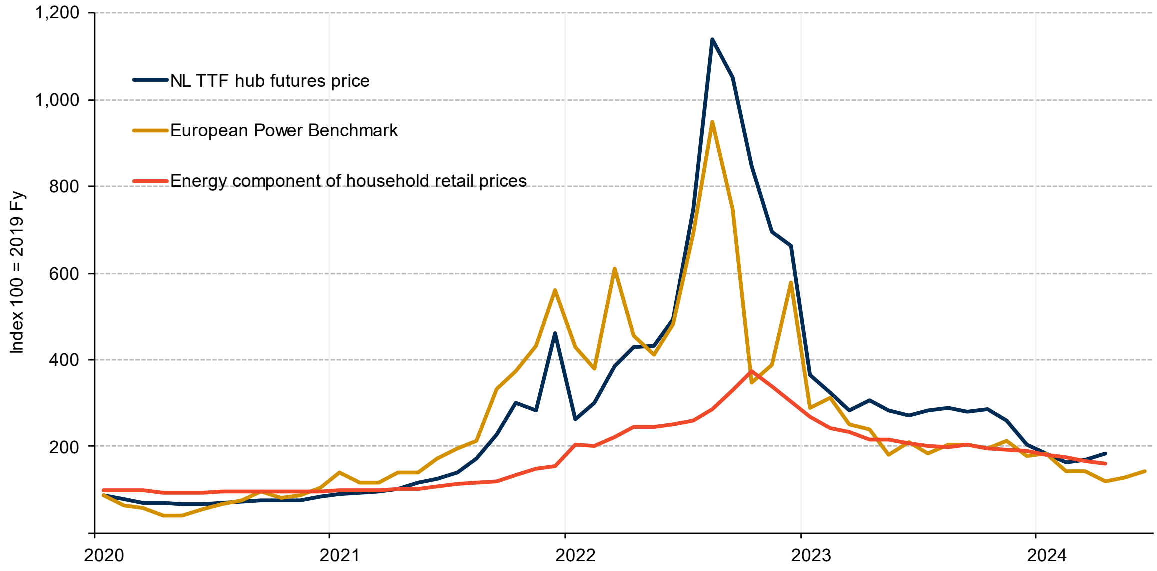

Figure 9: Day-ahead gas prices (NL TTF hub futures), day-ahead electricity prices (European power benchmark) and average energy component of household retail prices development since 2020 (index 100 = average 2019 price).

Source: ENTSO-E S&P Platts VaasaETT

2.1.2. Factors impacting day-ahead wholesale prices

On the liberalised electricity market, the wholesale electricity spot price is determined by the equilibrium of the overall electricity demand and the availability (scarcity or abundance) of supply. This section of the report explores how the demand and supply side factors developed on the EU's electricity market in the investigated time period, and how this equilibrium affected the wholesale market prices.

Demand side factors

In the long-term, electricity demand is continuously decoupling from the gross value-added (GVA) of various economic sectors. Despite the long-term trend of electrification of both industry and households, statistics still show this decoupling to continue. Figure 10 shows the longer-term developments of GVA of various important economic sectors (namely agricultural products, industry, and services) versus changes in electricity consumption in the EU-27. While electricity consumption has remained fairly steady, GVA has grown across all sectors.

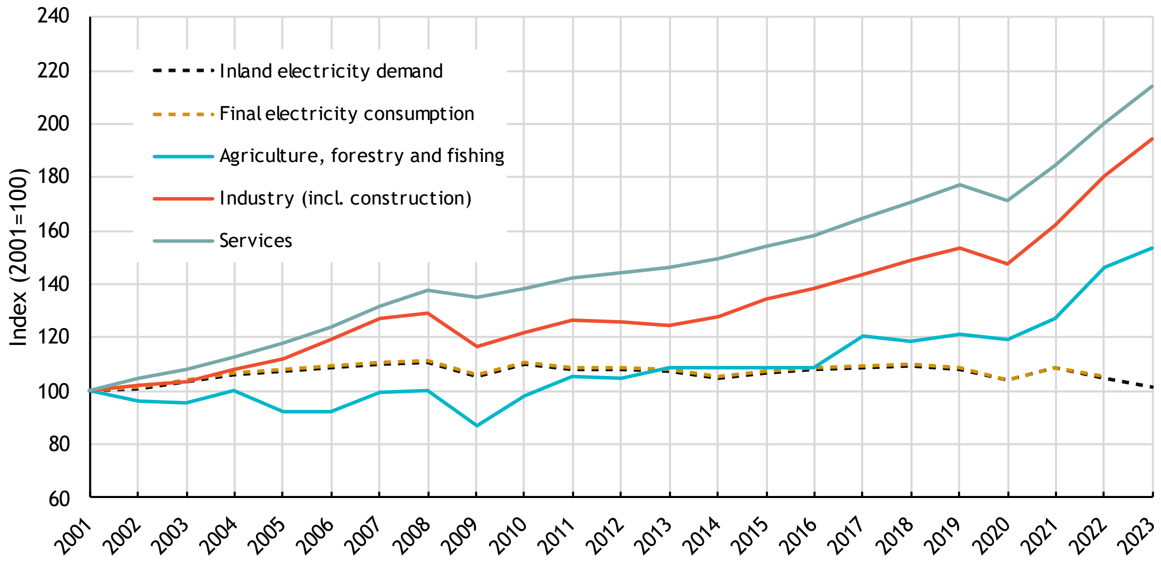

Figure 10: Changes in final electricity consumption and Gross Value Added (GVA) of major economic sectors (2001 values = 100).

Source: Eurostat

The shorter-term impacts of electricity demand on market prices are more significant. Wholesale electricity demand is influenced by a number of factors, such as weather conditions (by both extreme hot and cold weather), development of building stock, industrial activities, macroeconomic factors (such as inflation increasing production costs and reducing output) and geopolitical factors (such as reductions in output due to export limits). In the short-term, consumer behaviour has a weaker influence on market prices: electricity demand still has very low short-term price elasticity[64], meaning that consumer demand does not respond quickly and significantly to price changes.

Supply side factors

On the supply side, wholesale spot market prices in the liberalised European energy markets are mainly determined by the marginal plant (generation or storage asset) in the merit order of market clearing. The structure of total power generation across the EU, therefore, can provide some valuable insights into the trends of prices in wholesale spot markets.

Figure 11 shows the electricity generation mix across the EU. Wind and solar energy generation have continued to grow to 18% and 9% of overall generation in 2023 respectively. The share of nuclear energy decreased from 25% to 22% due to temporary down-times of French plants in 2022 and permanent closures of German nuclear plants in 2023. In 2023, this decrease was partially recovered as some French nuclear plants came back online, with nuclear energy reaching 23% of the overall mix. The remaining generation was provided by natural gas, coal, and other fossil fuels. In 2023, these fuels continued their downward trajectory compared to 2022: solid fuels fell from 16% to 12%, while fossil gas fell from 19% to 17%. Overall, nuclear and renewable energy made up 66% of the electricity mix in 2023, a new record high for the EU-27.

[64] *See for example Hirth et al. (2024). How aggregate electricity demand responds to hourly wholesale price fluctuations.*

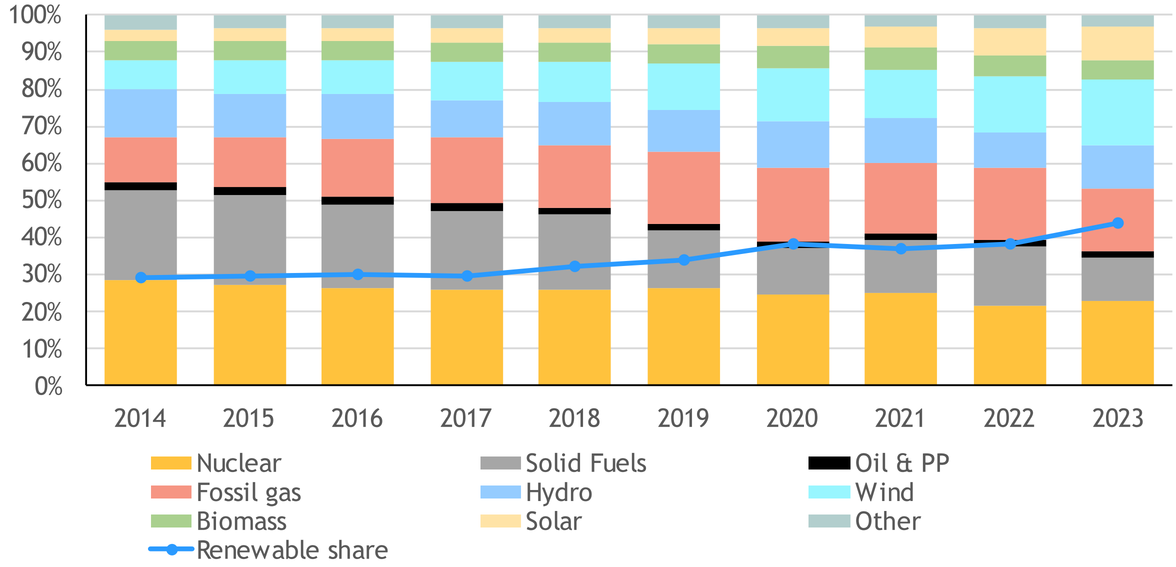

Figure 11: Electricity generation mix in the EU-27.

Source: Eurostat

The growth in renewable electricity generation continues and is supported by EU-level and Member State-level policies aiming for the expanded Fit-for-55 targets under REPowerEU and the Renewable Energy Directive. In the past, various schemes based on, among others, Feed-in Tariffs and Premiums, net metering, green certificates, and contracts for difference (CfDs), have promoted the deployment of renewable energy sources. Following the changes under the Electricity Market Reform, EU Member States are obliged to use two-sided CfDs (or equivalent schemes) when further support is required in the future. In addition, power purchase agreements (PPAs) between large energy users and renewable energy developers are more often used by corporations and public organisations to secure access to clean electricity over long periods of time.

In the past years, coal fired power generation has generally declined in the EU's electricity mix. However, in 2022 the amount of coal based power generation increased to 16% (448 TWh), a 2 percentage point increase from 2021. This coal-based electricity generation mainly made up for the decline in generation from nuclear plants during this period. This was following the need for technical maintenance and repair works of French and decommissioning of German nuclear plants. As French plants came online again in 2023, the share of nuclear generation regained some of these losses, reaching 23% of the EU's total mix.

The annual amount of electricity generation has remained rather constant throughout the past years, except for a noticeable decrease (4% of 10-year average) in 2020 due to the coronavirus pandemic (Figure 12). Seasonal variations in electricity production become more evident in the monthly figures below, such as the high solar energy generation during summer, and high wind energy generation during winter months. Higher temperatures during the winters of 2022-23 and 2023-24 reduced the need for coal- and gas-based power generation (with higher variable costs than other sources). Over the long term, nuclear power generation has declined mainly due to the closure of German plants. The difference is mainly made up by increases in solar and wind energy generation.

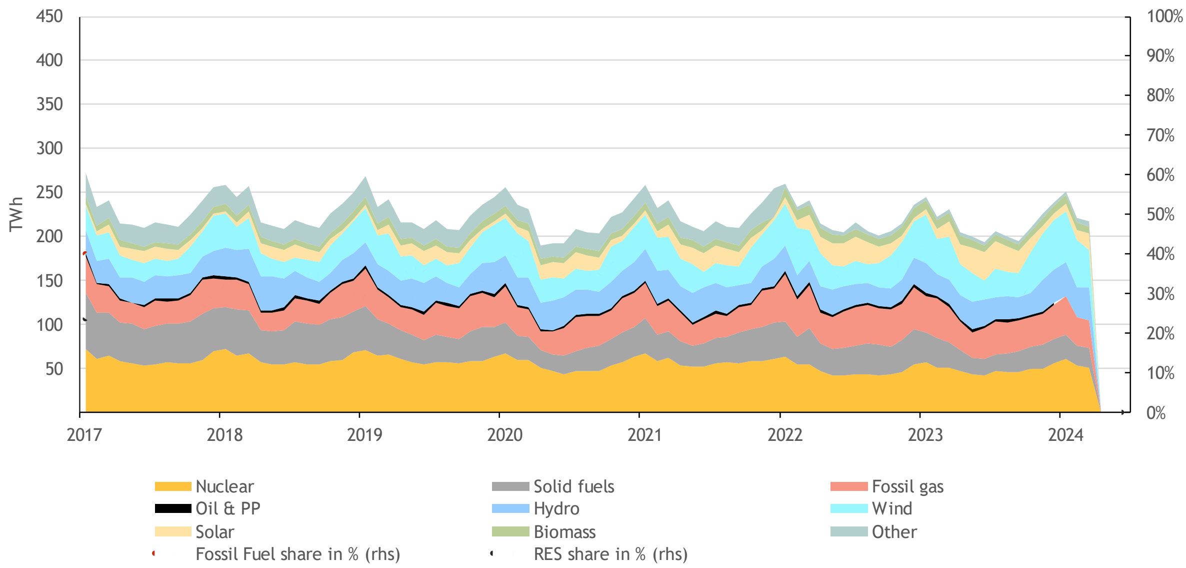

Figure 12: Monthly electricity generation in the EU-27 and the shares of renewables and fossil fuels.

Source: Eurostat

In addition to supply- and demand-side factors, various aspects of the costs structure of generation plants influence the evolution of wholesale prices in the EU. Wind, solar PV, hydropower, and nuclear plants have low variable costs, and bid at low per-MWh prices in wholesale spot markets. Fossil fuel-based generation, on the other hand, requires both fossil fuels and GHG emissions allowances, both of which increase variable costs per MWh of electricity generated. The EU's own fossil fuel production has been in a steady decline, further increasing such costs. In 2023, 85% of the EU's natural gas consumption was met via imports, and only 15% was met by domestic supply.[65] Gas-fired power plants come online when the other plants with lower variable costs are not sufficient, such as during peak periods in winter. In other cases, these plants offer ancillary services (e.g. reserve or balancing power) and congestion management to the system and are supported via capacity mechanisms in some regions.

A significant cost factor for coal- and gas-fired power plants is the ETS allowance price. Figure 13 shows the fluctuation of the EU ETS carbon emission prices from 2014 to early 2024, for both spot transactions and futures (with delivery in the nearest month of December). Considering the very close similarity of spot and futures prices, the report only expands on spot prices in the following text.

In 2017, the historically low and stable ETS prices started to rise again, and by 2019 they reached high levels (around EUR 25 per tonne, where they stabilized until 2020). In the Q1 of 2021, in anticipation of the tightening of the EU ETS cap as part of the Fit-for-55 package (and a simultaneous reduction of the overall allowances volume, and the expansion of the covered sectors)[66], the allowance prices started to rise again. They reached an all-time high in the first half of 2021, and have been hovering between EUR 70- 90/tonne ever since (up to Q1 2024). The rising ETS allowance price drove the energy transition in the desired direction before 2021, with renewables phasing out mostly the heavily-polluting coal and lignite generation plants. However, this tendency changed after the start of the energy crisis. Coal generation plants started to gain ground again due to soaring natural gas prices, and the increase in renewable electricity generation capacities happened at the expense of the relatively cleaner natural gas-based power generation capacities.[67] This tendency was not sufficiently mitigated by the ETS allowance price oscillating between the same 70-90 EUR_{2023}/tonne rate. Prices

[65] *ACER (2024). Analysis of the European LNG market developments - 2024 Market Monitoring Report*

[66] *European Council (2024). Fit for 55: reform of the EU emissions trading system*

[67] *EMBER (2024). European Electricity Review 2024 - Europe's electricity transition takes crucial strides forward*

reached a year-on-year low of 56 EUR_{2023}/tonne in February 2024. More recently, the price has started to climb again, with prices nearing 75 EUR_{2023}/tonne in late May 2024.

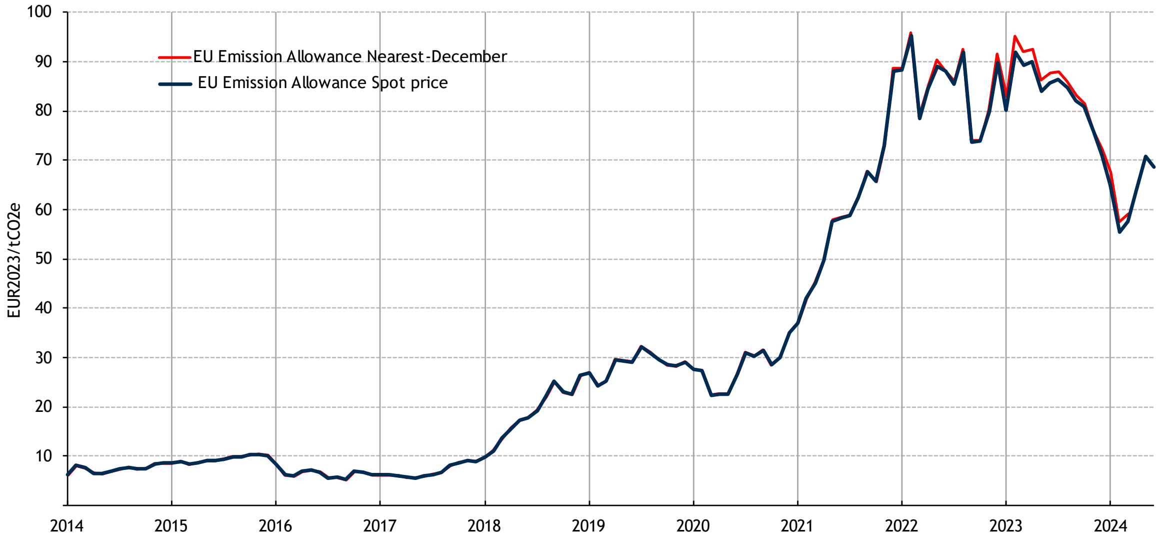

Figure 13 Monthly average EU ETS allowance prices in EUR2023/tCO2e.

Source: ICAP, EEX

Clean spark spreads present another view onto the profitability of gas- (and clean dark spreads for coal-) fired plants.[68] Recent developments in these values are presented in Figure 14. Clean spark spreads have fluctuated for Spanish and German markets during the energy crisis. The significant turmoil in both electricity and gas markets in these regions greatly impacted the profitability of gas-fired power plants. In Germany, the clean spark spread was generally negative over 2023, with an annual average of -8.01 EUR_{2023}/MWh. In Spain, significant fluctuations due to price fluctuations in the two related markets led to massive negative spreads in 2022. In 2023, clean spark spreads were usually in the negative, averaging over the year at -13.85 EUR_{2023}/MWh. In the UK, clean spark spreads over 2023 were also generally positive, on average at 11.22 EUR_{2023}/MWh.

[68] *"Clean spark spread" refers to the net revenue for a generation plant for electricity sale minus the input costs of natural gas and carbon allowance price. "Clean dark spread" refers to a similar concept, but for coal in coal-fired plants instead of natural gas.*

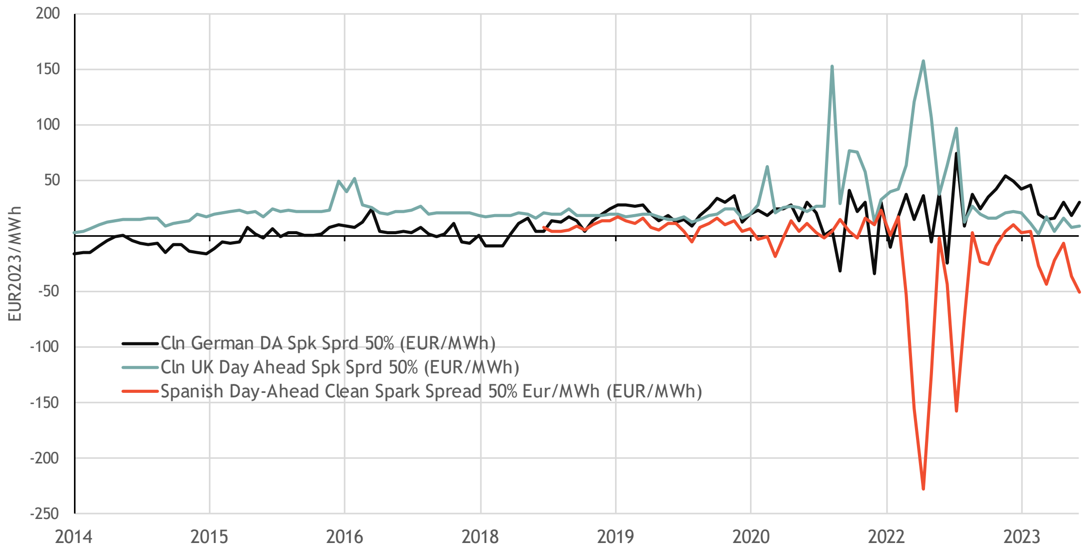

Figure 14: Clean spark spread for German, Spanish, and UK day-ahead markets in EUR2023/MWh.

Source: S&P Platts

Figure 15 shows the electricity flow positions of European regions over the past five years between the beginning of 2019 and the end of 2023. Market logic holds that, absent hurdles, commodity (in this case electricity) should flow from areas with lower prices to areas with higher prices. It is therefore reasonable to conclude that net exporter regions have, in general, lower wholesale prices compared to net importers. The following observations can be made on the different wholesale electricity markets of Europe:

- The **Central Western Europe region** is normally a net exporter, and is the main exporting region within the observed markets. This is due to its diverse power generation, including large nuclear power generation capacity, liquid and interconnected markets enhancing competition and a central geographical position. In 2021, however, technical difficulties and the unusually harsh droughts and higher temperatures throughout the continent caused a high planned and unplanned unavailability of the nuclear power plants in France[69,70], which in turn contributed to breaking this trend and turning the CWE wholesale electricity market a net importer. After the summer of 2022 the trends turned again and by the end of 2023 the export levels of the region (almost) returned to the pre-energy crisis levels, as the technical and market conditions both stabilised.
- The other main exporting region of Europe is **Northern Europe**. The high share of renewable electricity generation, coupled with the large hydro storage capacities shielded this market from the gas crisis and markedly increased its importance in exporting electricity (and gas[71]) to the neighbouring regions over 2022 and 2023. By the end of 2023, however, this trend seemed to have turned, and the export balance dropped to zero again.
- By the end of 2021, the previously net importer **Central Eastern Europe region** turned self-sufficient, and its import-export balance seemed to have stabilised near the zero line.
- **Italy** remains a consistent net importer of electricity from the neighbouring regions, and in this respect does not seem affected by the pandemic and the energy crisis. Similarly, the

[69] *European Commission (2022). Quarterly report on European electricity markets Q2 2022*

[70] *Banque de France (2023). Energy balance in 2022: the crisis in nuclear power generation came at the worst possible time*

[71] *European Council (2024). Where does the EU's gas come from?*

British Isles display a robust trade balance around zero, unaffected by the pandemic and the energy crisis.

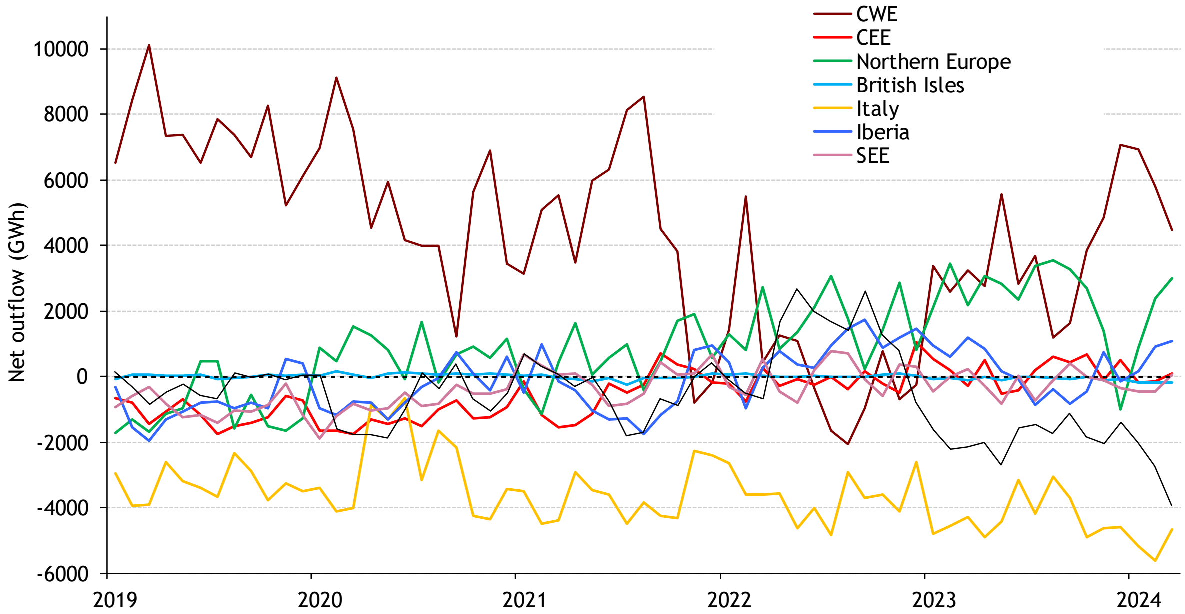

Figure 15: Net electricity flow positions of individual European countries/regions.

Source: ENTSO-E

2.1.3. International comparisons

This section compares wholesale electricity prices development in the EU-27 with its main trading partners. These values give an indication of the energy market price trends of different countries and regions and the competitiveness of energy-intensive industries. Most energy-intensive industries buy a large part of their energy (including electricity) via long-term contracts and on the forward market, with only a small part bought at spot markets. However, data on forward prices and long-term contracts is not available. Still, spot prices can be used as an indicator for relative price differences between regions. A more detailed investigation into the competitiveness of these industries in the EU-27 is conducted in Task 2 of this project.

Figure 16 shows a comparison of wholesale electricity spot prices in the EU with key global trade partners (namely the US, UK, and Japan) from 2014 up to the beginning of 2024.

Even post-Brexit, the UK's electricity prices remain highly interlinked with those of the EU-27, including in recent years. The UK maintains a large and in some cases growing interconnection capacity with nearby EU countries, including Denmark, Ireland, Belgium, the Netherlands, and France. Similar market drivers across these two regions also boost the price convergence between EU and UK electricity markets, such as imports of oil and natural gas (both via pipelines and LNG terminals).

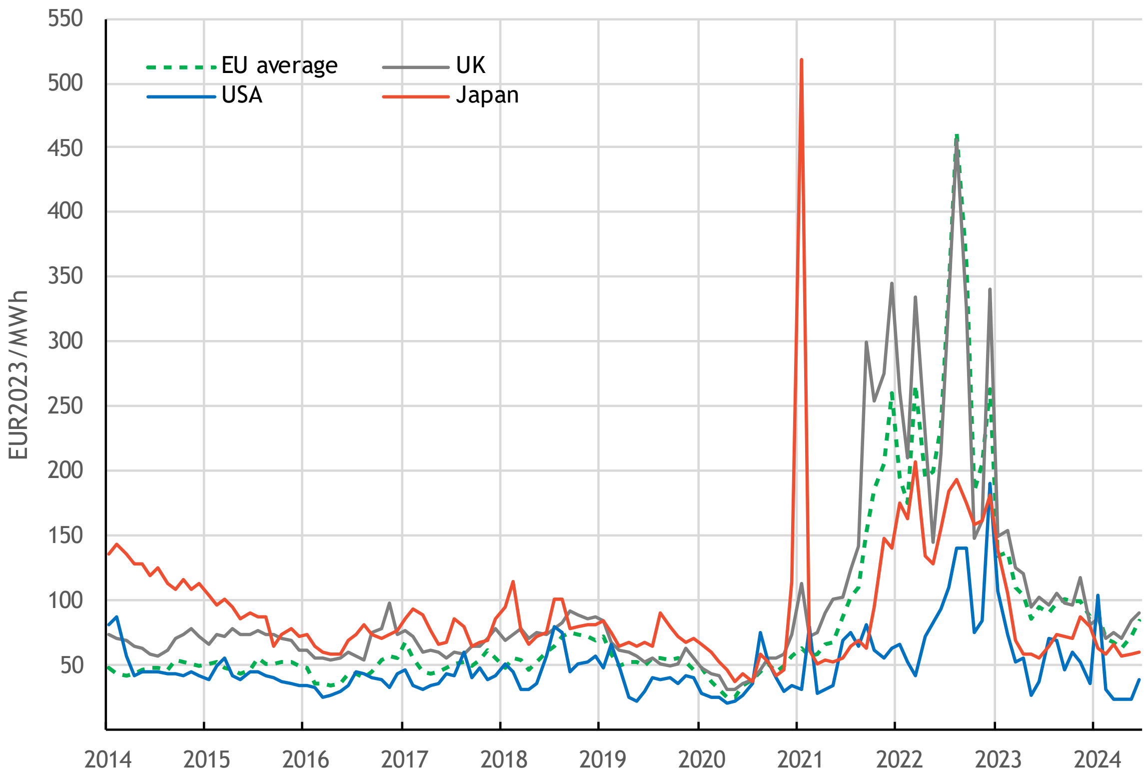

Figure 16: Comparison of monthly average day-ahead wholesale electricity prices in the EU with global trade partners (US, UK, Japan) in EUR2023/MWh.

Source: ENTSO-E, Enerdata EnerMonthly

Japan traditionally displays comparatively high electricity prices, despite low tax rates (contributing to only 2% of the price formation). Partial liberalisation of the Japanese electricity market was introduced in 2016 but regulated electricity prices for household consumers still remain as a(n open-ended) transitional measure, affecting 78% of total consumers. The price formation of electricity in the country, therefore, cannot be explained purely by market forces, and only partially follows market trends. The 2011 nuclear incident lead to increased import of fossil fuels, and contributed to higher electricity prices, which then started to slowly decline back to pre-2011 levels (by 22-23% for industry and households) in 2017.[72] In the beginning of 2021, Japan experienced an unprecedented hike in electricity prices, caused by a congruence of multiple factors. These included the cold weather, the pandemic lockdown measures (and consequently increased demand in residential heating), limited LNG supplies (and higher LNG prices, see further details in Chapter 0 on gas), lower output of solar photovoltaics caused by snowfall and large-scale unavailability of nuclear capacities due to technical reasons.[73] The unusual constellation of challenges on both supply and demand side did not last, and prices swiftly normalised until the 2022 energy crisis hit the country again, causing a similar, albeit lower price increase than in Europe. Breaking with the pre-crisis trend, throughout 2023 the Japanese average day-ahead market prices remained below the EU average and started to converge again only by the beginning of 2024, when both markets reached around EUR_{2023} 65/MWh. This price is still above pre-2022 levels for Europe, but not for Japan.

The USA's wholesale electricity spot market average was at a comparable level to that of the EU in the period between 2014 and 2021. However, structural differences between the two regional energy systems and Europe's fossil fuel import dependence put the observed prices on a diverging path in 2021, with the start of the Russian gas crisis. The structural differences are related to multiple aspects,

[72] IEA (2021). *Japan 2021 - Energy Policy Review*

[73] KYOS (2021). *High power prices in Japan*

including the US's significant domestic production of natural gas and oil, differences in electricity infrastructure and market design, as well as in demand patterns (final consumption). While the US experienced a price spike on the wholesale electricity spot market in 2022 similar to Europe, the peak was far below the EU average (200 EUR_{2023}/MWh in US versus. 450 EUR_{2023}/MWh in the EU). Over the course of 2023 and early 2024, the US price levels decreased to the market average before the crisis, whereas the European prices remained well-above it (35.9 EUR/MWh in the US vs. 65.4 EUR/MWh in the EU in February 2024). The EU's increasing dependence of US-sourced energy products (e.g., LNG, see Chapter 0), which are more expensive than prior pipeline imports from Russia, points to this becoming a lasting change with resulting impact on European economic competitiveness. On the other hand, expected decreases in overall natural gas demand in the EU in the long term will also reduce imports of the most expensive source, in most cases LNG imports, possibly to pre-crisis levels, putting downward pressure on prices.

The next figure (Figure 17) illustrates the evolution of wholesale electricity spot prices in the EU-27 versus Australia, Brazil, Canada, India, Norway, South Africa, South Korea, Switzerland, and Türkiye. These countries have differed quite considerably in the evolution of wholesale electricity prices, and continue to differ in price developments following the energy crisis of 2022.

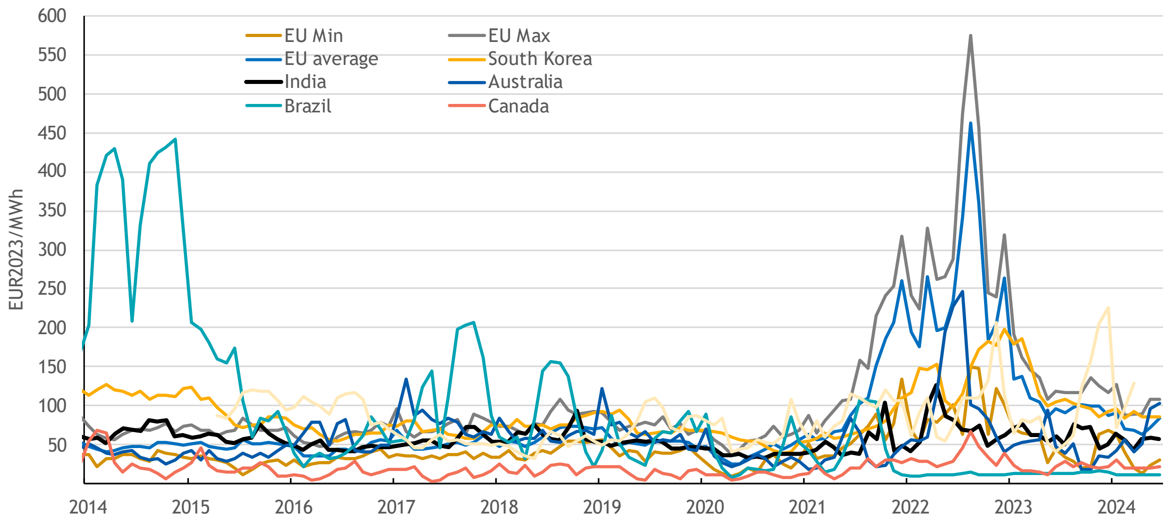

Figure 17: Comparison of average monthly day-ahead wholesale electricity prices in EUR2023/MWh in the EU-27 with global trade partners (Australia, Brazil, Canada, India, Russia, South Africa, and Turkey).

Source: ENTSO-E, Enerdata EnerMonthly

The **Canadian electricity market** proved to be resilient during the crisis, with a low price-base and comparatively minor spike in 2022 (71 EUR_{2023} /MWh in August). Canada's electricity production is heavily reliant on hydropower (above 60% of generation mix in 2022) and has little exposure to natural gas (about 11% of electricity generation mix in 2022). At the same time, Canada is a major oil and gas producer, and also a net exporter of electricity.[74] Due to this, Canadian electricity markets historically clear on a lower price level than their European counterparts, and managed to mitigate the natural gas price driven 2022 electricity price spikes.

The **Indian electricity market** started on a higher price base in 2014, and displayed higher electricity prices until the start of the 2021 gas crisis in Europe, when the EU average electricity price growth outpaced the Indian prices, which – apart from a small spike during the summer of 2022 – remained relatively stable due to their reliance on power plants using locally mined coal.

[74] *Canada Energy Regulator (2020). Market Snapshot: Even though Canada exports a lot of electricity, it imports a lot too*

The **Swiss and Norwegian electricity spot prices** moved in parallel with the rest of Europe. However, the abundantly available hydropower capacities somewhat shielded the Norwegian market at the height of the crisis – settling the Norwegian peak significantly lower, at around 250 EUR_{2023}/MWh, compared to the EU average of 450 EUR_{2023}/MWh. Similar to the EU, the prices entered a rapidly declining trend after the crisis, and by 2024 electricity prices seem to be approaching pre-crisis levels (at 50 EUR_{2023}/MWh in February 2024).

Data on Russia's electricity wholesale market was not available. However, based on literature review, the Russian electricity market seems to display stability, with consistently low prices and very little volatility in the past decade. Despite the sanctions, Russia remains an important fossil energy supplier on the global stage. Russian decision-makers seemingly make little to no effort in decarbonising the domestic electricity production[75] with about 60% coming from coal and natural gas, and only 1% coming from renewables, as of 2022[76]. The Russian occupation of the Eastern-Ukrainian regions generated significant financial losses for the Russian power generators, who in compliance with the Russian government's decision had to start delivering electricity below cost to the occupied regions (where electricity is cheaper). In compensation, the government had to raise the regulated capacity tariff component of the consumer prices in Russia at the end of 2023[77], which can have a noticeable effect on retail market prices in 2024.

2.2. Retail prices

Main Findings

- **Average household retail electricity prices have increased in 2022 and 2023**. This followed significant rises in wholesale electricity prices, which were passed on to consumers with a time delay. Early indications from Q1 2024 indicate that prices across the EU-27 have largely continued at similar levels to 2023 prices.
- **The average energy supply component of household retail prices increased considerably in this period (it almost doubled)**. On the other hand, taxes and levies decreased (by about 30% over 2021-2023), driven by temporary compensation measures taken by national authorities across the EU-27, as well as the removal of renewable levies in some Member States. Network costs remained more or less stable.
- **Household retail prices continue to differ significantly across the EU-27 in 2023**, with some MS having very high (Netherlands: 401 EUR/MWh) and other quite low (Bulgaria: 116 EUR/MWh) prices. Member States also differed greatly in the composition of their prices, with some providing consumption subsidies (in lieu of taxes) to compensate for the increases in the energy supply component.
- **The EU continues to maintain high household electricity prices compared to the rest of the world**. Internationally, prices in Japan, Australia, and Brazil remain closer to those of the EU (while still 20% to 50% lower), while those of other countries can be over 50% lower (e.g., the US). The exception in this case is the UK, which over 2022-2023 had prices well above those of the EU. The UK's prices have since then fallen to close to those of the EU (in Q1 2024).
- **Industrial electricity prices have similarly risen in the EU-27 across 2022-2023** – with less delay following wholesale electricity price increases. For the ID consumption band for example, prices in 2023 remained 97% above their 2014-2020 average.
- **These price increases were primarily due to a massive increase in the energy supply component** (133% growth in 2022-2023 period; ID consumption band). On the other hand, a decline in taxes and levies (50% decrease in 2022-2023 period; ID consumption band), slightly

[75] *EMBER (2021). Global Electricity Review G20 Profile - Russia*
[76] *U.S. Energy Information Administration (2024). Russia*
[77] *S&P Global (2023). Russia sets additional increase in some nuclear electricity rates*

offset the price increase. Network costs for industrial users also remained stable over this period.

- **Industrial end user prices have diverged significantly across the EU-27 in the 2022-2023 period**. Different price interventions were activated at different times by different countries, leading to a larger range of prices across the EU in early 2024, for both the ID and the IF consumption band.
- **Industrial end user prices in the EU are relatively high in the global comparison**, affecting the competitiveness of EU industry. Prices in the UK have substantially increased (304 EUR_{2023}/MWh) and remain above EU levels (149 EUR_{2023}/MWh in Jan 2024), while those of Japan are at comparable levels (134 EUR_{2023}/MWh). For the US, Canada, and Türkiye, prices are much lower (74.3, 92.4, and 76.4 EUR_{2023}/MWh, respectively).

Box A - Sectoral split of electricity consumption

Households accounted for 28% of the total EU-27 electricity consumption in 2022; the most recent year for which data is available. This is similar to the multi-year average, which is around 28-29%. There are large differences in shares between Member States though. The share of electricity consumed by industrial users dropped from its pre-pandemic multi-year average of 37% to 35%. Commercial establishments and public institutions maintain a consumption share of 29%. The same applies for the transport sector, which continues to account for 2% of the total electricity consumption, primarily for rail transport.

2.2.1. Household electricity prices

This analysis covers the prices (including energy supply costs, network costs, taxes and levies) paid by household electricity consumers. The weighted average for the EU-27 for the DD consumption band (covering an annual consumption between 5000 and 15000 kWh) is first analysed (details about consumption can be found in the methodology section. Next, a comparison of reporting countries based on the most representative band is also included. In this case, all Member States (and selected non-EU countries) are represented by the consumption band accounting 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.

The household electricity retail prices of the DD consumption band showed relative stability between 2014 and 2020 – oscillating between 234 and 264 EUR_{2023}/MWh, showing about 10% YOY change in this period. 2021 brought a noticeable, 5% jump in prices, followed by more increases in 2022 (7% YOY) and 2023 (4% YOY). This can be observed on Figure 18 (left).

In the period preceding the 2022 energy crisis a clear tendency of gradually increasing share of state-imposed contributions can be observed in the household retail price structure – with taxes and levies contributing as much as 44% by 2019, as shown in Figure 18 (right). However, this trend turned noticeably in 2021, when the energy and supply (or 'commodity') cost share of electricity prices rose to 38% (from 32% in 2020), and continued to rise in 2022 and 2023, reaching 57% in 2023, dominating the price composition. At the same time, the share of taxes and levies shrank both in absolute and relative terms thanks to multiple national governmental interventions to mitigate the burden on households, as well as the abolishment of renewable levies in large MS such as the Netherland and Germany in 2022 and 2023, which now financially support renewables via the State budget instead. Still, in 2023 the share of taxes and levies remained a substantial part of retail electricity prices in some EU Member States (e.g. in Denmark), whereas the governmental interventions resulted in a negative share in some other Member States (e.g. in the Netherlands, Austria, Ireland and Luxembourg), where the cuts and tax credits surpassed the average commodity cost.[78] These changes are further discussed in the section where cross-Member State comparisons are presented.

Network costs have shown a slightly declining trend between 2014 and 2021, while representing a relative share in the electricity price between 24% and 27%. Overall, the network costs' relative share in the household electricity prices declined to only 21% in 2023.

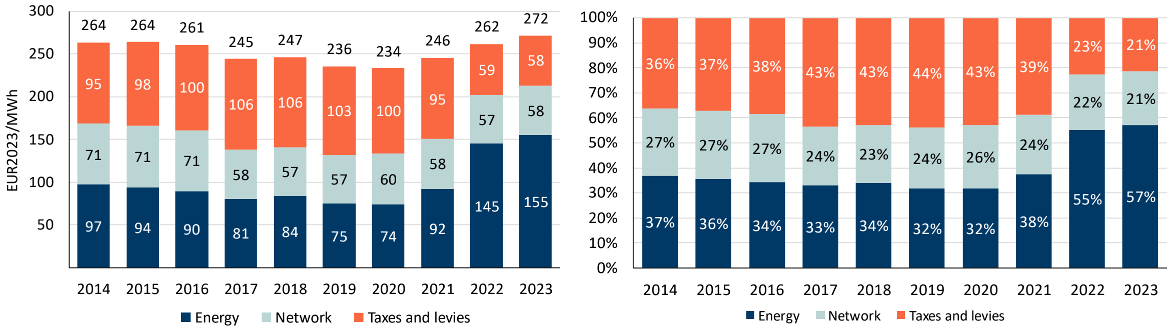

Figure 18: Evolution and composition (left) and relative composition (right) of the EU household electricity price in EUR¬2023/MWh (DD band).

Source: DG ENER in-house data collection, Eurostat

Composition of taxes, levies, fees and charges

Taxes (including VAT) and levies on electricity consumption of households are applied by EU Member States to gather revenues for various goals. Taxes and levies represented a significant, in some years main, share in retail electricity prices, but in recent years this share has dropped considerably in comparison to other cost components (at 21% of total costs in 2023). Taxes and levies can be further broken down into six subcomponents: VAT, renewable energy levies, capacity taxes, environmental taxes[79], nuclear taxes and other charges. As EU Member States have a certain level of freedom in applying taxes and levies in their national legislation, these subcomponents are less uniform throughout the EU-27 than the other two main components of retail prices. Further explanation can be found below, and Figure 19 shows the evolution of the EU average levels of these components of taxes and levies in household retail electricity prices.

[78] *Qery (2024). Consumer Energy Prices in Europe: Electricity Prices for Households*

[79] *This category includes general energy taxes, which are typically classified as having an environmental purpose*

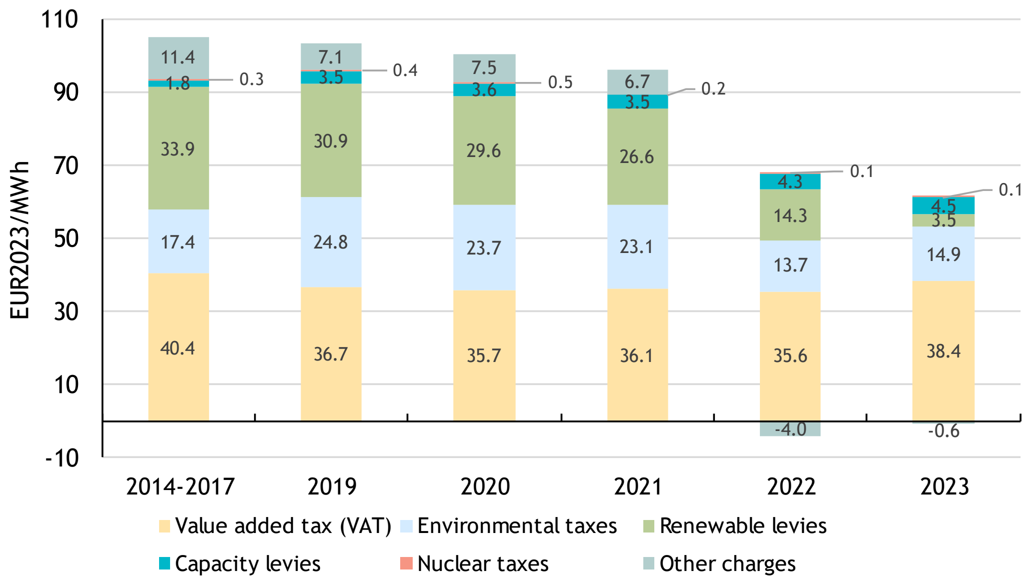

Figure 19: Evolution of taxes, levies and charges in the electricity bill for EU households in EUR2023/MWh.

Source: DG ENER in-house data collection, Eurostat.[80]

- **Value added tax (VAT)** is the most common component being applied in EU countries. It is a general form of taxation, in principle applied to all commercial activities involving the production and distribution of goods and services. The EU VAT Directive explicitly allows Member States to apply reduced rates to electricity.[81] As a result, electricity VAT rates in the EU range between 5% (in Malta) and 27% (in Hungary)[82] and the VAT represented in 2014-2023 at EU level on average 15-19% of the overall electricity bill. 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. The share of VAT in overall taxes and levies for households has slightly grown in recent years, representing in 2023 about 63% of all taxes and levies.
- **Environmental taxes** are levies raised by the state on assets or activities that have an expected negative impact on the environment. Environmental taxes on energy form about three-quarters of the total environmental taxes collected in the EU[83] but with great variation – going from about 50% in Malta to about 93% in the Czech Republic (up to 2020).[84] This sub-component includes any manifestation of excise duty, environmental, greenhouse gas emission, transmission and distribution taxes, excluding VAT. Their common characteristic is that the state revenues generated by these taxes are not earmarked to energy-, climate- or environment-related policies, meaning that they flow into the central budget.[85] Similar to VAT, environmental taxes are levied in all 27 EU Member States.[86] They make up the second most significant part of the taxes and levies component of the retail electricity price,

[80] *Note that the major reduction of renewable levies in 2022 is the result of the abolishment of several levies in large MS (Netherlands, Germany) where renewable subsidies are instead now funded by the general State budget.*

[81] *Official Journal of the European Union (2003). Council Directive 2003/96/EC of 27 October 2003*

[82] *European Commission (2021). VAT rates applied in the Member States of the European Union*

[83] *Eurostat (2024). Environmental tax statistics*

[84] *Famulska et al. (2022). Environmental Taxes in the Member States of the European Union - Trends in Energy Taxes*

[85] *Publications Office of the European Union (2024). Study on energy prices and costs - Evaluating impacts on households and industry: 2023 edition*

[86] *Famulska et al. (2022). Environmental Taxes in the Member States of the European Union - Trends in Energy Taxes*

representing 25% of total taxes and levies in 2023. Environmental taxes peaked in the EU in the 2019-2021 period, at around 23 EUR_{2023}/MWh, but have declined significantly to 15 EUR_{2023}/MWh in 2023.

- **Renewables levies or energy and energy efficiency levies** are the state-imposed levies collected for the specific purpose of subsidising the expansion of renewable energy generation capacities. These are classified in Eurostat as renewable taxes. This sub-component, therefore, includes any financial burden levied on electricity consumers, aimed at supporting wind and solar power plants, combined heat and power generation (CHP), biomass, etc. Renewable energy levies were applied in most EU Member States, except the MS[87] below:
  - **Germany and the Netherlands**, whereas of 2022 (Germany) and 2023 (Netherlands) the levy was abolished and the renewable energy subsidy (EEG for DE and SDE++ for NL) is instead now paid from the general State budget.[88] [89]
  - **Finland and Malta**, where 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.
  - **Hungary**, where household electricity consumers, unlike their industrial counterparts, are exempted from renewable energy surcharges,
  - **Bulgaria**, where no renewables levies are imposed on households.

  Renewable energy levies shrank dramatically in 2022 and 2023, most notably due to the abolishment of levies in major MS such as Germany and the Netherlands, as mentioned above. While in 2021 and prior years, these taxes made up about a quarter to a third of all taxes and levies, in 2023 they made up only 6%, or 3.5 EUR/MWh in real value.
- **Capacity levies** include any charges that are levied for ensuring adequate generation, storage and demand response capacities in the power system. This category includes taxes, fees, levies or charges related to ensuring power system adequacy, 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 levies were applied in 12 Member States in 2023. While the impact of these charges has been growing in past years, it is still limited compared to other taxes and levies, at about 7% of the total taxes and levies. Nonetheless, the impact can be quite large in some countries with higher capacity levies, such as Slovakia (27 EUR/MWh) and Germany (10 EUR/MWh).
- **Nuclear taxes** cover all levies collected to subsidize the nuclear sector, and its related activities – including decommissioning of power plants, and handling of nuclear waste. Only 12 of the 27 EU Member States operate nuclear power plants.[90] Nuclear taxes are collected only in Slovakia. Their impact on the electricity retail bill is hence negligible at the EU level.
- The **other charges** category includes all other taxes, fees, levies or charges not covered by any of the previous five categories, such as levies to support 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 -0.6 EUR/MWh in 2023, this component has now turned into a subsidy, mainly through retail

[87] *It is important to note that even in these cases electricity consumers still indirectly contribute to the support of renewable energy as they are also taxpayers. In several countries, renewable energy is supported also from other sources than taxes on consumer bills.*

[88] *Bundestag (2022). Renewables Levy Abolished.*

[89] *Tax Authority NL (2023). ODE tariffs Netherlands.*

[90] *World Nuclear Association (2024). Nuclear Power in the European Union*

market interventions aimed at reducing the impact of energy cost increases on household consumers.

Nuclear taxes specifically represented a marginal share in the taxes and levies component of the electricity price in Europe within the past decade. Some other components, like the VAT and the environmental components, play both a significant role, and represent a relatively stable share in the taxes levied in Europe – whereas the renewable energy levies have been in a clear decline especially since 2021, and by 2023 they play a marginal role on average as well. This trend was further accelerated by the 2022 abolition of the EEG surcharge in Germany. [91]

Situation in individual Member States

Figure 20 presents household retail prices in the DD consumption band across the EU Member States in 2023. Following from the retail market interventions in 2021-2022, there were significant differences in the price compositions across EU Member States. Many countries instituted subsidies (via premiums or changes in tax and levy instruments) to alleviate the impact of wholesale price increases on retail prices. Consequently, many countries presented very low or even negative taxes and levies (i.e., rather consumption *subsidies)* for electricity for households, including Ireland (66 EUR/MWh subsidy in 2023), Portugal (40 EUR/MWh subsidy) and Greece (37 EUR/MWh subsidy). The Irish case is particularly notable, where the consumption subsidy mitigated the exposure of retail prices (via the "Energy and supply" component) to the high wholesale market prices (339 EUR/MWh in 2023.

The impact of some interventions in the retail markets has since 2023 reduced or in some cases disappeared. For example the Dutch tax subsidy of 27.9 EUR/MWh in 2022 has changed to a tax of 113 EUR/MWh in 2023 on average after the temporary measures were lifted. This change brings the tax to its prior levels before the energy crisis.

Similar to previous years, there is still a great difference in prices for household customers across Member States. CWE region countries maintain (mostly) high electricity prices, while those of Eastern Europe are (mostly) lower. In 2023 the Netherlands has the highest retail market price of 401 EUR/MWh, where Bulgaria's prices are the lowest in the EU at 116.4 EUR/MWh.

[91] *German Federal Government (2022). Renewables levy abolished*

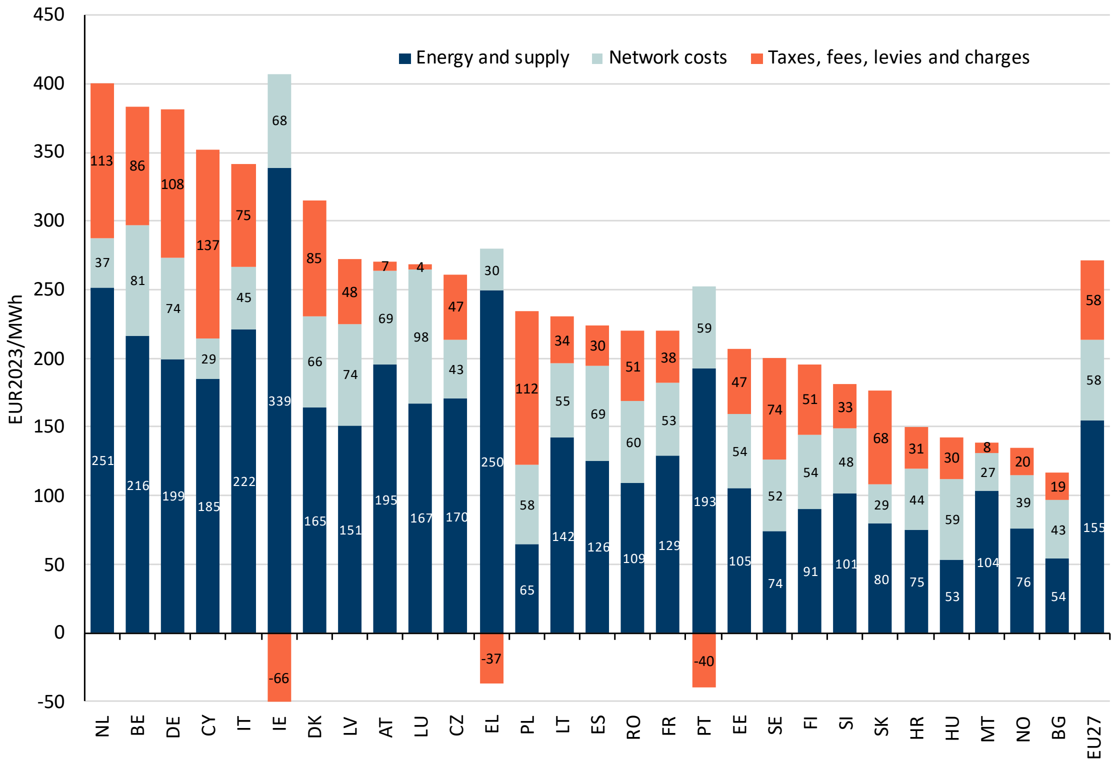

Figure 20: Household electricity prices in 2023 in EUR2023/MWh (DD consumption band).

Source: Eurostat.

The household price trends in the different Member States across time can also be seen in Figure 21. Many countries showed a diversity of price movements (and policy interventions to limit these) in the late 2021-2023 period. Generally, prices have meanwhile settled again and similar trends as previous years define the inter-Member States comparison.

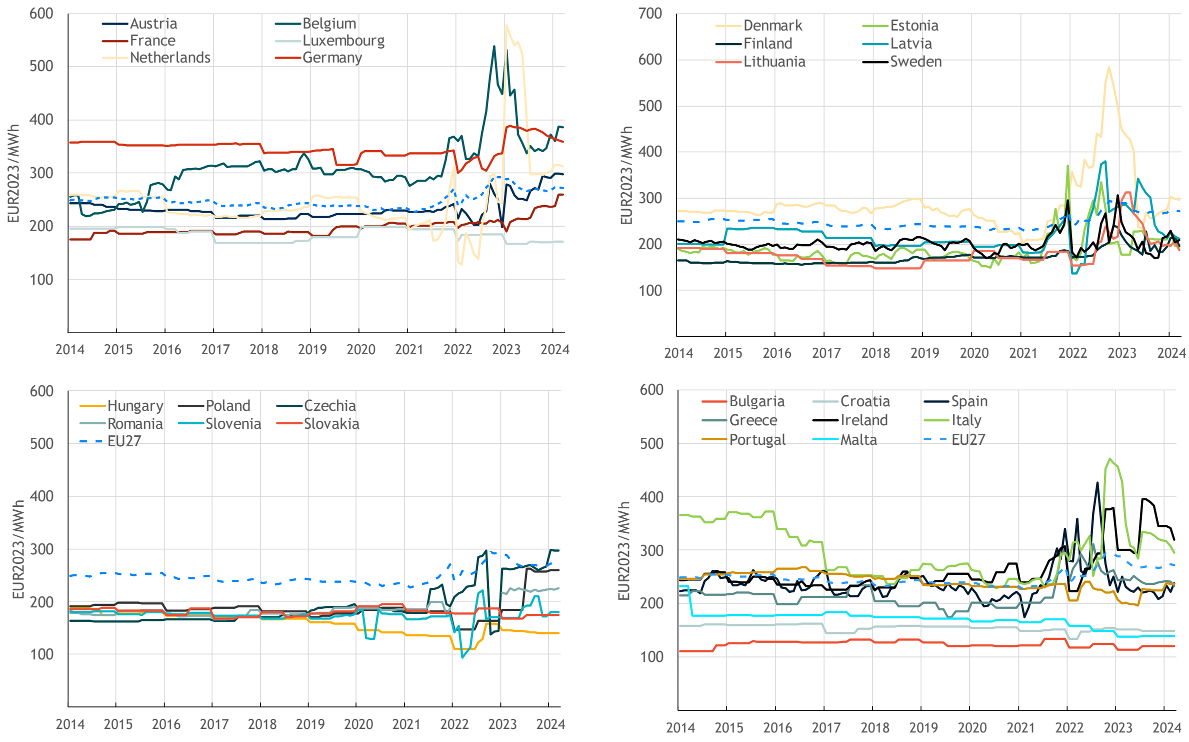

Figure 21: Average household retail electricity prices (DD band) in the EU, Jan 2014-Mar 2024, for select countries in CWE (top left), Northern Europe (top right), CEE (bottom left), and South European countries (bottom right).[92]

Source: Eurostat.

The composition of household electricity prices in 2023 has changed considerably compared to the pre-crisis period. The impact of taxes and levies on driving energy costs has reduced considerably. Changes in EU-27 averages were discussed in prior sections, and most notable information here are the significant reductions of taxes and levies in some countries, namely Denmark and Germany. While the average impact from taxes and levies has substantially decreased, there is still significant variation across the EU Member States in terms of how different price components impact the overall electricity price for households.

The correlation between day-ahead wholesale market prices and the energy component in retail prices was in 2022-2023 relatively lower than in the pre-crisis period due to national price interventions. More details on this can be found in the special chapter on price pass-through. Figure 22. 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 2023. Many factors influence the procurement cost of electricity for energy suppliers, and thus the retail prices they offer to households. These factors include their level of vertical integration, forward wholesale prices in the previous year(s), spot market prices, hedging strategies and related risk premiums, consumption/prosumption profiles of their customers portfolio, supply contract types (fixed/variable/dynamic prices) and duration, balancing costs, various forms of price regulation, and exchange rates.

[92] 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.

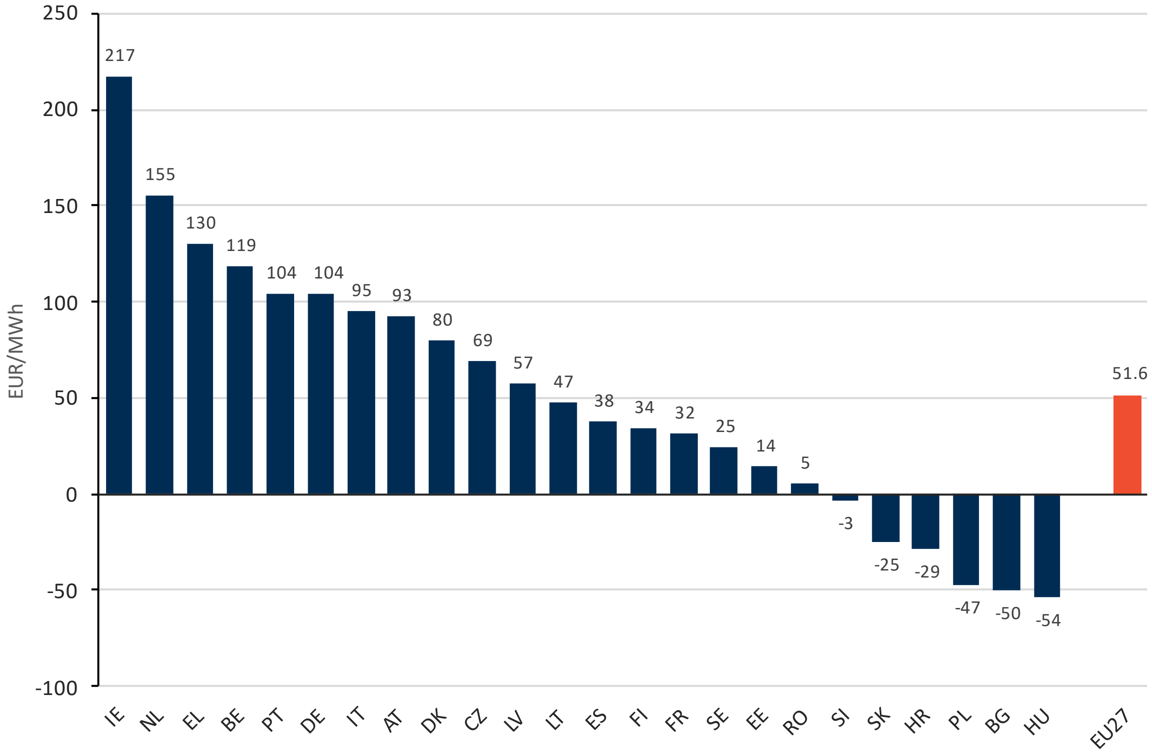

Figure 22: Difference between the energy component of household retail prices and average day-ahead baseload wholesale prices in individual markets in 2023 (DD consumption band). A positive price means household prices are higher than wholesale prices.

Source: Eurostat, S&P Platts, ENTSO-E

Prior editions of this report showed that the energy component of retail prices was higher than day-ahead wholesale prices in all countries. This is expected, as retailers have to cover additional costs (from balancing activities, administrative costs, and hedging premiums, among others). In 2021, the situation changed, and retail prices were in some countries lower than day-ahead market prices, indicating a possible shortfall of revenue for energy suppliers. Suppliers in countries with strong retail price regulation were especially affected, such as Hungary and Croatia. Bankruptcies of energy retailers were quite common in some markets, leading to a reorganisation of retail markets in many Member States in the 2020-2023 period.

This situation has improved in 2023, for both retail and wholesale prices. As Figure 22 illustrates, the energy supply component of retail prices was in most countries higher than the day-ahead wholesale market prices. On average, across the EU-27, this price difference amounted in 2023 to 57.4 EUR/MWh, which is about 37% of the energy supply component of retail prices. In some Member States, particularly those in Western Europe, retail prices are highly inflated compared to wholesale prices. Other markets, such as those with strong retail market regulations, still maintained in 2023 retail prices below wholesale spot market price, i.e. in Bulgaria, Hungary, Poland, Croatia, Slovakia, and Slovenia.

Box B - Definition of the most representative band.

As mentioned in the methodology section, 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 consumption level at which most electricity is sold. While the DD 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), 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 iterations of this report.

- DB band: LV, LT, PL, RO (1000 to 2500 kWh/annum): very limited use of electricity for heating and cooling.
- DC band: DE, BE, DK, IT, NL, ES, EL, PT, HU (2500 to 5000 kWh/annum)
- DD band: CY, IE, AT, LU, CZ, FR, EE, SI, HR, MT, BG (5000 to 15000 kWh/annum)
- DE band: SE, NO, FI (15000 kWh/annum or over): high use of electricity for heating.

Looking at household electricity prices in the most representative band per MS gives an indication of the most relevant prices for households in each MS. In most countries, this was the DC or DD consumption band, and in a few countries the DB band (1000 to 2500 kWh/annum; examples include Latvia and Poland) or the DE band (15000 kWh/annum or more; examples include Finland and Sweden). In most cases, the energy price component for the most representative band was not significantly different from that of the DD band; for some MS, these price levels were higher (such as in Latvia, where the energy and supply component for the DD band is 64 EUR/MWh lower than for the DB band) while for other MS, these values were lower (such as in Romania, where the energy component in the DD band is 55 EUR/MWh more expensive than in the DB band). The fact that the energy component prices in Latvia and Romania are higher in the DD band than in the DB band, is not in line with usual market practices but may be related to specific price regulation.

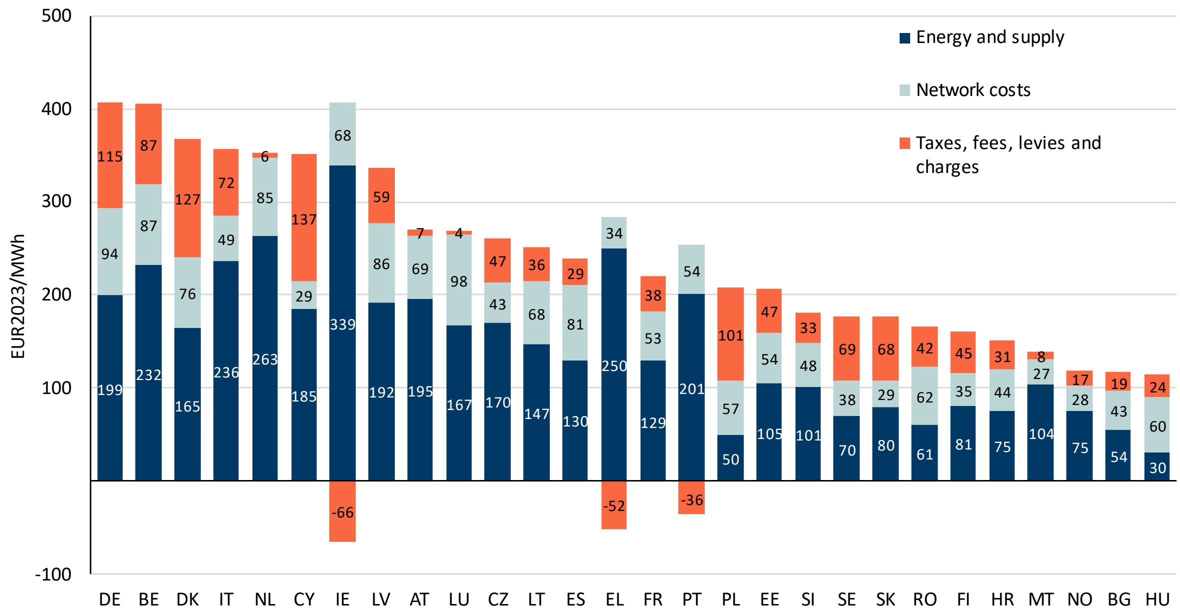

Figure 23: Household electricity prices in 2023 in EUR2023/MWh (most representative band).

Source: Eurostat

International comparisons of household prices

The figure below (Figure 24) shows comparisons of household retail prices of EU-27, Japan, the UK and the US. These prices in the EU have historically been close to that of Japan, while remaining above that of the USA and the UK. More recently, Japanese prices have stabilised at lower levels than the EU, namely at 183 EUR_{2023}/MWh in March 2024. The prices in the UK have over the course of 2022 risen to well above EU prices, reaching a maximum of 465 EUR_{2023}/MWh. Over 2023, they have dropped to be close to EU prices in early 2024. The US's prices remain well below the retail prices of the aforementioned countries.

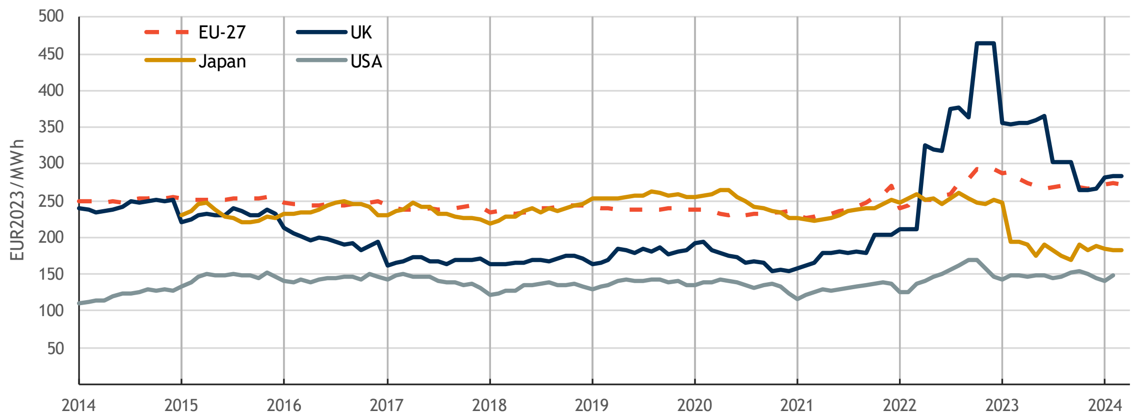

Figure 24: Household retail electricity prices in EU-27 (DD band), USA, UK, and Japan, 2014 - Q1 2024 in EUR2023/MWh.

Source: Eurostat, Enerdata EnerMonthly

Price comparisons with other major nations can also indicate how prices in the EU compare in an international context. Figure 25 presents this comparison over the past years for a few countries. For some countries, data was available only on an annual basis. The EU's retail prices for households, has, since late 2019, remained firmly above those of all other analysed countries. Australia and Brazil maintain somewhat elevated retail prices, with prices in 2023 at 208.8 EUR_{2023}/MWh and 155 EUR_{2023}/MWh, respectively. Prices in other countries have remained far below those of the EU, and have remained at low levels throughout the 2022-2023 period. It is worth however noting that purchasing power varies greatly among these countries, with the EU maintaining a very high level. Thus, comparisons of energy affordability based on this data face this caveat.

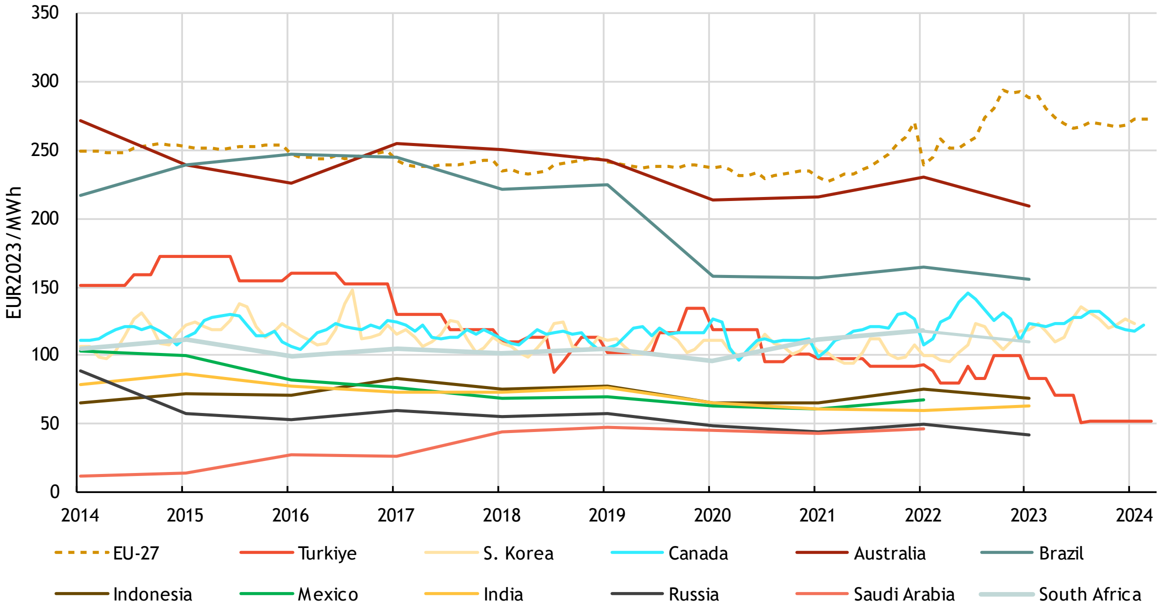

Figure 25: Household retail prices in EU-27 and other G20 countries, 2014-Q1 2024 in EUR2023/MWh.

Source: Eurostat, Enerdata EnerMonthly

2.2.2. Industrial electricity prices

The following section analyses prices paid by non-household electricity consumers at EU (average) and Member State levels, examining prices of the Eurostat ID band covering annual consumption of 2 000 - 20 000 MWh. This band can be considered representative of commercial and small industrial electricity users across many sectors of the economy, and will be referred to as "small industry" in the following text. Price trends in the IF band (annual electricity consumption between 70 000 - 150 000 MWh) are also analysed, which is more representative for large enterprises and energy-intensive industries. These will further be referred to as "large industrial" users. Details on the main industries considered in the ID and IF bands can be found in Chapter 5.

Evolution and drivers of industrial electricity prices in the EU

Before the energy crisis, industrial electricity prices (for the ID band) were at relatively stable levels of around EUR100/MWh (Figure 26). Following price increases in gas markets in 2021-2022, and resulting electricity wholesale price increases, industrial prices rose quickly to unprecedented levels. In 2022, prices reached on average EUR_{2023} 199 /MWh, i.e. a growth of 45%. Prices in 2023 remained very high at EUR_{2023} 197 /MWh.

Unlike household prices, industrial electricity prices are presented exclusive of VAT, since VAT is recoverable for most industrial consumers. Thus, these prices are driven more by electricity wholesale market prices and network charges. This impact can be seen clearly in the last 2 years, with a massive growth in the share of the energy and supply price component (121% growth from 2021 to 2022) in the overall electricity prices. Some impact is also seen from reductions in taxes and levies (34% decline from 2021 to 2022).

Following these trends, the energy price component represented in 2023 well over half of the overall electricity costs for industrial consumers in the ID band (75% in 2023). Network charges' share has shrunk to represent 14% of costs in 2023 (from about 30% in prior years), while taxes and levies in 2023 represented only 11% of overall costs.

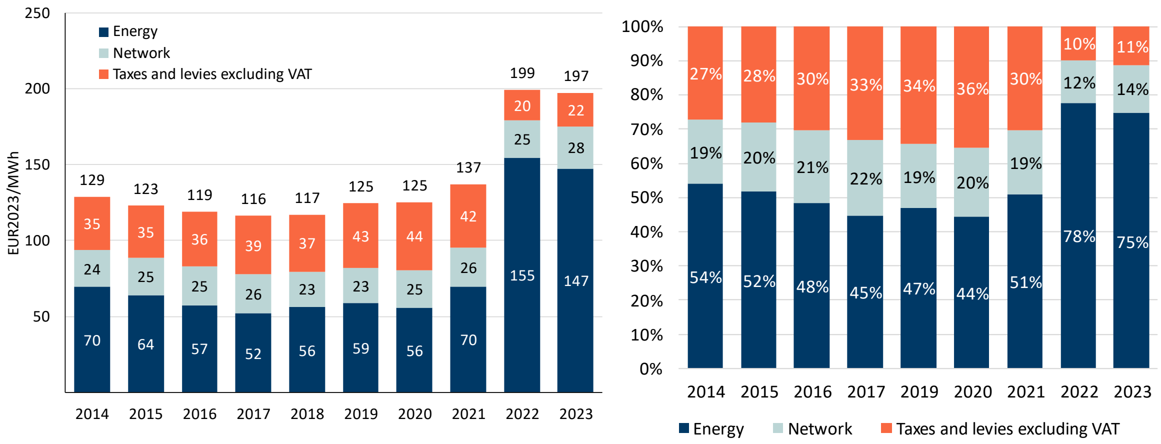

Figure 26: Evolution and composition of the EU-27 industrial end-user prices in EUR2023/MWh (ID band; medium-sized enterprises), absolute (left), share (right).

Source: DG ENER in-house data collection, Eurostat

Situation in individual Member States (ID Band)

Developments in the industrial electricity prices (in the ID band) for EU-27 countries are shown in Figure 27. Prices across all major economies increased significantly during the energy crisis, with some topping at very high levels. Some countries which were more strongly exposed to international gas prices had extended periods of very high electricity prices, such as Italy and Hungary, with 2022 annual averages at 287 and 227 EUR_{2023}/MWh, respectively. Other countries were far less exposed to international gas prices and noticed milder price increases, if at all; these countries include Finland and Sweden, with 2022 annual average prices at 113 and 124 EUR_{2023}/MWh. Since early 2024, prices have started to stabilise at levels higher than those of the pre-crisis years.

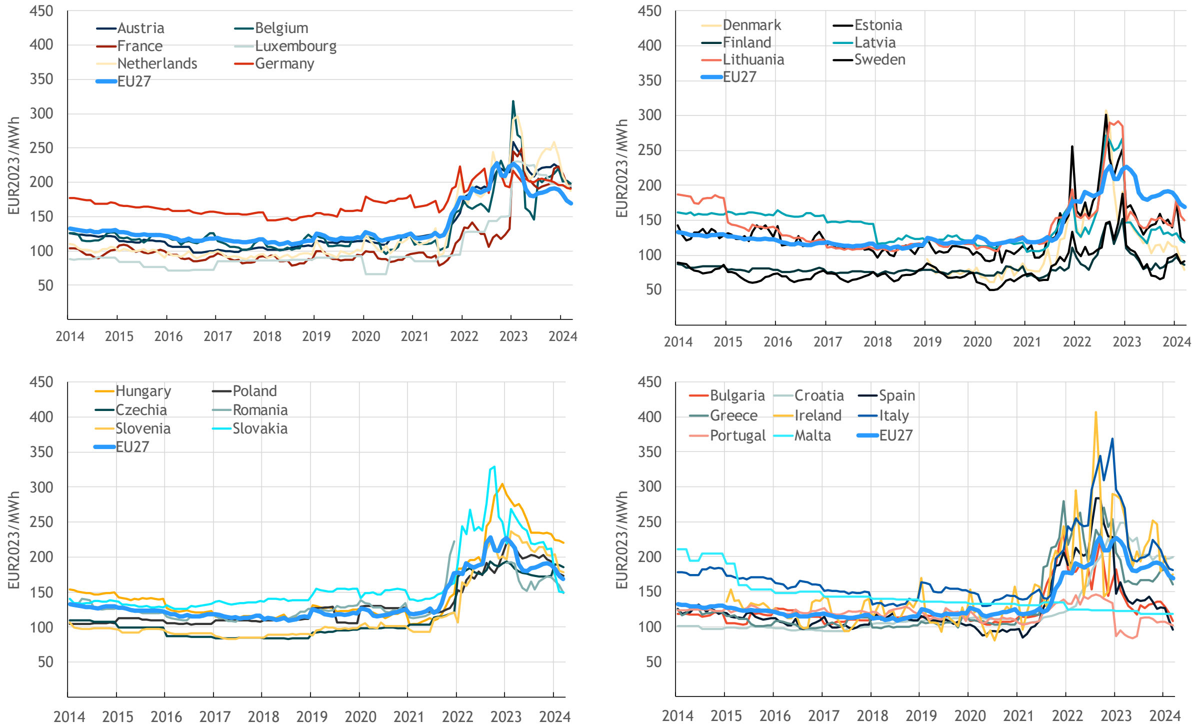

Figure 27: Average industrial (ID band) electricity end-user prices in the EU-27 in EUR2023/MWh, 2014 – Q1 2024

Source: Eurostat, Enerdata EnerMonthly.[93]

Industrial end-user prices in the EU-27 have thus diverged noticeably in the past 2-3 years. This bucks a historical trend where industrial prices have been converging, with more similar prices across the EU-27. In prior years, increasing wholesale markets' integration and greater cross-border transmission capacity have enhanced competition between suppliers leading to lower variations in the energy component of end-user prices between Member States. However, more recently, two factors have noticeably influenced this trend.

First, the different national dependence levels of wholesale (and thus end-user) electricity prices on international natural gas price developments have increased price divergence (see Chapter 0 for more details). The different levels of exposure to natural gas price fluctuations, have caused the prices of countries to move in different directions, depending on their exposure. It can be seen for example that industrial users in Italy have experienced very high price increases, while Sweden has maintained relatively low prices.

Second, the impact of political interventions on the wholesale (only in some MS) and/or retail markets have differed greatly across Member States. Following from Regulation 2022/1854, emergency market interventions were implemented to limit the impact of energy price changes on consumers and markets. These interventions were carried out differently, to differing levels of effectiveness, across the Member States,[94] leading to a further divergence in recent years of electricity prices for industrial users specifically, adding to the divergence caused by different natural gas price exposure.

The price components for small industrial end-user prices also differ across the EU-27 MS. A snapshot of these price components in 2023 compared across the EU-27 plus Norway is shown in Figure 28.

[93] *Note: Data on Denmark was not available, and data on Ireland and Romania was limited.*

[94] *EC (2023), COM/2023/302 final: REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the review of emergency interventions to address high energy prices in accordance with Council Regulation (EU) 2022/1854.*

The major component in all countries remains the cost of energy and supply, which (as detailed previously) has increased greatly in the past 2-3 years. The highest energy and supply costs were in 2023 observed in Ireland (211 EUR/MWh) and France (192 EUR/MWh). Network costs are the next notable price component in all countries, with the highest value in Hungary (68 EUR/MWh in 2023).

Taxes and levies differ greatly among countries. The primary reason for this is that retail market interventions were often implemented in the form of tax breaks, which differed greatly across countries. In some countries, subsidies were granted, such as in Portugal (33 EUR/MWh in 2023) as well as in other countries, although this did not lead in all countries to a net negative tax level. Bulgaria has also granted a subsidy on consumption for small industrial users for a few years.

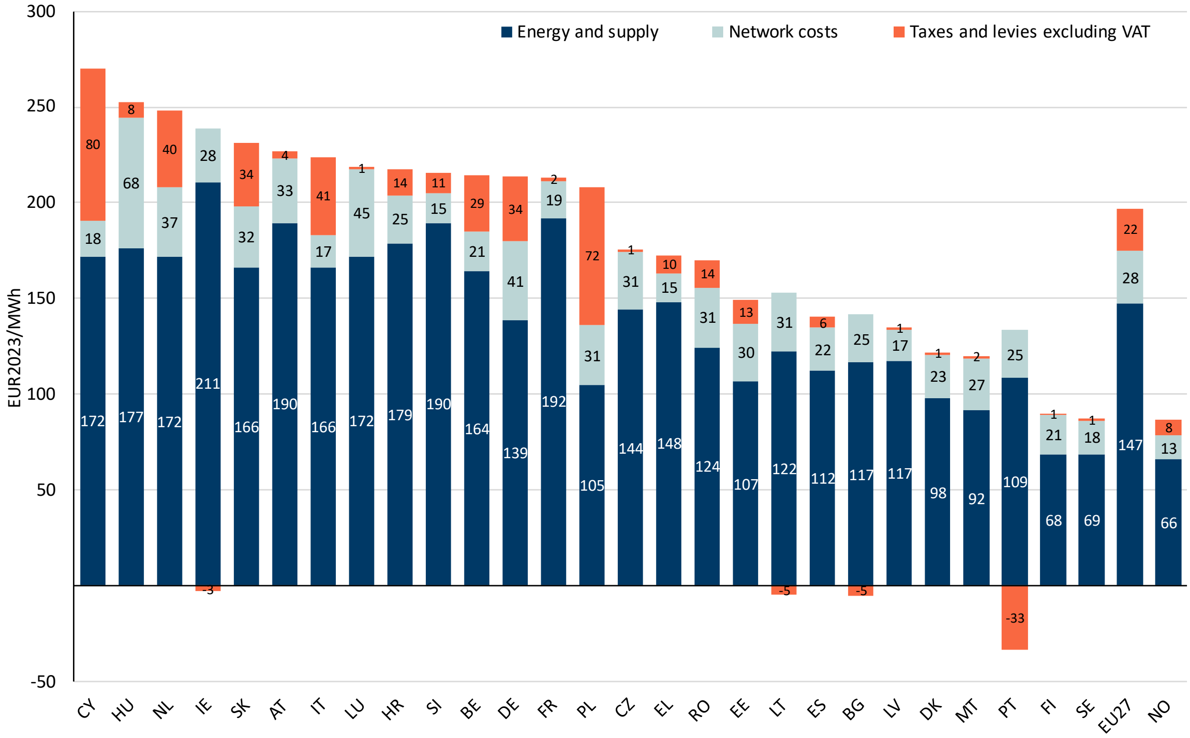

Figure 28: Industrial end-user electricity prices in 2023 (ID band; medium-sized enterprises).

Source: Eurostat

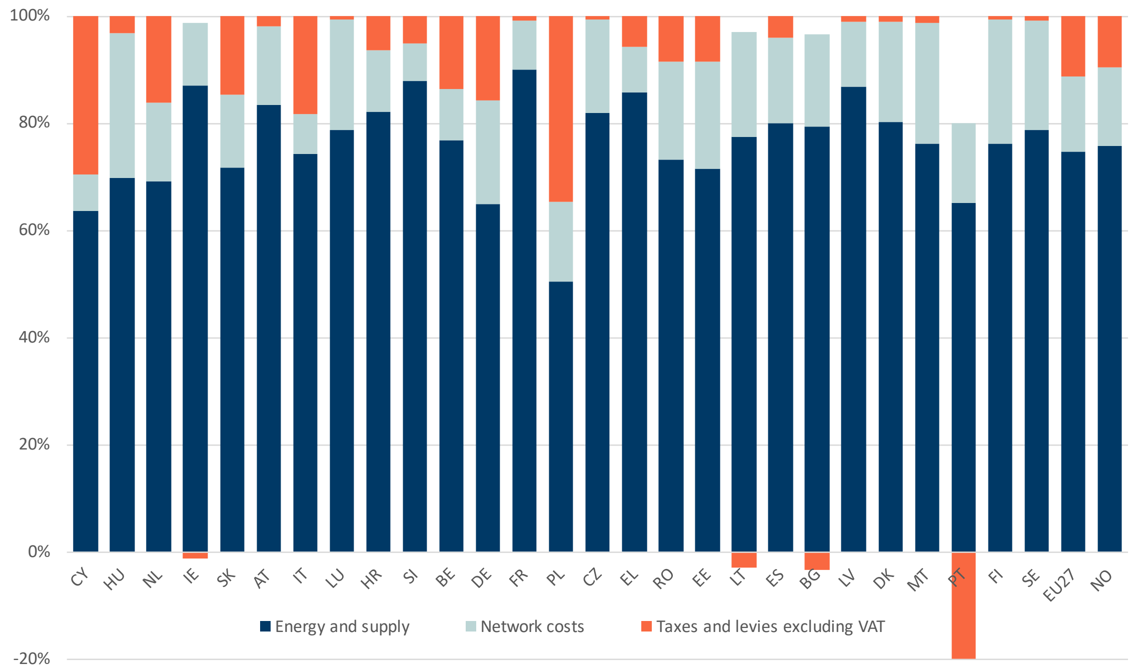

Figure 29: Relative composition of industrial end-users electricity prices in 2023 (ID band; medium-sized enterprises).

Source: Eurostat

Tax levies, fees, and charges for small industrial users

This section discusses the various fees and charges that small industrial users pay, separate from the energy and supply and the network costs. More details about taxes and levies can be found in chapter 8 and on industrial costs in chapter 5. The contents of these fees are described further below, where the developments for each levy and fee is detailed:

- **Value added tax:** VAT is recoverable for industrial consumers in the EU. Therefore, this report analyses industrial prices excluding VAT. Other recoverable taxes are also excluded from the presented prices.
- **Environmental tax:** Environmental taxes increased in the past 2 years. In the 2019-2022 period, these taxes were, on an annual basis, about 10.4 EUR/MWh. In 2023, they have increased to 12.1 EUR/MWh (a growth of 17%). These taxes vary greatly among EU MS, with some at zero (LU, FI, LV), and other at high levels (67.8 EUR/MWh in Cyprus, 56.4 EUR/MWh in Poland). Environmental taxes represented in 2023 the largest share of taxes and levies for the ID band, at 49% of the total in this price component.
- **Renewable energies and energy efficiency levies:** Levies financing the support of renewable energy, Combined Heat and Power (CHP) and energy efficiency measures dropped significantly in 2022-2023. By 2023, renewable energy levies had decreased 70% compared to their 2019-2021 average annual level. Some countries did not impose renewable energy levies (such as BG, CZ, LV, MT, and FI), while others had a negative renewable energy levy according to Eurostat. A negative tax or levy in Eurostat likely is the result of end-user prices being below the energy and supply cost, hence assigning 'negative' tax levels or 'subsidies' to reach the often subsidized final end-user price.
- **Capacity levy:** Charges related to security of electricity supply or the financing of regulatory authorities[95] were collected in 12 EU MS in 2023. 2 countries (Ireland, Portugal) had 'negative' capacity levies due to end-user prices below the energy and supply plus network cost. The

[95] *Officially does not fall under the CRM levy category, but Eurostat classifies both in the same category called "capacity taxes".*

impact of security of supply related charges remained limited, below 2% (2023) of the average EU-27 price.

- **Nuclear tax:** In 2023, based on Eurostat data, nuclear taxes were collected in only Slovakia. Their impact on small industrial users prices at EU level remains negligible.
- **Other charges:** The absolute value of this residual subcomponent amounted in 2023 to 1.9 EUR/MWh, and its impact on end-user prices hence remained small.

Overall, Figure 30 shows how the taxes and fees have developed for small industrial users (in the ID band) in the past 5 years (2019 – 2023). Following the political market interventions during the energy crisis, the amount and composition of these levies have changed drastically. In prior years, renewable energy levies (56% in 2021) made up the lion's share of this price component, with significant chunks for environmental taxes (27% in 2021) and capacity (CRM) levies (7% in 2021). However, more recently, renewable energy levies have dropped significantly and only made up 27% of all taxes and levies in 2023, while environmental taxes have grown to represent almost half (49%) of all taxes and levies. The total amount of taxes and levies has changed as well: it has dropped from an average of 37.4 EUR_{2023}/MWh over 2019-2021, to 24.7 EUR_{2023}/MWh in 2023 (a drop of 34%).

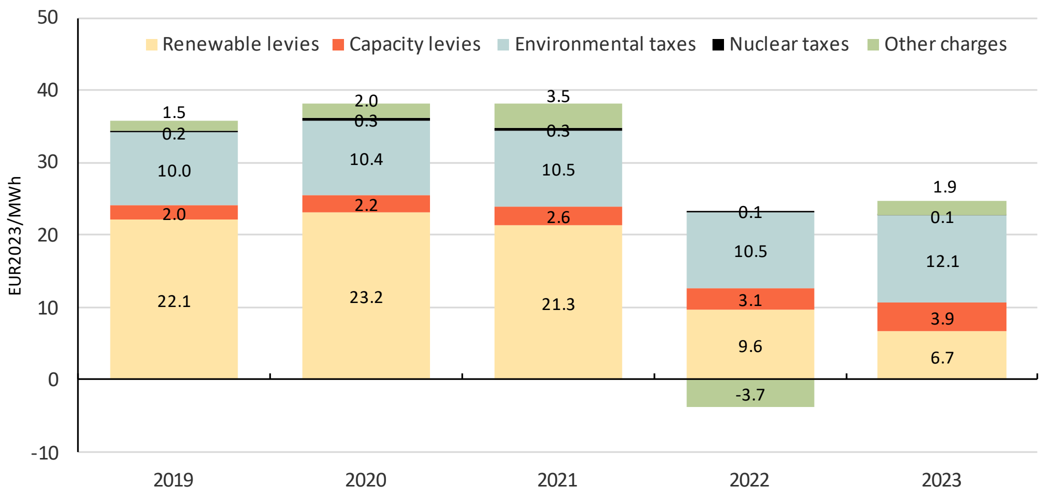

Figure 30: Comparison of electricity taxes and levies in 2019-2023 on annual basis for small industrial users (ID band).

Source: Eurostat

Situation of large enterprises and energy-intensive industries

This section analyses end-user electricity prices for the IF band (consumption between 70 to 150 GWh per annum). This consumption band captures the largest consumers of electricity in energy-intensive industry, such as basic metals and chemicals. Electricity prices for these large industrial users have grown dramatically in 2021-2023, reaching 192 EUR_{2023}/MWh in 2022 and 161 EUR_{2023}/MWh in 2023 (Figure 31). Compared to the pre-crisis (2014-2020) annual average of 90 EUR_{2023}/MWh, this represents a growth of 112%. This growth is evidently driven by massive increases in the electricity supply price component, which has grown by 196% (when comparing the same two periods). It is apparent that the wholesale market price increases have heavily impacted the large industry.

Unlike the electricity supply component, the network component and the taxes and levies have stayed at similar or lower levels. Network costs stayed similar at 15 EUR_{2023}/MWh in 2023, while taxes and levies decreased to 15 EUR_{2023}/MWh, compared to 23 EUR_{2023}/MWh pre-crisis levels, among others due to temporary tax reductions and some renewable levies being displaced by financing via the general budget.

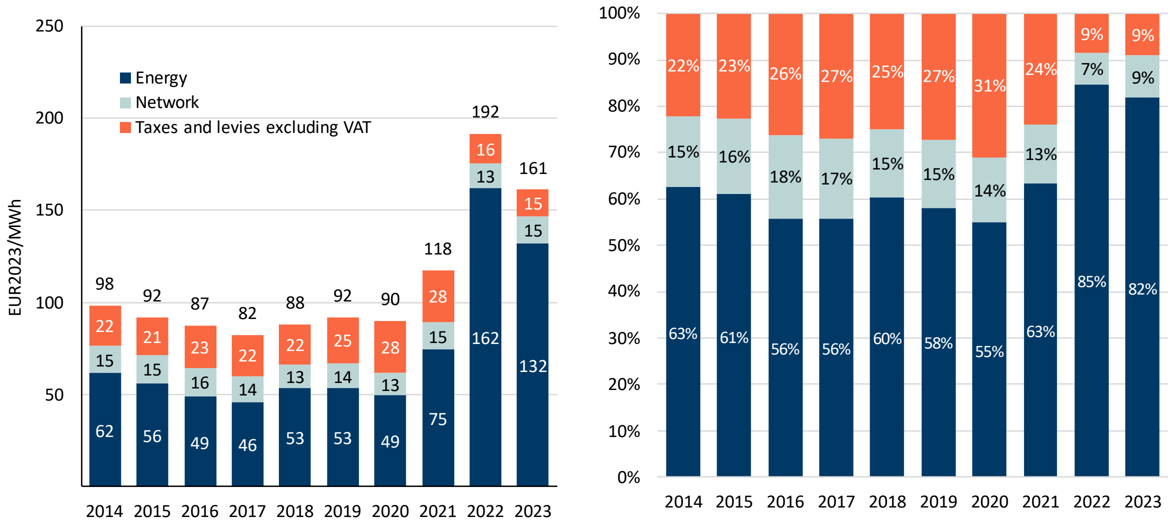

Figure 31: Evolution and composition of the EU-27 industrial prices (IF band).

Source: DG ENER in-house data collection, Eurostat

Electricity prices over time for large industrial users across the EU-27 MS are similar to those for small industrial users (ID band). Figure 32 shows monthly data up to Q1 2024 for EU-27 MS. Political end-user price interventions and the different exposure of countries' electricity generation mix to gas markets determined to a large extent the price fluctuations and differentials in recent years. End-user prices for large industrial consumers have started to stabilise in 2023 and early 2024, albeit at levels higher than those of the pre-crisis years. The EU-27 average price in Q1 2024 amounted to 142 EUR/MWh, 60% above the 2014-2020 average of 88.9 EUR/MWh. Similar to the prices for small industrial users, large industrial users' prices have also strongly diverged between EU MS, with some (Sweden, Finland for example) at very low levels close to their historical values, and others (Netherlands, Hungary, for example) settling at prices far above their historical values.

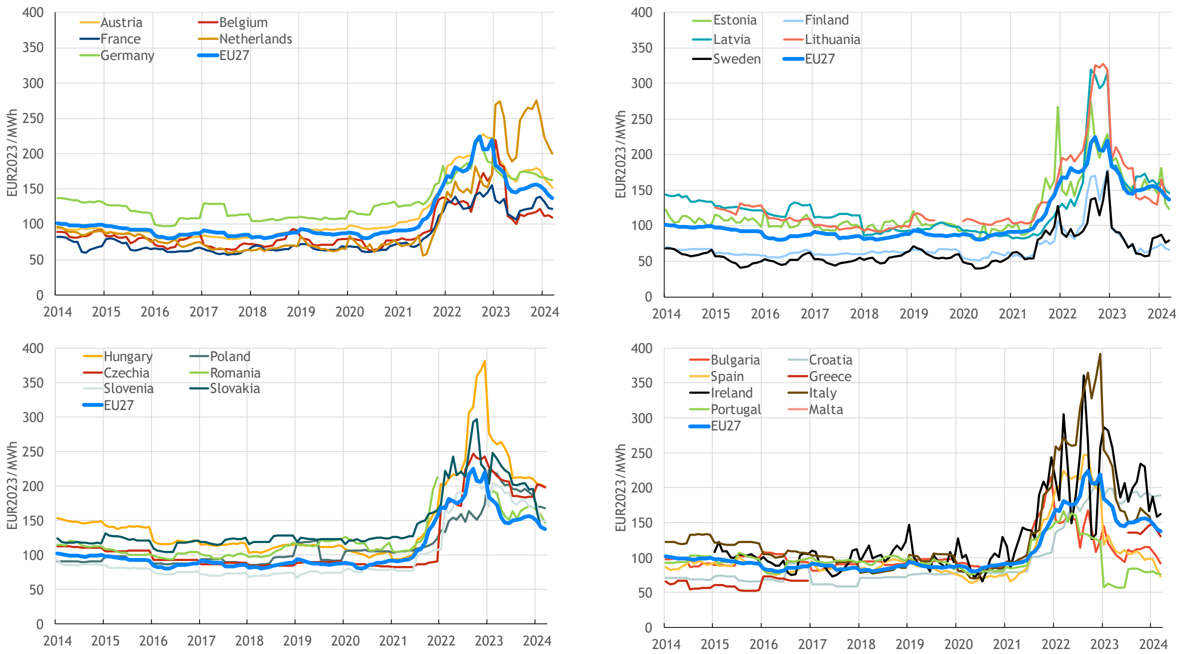

Figure 32: Average retail electricity prices in the EU-27 for large industrial (IF band) end users, 2014 to early 2024.

Source: Eurostat.[96]

A snapshot of prices in 2023 for large industrial users across the EU-27 MS is shown in Figure 33. For some MS data is missing in this area, either due to unavailable or confidential information. Similar to small industrial users, the energy supply price component represented in 2023 the largest share in the overall electricity costs across the EU-27 for large industrial users. The highest electricity costs for this market segment were observed in the Netherlands (208 EUR_{2023}/MWh in 2023) and Ireland (211 EUR_{2023}/MWh), compared to an EU-27 average of 132 EUR_{2023}/MWh. Network costs and taxes and other levies are less significant cost components, on average 15 EUR_{2023}/MWh each across the EU-27. Network costs are a small but low-variation cost component, while taxes and levies in 2023 differed dramatically between EU-countries (discussed further in the following text).

[96] *Note: Data for Denmark and Luxembourg were not available, and data for Cyprus, Greece, Romania, and Lithuania was limited, among others due to limited large industry in some of these MS.*

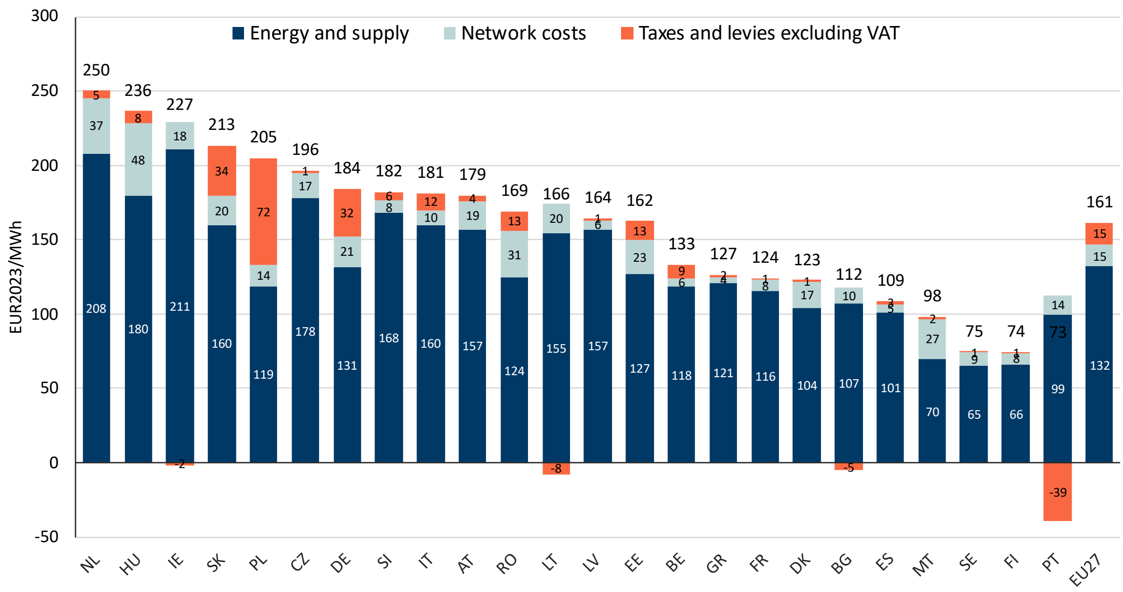

Figure 33: Industrial electricity end-user prices in 2023 per EU-27 Member State (IF band).

Source: Eurostat. Data for Cyprus, Croatia, and Luxembourg are either unavailable or confidential

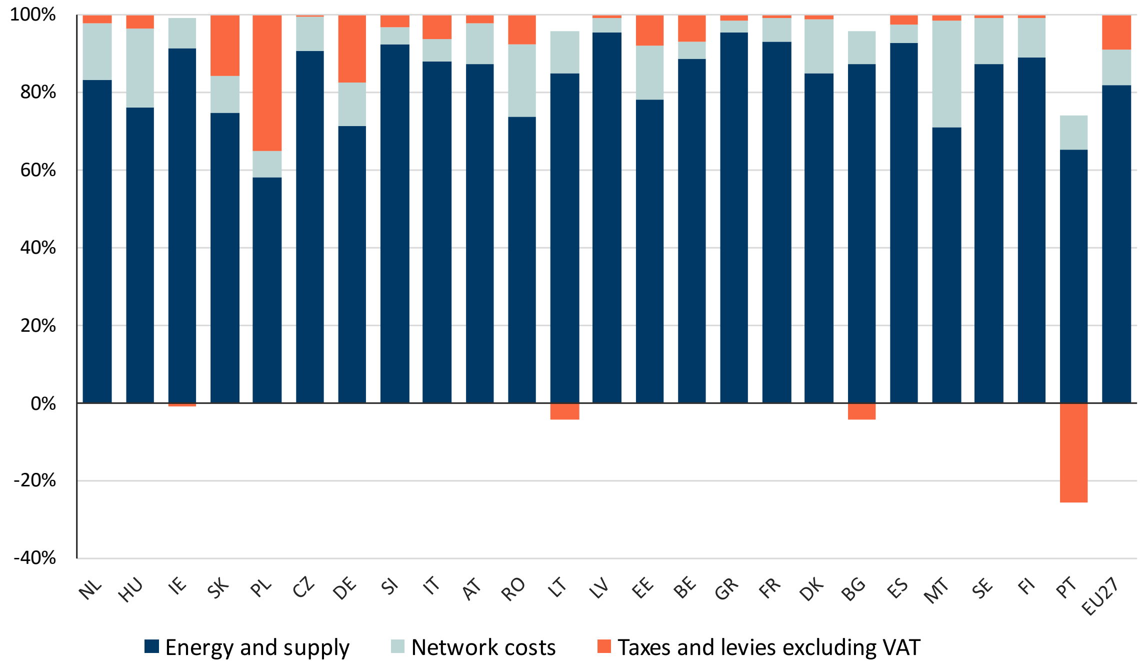

Figure 34: Relative composition of industrial end-user electricity prices in 2023 (IF band; energy-intensive industry).

Source: Eurostat. Data for Cyprus, Croatia, and Luxembourg are either unavailable or confidential.

Taxes, levies, fees, and charges for large industrial users

This section discusses the fees and charges applicable to large industrial customers. The contents of these fees are described further below, where the developments for the most relevant taxes, levies and fees is detailed (note that countries with no data are excluded from the analysis, namely Luxembourg, Croatia, and Cyprus):

- **Value added tax:** VAT is recoverable for large industrial consumers in the EU and is hence not analysed. Other recoverable taxes are also excluded from the prices presented in this report.
- **Environmental tax:** Environmental taxes have on average increased from 7.5 EUR/MWh in 2021 to 9.5 EUR/MWh in 2023, presenting a total growth of 27% (or 13% per year). Environmental taxes were not levied in 3 countries: Finland, Lithuania, and Latvia. Nonetheless, these taxes made up the majority of this cost component across large industry in the EU-27, at 60% of total amount.
- **Renewable energies and energy efficiency levy:** These levies finance the support of renewable energy, CHP plants, and energy efficiency measures. The levies dropped significantly in 2022-2023, from 14.5 EUR/MWh in 2021 to 2.1 EUR/MWh in 2023 (a decrease of 86%). By 2023, renewable energy levies made up only 13% of overall taxes and levies on large industrial users (minus 70% compared to their 2019-2021 average annual level). As with small industrial users, Portugal, Ireland, and Lithuania actually had negative tax levels, meaning large industrial users were subsidized.. Energy levies no longer make up a significant portion of overall taxes and levies on industrial users (at 13% of total in 2023).
- **Capacity (CRM) levy:** Charges related to security of electricity supply or the financing of regulatory authorities[95] grew from 2 EUR/MWh in 2021 to 3.2 EUR/MWh in 2023. While the relative growth rate is significant at 60%, these charges remain a minor portion of total taxes and levies (20%).
- **Nuclear tax:** Similar to small industrial users, only large industrial users in Slovakia had to pay a nuclear tax (according to Eurostat data). The impact of these charges on end-user prices at the EU level remains hence negligible.
- **Other charges:** Other charges not otherwise accounted for in the other components made up 1 EUR/MWh in 2023 and were a very small contributor (6%) to overall electricity costs for this market segment.

Figure 35 shows how taxes and other fees have developed for large industrial users (IF band) in the past 3 years (2021 – 2023). The political market interventions during the energy crisis, have changed the amount and composition of these taxes and levies drastically. Similar to the situation of small industrial users, renewable energy levies for large industrial users have shrunk to only 13% of total taxes and levies in 2023. However, environmental taxes have grown to represent the majority of this cost component (60%). Capacity (CRM) costs maintained their share of about 20% in the overall taxes and levies, while nuclear taxes are negligible. Other charges and fees are also at a low level, with only 6% of the overall taxes and levies component. The total amount of taxes and levies has for this market segment also dropped significantly, from 28.3 EUR/MWh in 2021 to 15.9 EUR/MWh in 2023 (a drop of 44% over 2 years).

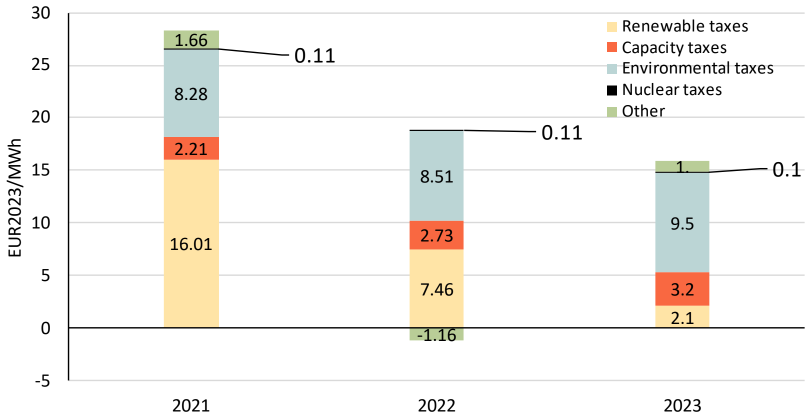

Figure 35: Comparison of taxes and levies from 2021-2023 on annual basis (IF band).

Source: Eurostat

International comparisons of industrial end-user electricity prices

The figures below show the trends in industrial end-user prices for the EU-27 and other G20 countries in the period between 2014 and Q1 2024. Prices in the main EU-27 trading partners and the EU-27 average are somewhat divergent. The electricity prices faced by European heavy industry were in Q12024 at the level of Japan, whereas the EU industry used to have a competitive advantage in previous years (close to the relatively low levels in the USA). The UK's electricity prices have maintained very high levels in 2023 and Q1 2024, while prices in the USA were relatively stable and continued close to their historical levels. Electricity prices in Japan had substantially increased due to price upticks in the LNG market, but have decreased greatly throughout 2023 to previous historical levels. Data for China is missing, but it is expected that industrial consumers in China face electricity prices below those of the USA, and are hence also significantly lower than in the EU.

The EU-27's industrial electricity prices are in the next graph also compared with those in other industrial countries. Excluding the UK, the EU had in 2023-Q1 2024 industrial electricity prices well above all other countries shown in Figure 36 for which data was available. Türkiye's downward electricity price developments as shown on the figure are primarily due to the high national inflation rate in recent years. South Korea and Canada's prices also remain at low levels compared to the EU, at about 120 EUR/MWh and 92.4 EUR/MWh in January 2024, respectively.

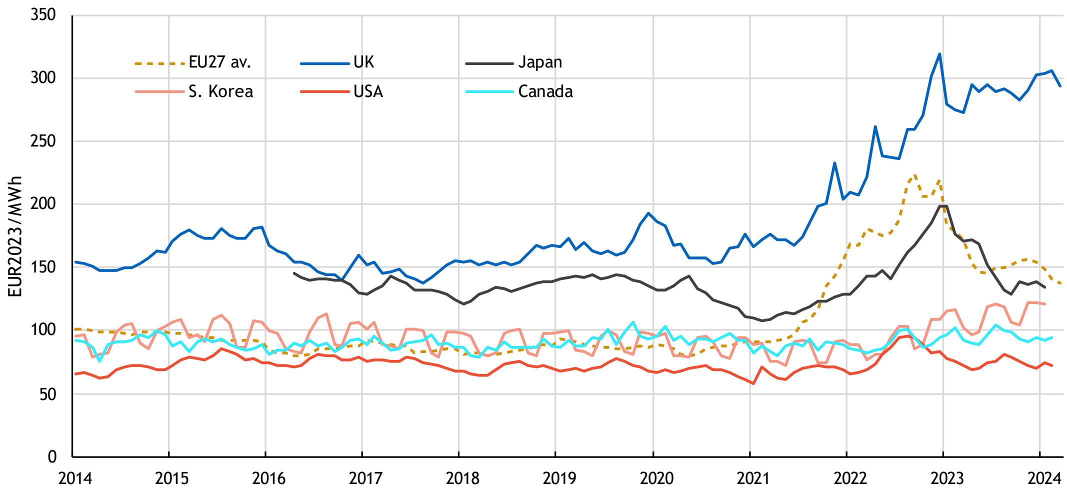

Figure 36: Industrial end-user electricity prices in the EU-27, USA, UK, Japan, Canada and South Korea from 2014-Q1 2024 in EUR2023/MWh.

Source: S&P Platts, Eurostat, Enerdata EnerMonthly.

3. Natural Gas prices

3.1. Wholesale prices

Main findings

- Wholesale natural gas prices were generally stable until 2020 in the EU at around 20 EUR_{2023}/MWh. Since then, the EU went through an **exceptional period of volatile and high wholesale gas prices** that have drastically changed the gas and broader energy system in the EU. After having decreased to very low levels in Q2 of 2020 due to the global Covid-19 pandemic, prices kept increasing. In Q3 and Q4 of 2021 spot prices were already at very high levels, ending the year at 123 EUR_{2023}/MWh in December, due to the economic rebound after Covid, an exceptionally cold winter, combined with first Russian attempts to destabilize the European energy market, e.g. through offering limited gas volumes on spot markets.
- The Russian invasion of Ukraine and subsequent uncertainty and sanctions led to **continuing exceptionally high spot prices**, staying above 100 EUR_{2023}/MWh until June 2022. In this period, Russian pipeline gas supply kept decreasing from 50% of EU imports to 10%, with the supply via e.g. Nord Stream 1 and 2 dropping to zero. This resulted in a very tight gas supply market, with significantly increased prices, notwithstanding reduced demand, mainly from industry and power generators. This supply crisis enhanced the acute need to increase LNG import capacity and deliveries.
- Notwithstanding lower demand levels in summer months, **prices increased further, reaching an all-time high peak spot price** in August 2022 at 231 EUR_{2023}/MWh. There are several reasons for this exceptional gas price peak in August: decreasing pipeline supply from Russia, overall gas supply uncertainty, and the European policy and consequent legal obligation to fill up gas storages played a major role.
- **Starting in September 2022, gas spot prices decreased quickly** from the 231 EUR_{2023}/MWh peak in August 2022 to 42 EUR_{2023}/MWh in April 2023. This happened due to several reasons – among others, storage levels were very high at the beginning of the winter, and there was reduced uncertainty about Russian pipeline supply, given its role became marginal with positive signs that LNG import capacity would be sufficient to cover demand. In addition, gas demand in the EU was quite low due to the mild winter and also demand from other regions was lower than anticipated, especially in China due to its slow economic recovery.
- In 2023 and 2024, **a new 'price equilibrium'** has emerged at around ~30-40 EUR_{2023}/MWh (**still relatively high** compared to 20 per EUR_{2023}/MWh pre-crisis level). Due to the phasing out of Russian pipeline gas and reduced domestic production in the EU, the market has shifted mainly from cheap pipeline supply to a higher reliance on more expensive LNG imports, which is reflected in the new price 'equilibrium'.
- **Monthly spot price volatility** levels also decreased since mid-2023, with monthly average spot prices at major trading hubs during Q2 2023 to Q1 2024 ranging between ~25-45 EUR_{2023}/MWh.
- **Spot price differences between European gas hubs** during the crisis widened compared to the pre-crisis situation, with the 2-year average (unweighted) hub prices ranging between 60 EUR_{2023}/MWh in the UK and 79 EUR_{2023}/MWh in Italy and Austria, while TTF prices average reached 71 EUR_{2023}/MWh. Main factors influencing this price differential were the extent to which reduced Russian pipeline gas imports had to be replaced with spot market supply and the access to LNG imports.
- In the past 20 years, gas pricing has largely transitioned from **oil-indexed pricing** to hub pricing. While generally TTF hub prices were consistently lower than oil-indexed gas prices, during the energy crisis oil-indexed price contracts were significantly lower than hub prices. Since Q2 2023, hub prices are again (slightly) lower than oil-indexed prices.

- Due to the gas supply crisis, LNG has become a more important factor in the European gas system. The share of Russian pipeline supply in **gas imports** shrunk from 40% in 2021 to about 8% in 2023. Simultaneously, the LNG import share increased from 22% (75 bcm) in 2021 to 39% (115 bcm) in 2023. The largest increase in LNG shipments came from the US (51 bcm), which has become in 2023 the largest LNG import source of the EU, followed by Qatar and Russia.
- Thanks to the further diversification of gas import sources, the high **utilisation rate of LNG terminals** in 2022 and 2023 and the commissioning of additional 'emergency' regasification facilities, there was no gas supply disruption in the EU during the energy crisis.
- Gas prices in the EU – as well as in other, LNG-dependent countries such as Japan and South Korea – during the energy crisis were substantially higher than in its main **trading partner markets**. Although they increased in all markets, gas prices in major gas producers such as the US and Canada remained at below 87 EUR_{2023}/MWh levels. In China prices increased considerably, but not to the same extent as in the EU, for different reasons (China has some domestic supply leading to considerably lower import dependence, with quite elastic spot gas demand, etc).

3.1.1. Evolution of wholesale gas prices

This chapter discusses the development of wholesale gas prices across the EU, including prices at trading hubs, estimated border prices and prices reported by commercial data providers/other sources.

From 2010 up until 2020, wholesale gas prices have remained at around 20 EUR_{2023}/MWh. Although extreme events (unusual weather conditions or sourcing disruptions) have led to short periods of (regional) price volatility, the overall trend observed in these years was one with **relatively stable wholesale prices**. This has, however, radically changed in 2020, with multiple disruptive events having led to a new reality with more volatile and much higher prices.

First, in 2020 gas prices started to decline – mainly due to the **COVID-19 pandemic**, which led to a significant reduction in industrial activity and hence in gas demand. This was accompanied by increasingly high shares of renewable energy sources in the power generation mix, further reducing gas demand for electricity production. As a result, by May 2020, the wholesale gas price on the Dutch TTF hub dropped to 5 EUR_{2023}/MWh – the lowest level since the hub started trading in 2003.

In 2021 wholesale gas prices started to increase considerably due to **rising demand amid the post-COVID-19 economic rebound**, combined with an unusually cold spring weather. **Russia tried to increase the gas market prices**, which was aimed to influence the Nord Stream 2 permitting process in its favour.

The **Russian invasion of Ukraine**, starting **in February 2022** pushed gas prices further up to unprecedented levels. Consequent EU sanctions (though not directly related to natural gas imports)[97] led to Russia restricting its gas exports to the EU (specifically to Poland and Bulgaria in April, and to Germany by limiting the Nord Stream 1 flow in June), leading to a shock on the European energy markets caused by the reduced gas supply to the EU – but also creating long-term uncertainty on future gas flows from Russia (the EU's main supplier, representing 40% of the EU's gas imports in 2021) to the continent.

Natural gas spot prices peaked in August 2022 at around 240 EUR_{2023}/MWh on the day-ahead market. There were several main drivers for these peak prices – quite unusual especially during a summer period with lower gas demand. Key price drivers on the supply side were the continued reduction of gas flows from Russia (the operation of Nord Stream 1 halted completely by August) combined with the growing expectations that supply cuts from Russia could become permanent. On the demand side, consumption proved to be relatively price inelastic, with some additional demand

[97] *Council of the European Union. (n.d.). Timeline - EU sanctions against Russia*

arising from the obligatory gas storage injections (to reach the EU goal of 80% storage capacity filled by winter) and rising use for gas-fired power production.[98, 99]

By the beginning of the winter of 2022-2023, gas storage filling levels in the EU were high, notwithstanding the majority of pipeline supply from Russia (mainly via the Nord Stream 1 and Yamal pipelines) being halted since July 2022. Furthermore, the winter proved to be exceptionally mild, the LNG import capacity of the continent increased (notably in Germany), LNG supply was secured for Europe via short-term contracts, and Chinese LNG demand was low due to continued lockdowns and slow economic recovery. In addition, gas demand – mainly in industry – reduced as a response to the high prices (which also triggered energy efficiency measures, which may have lead to a permanent gas demand reduction).[100] These drivers among others led to **decreasing gas spot prices** from the 240 EUR_{2023}/MWh August 2022 peak to 62.5 EUR_{2023}/MWh in January 2023. EU initiatives, such as the gas price cap introduced in December 2022 as well as the REPowerEU plan, also put downward pressure on gas prices.[101] Additionally, events such as the Nord Stream 1 and 2 explosion at the end of September 2022 had little upward effect on gas prices, showing that both gas supply and prices were in a more stable situation.

From January 2023 to February 2024, prices did not reach the previous peak levels observed during the gas crisis of 2022 anymore, with monthly TTF prices since March 2023 not exceeding 44.3 EUR_{2023}/MWh. This shows the European gas market has (quite rapidly) transformed to a new equilibrium with permanently low Russian pipeline supply[102] and increasing reliance on other gas supply sourcing countries and routes including global higher-cost LNG imports. In this new 'equilibrium' situation, prices are, however, still higher than the pre-2020 levels: the average 2023 spot price (40.5 EUR_{2023}/MWh) was still 90% higher than the 2017-2019 average.

Lastly, regional wholesale spot price differences (e.g. between TTF, UK hub and German hub) are largely explained by the different market situations, interconnection capacities and levels of competition. In general, markets with multiple import sources (e.g. several gas pipelines and access to LNG, see section 3.1.2.) and several importers show a lower price level than markets with only one supply source.

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[98] European Securities and Markets Authority (2023). The August 2022 surge in the price of natural gas futures

[99] A more elaborate analysis of price developments in 2022 can be found in ACER (2023). European gas market trends and price drivers

[100] See in-depth analysis on demand reduction drivers from IEA (2023). Europe's energy crisis: What factors drove the record fall in natural gas demand in 2022?

[101] European Commission (2023). Actions and measures on energy prices by the European Commission.

[102] In 2024 only the Ukrainian and Turk stream routes still deliver gas to the EU.

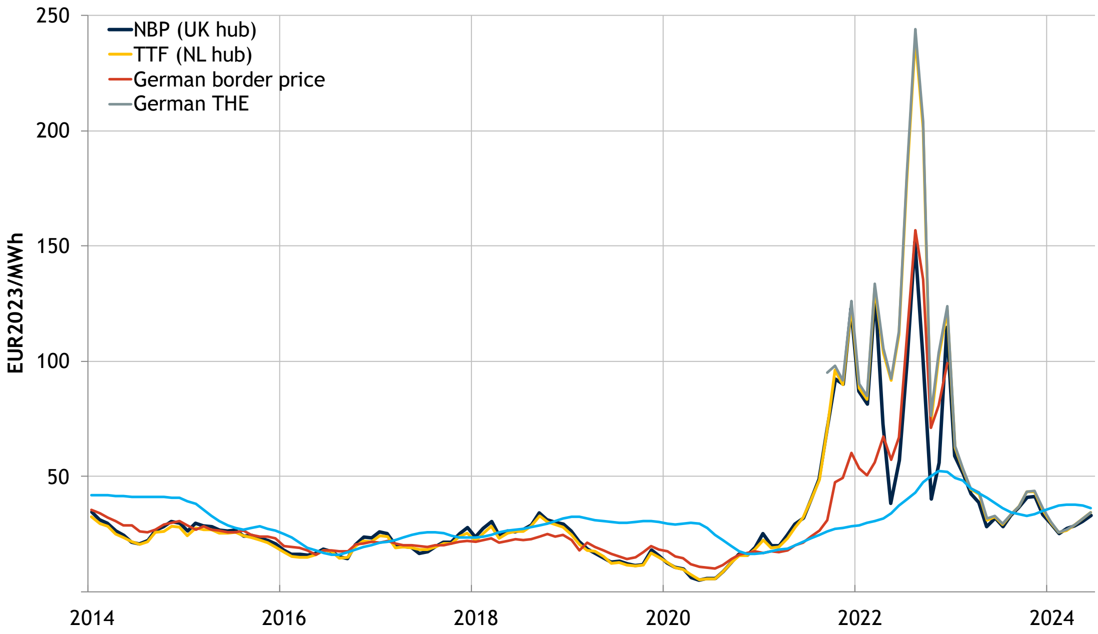

Figure 37: Selected wholesale day-ahead gas hubs in Europe in EUR_{2023}/MWh.

Sources: S&P Platts, Enerdata EnerMonthly

The monthly average spot prices depicted in Figure 37 hide a high degree of daily volatility. For short periods, daily prices can reach very high levels, typically when cold snaps sharply increase demand while supply is limited by infrastructure constraints or other factors. Figure 37 shows a few such price hikes occurred over the last twelve years. Cold spells occurred for instance in 2017 and 2018. The regional nature of such cold spells is reflected by the fact that price peaks were not as severe in all gas markets. Extreme low prices can also occur, when demand for gas falls unexpectedly: this was the case in 2020, when gas demand fell due to exceptionally low industrial activity. While spot prices showed abrupt falls or rises due to exceptional events, forward prices were not affected to the same extent, showing that unexpected ephemeral changes in demand or supply are mainly affecting the spot markets.

Figure 38 illustrates that gas hubs in the EU show, in general, very similar spot price patterns and prices (besides exceptional local price spikes or falls) do not differ that much. The (unweighted[103]) average spot prices at the hubs for which full 2014-2020 data[104] is available was 20 EUR_{2023}/MWh, with the lowest average price being 16% lower (at 16.8 EUR_{2023}/MWh in Spain) and the highest average price more than 10% higher (23.5 EUR_{2023}/MWh in France), all others evolving in the 19 EUR_{2023}/MWh and 21.1 EUR_{2023}/MWh range.

The spot price spikes between 2014-2020 are dwarfed in comparison with the prices observed in 2021 to 2023 though. Day-ahead wholesale prices then were reaching up to 341.8 EUR_{2023}/MWh while the peak price in the 2014-2020 period was 105.5 EUR_{2023}/MWh (UK hub). Note that Figure 39 further zooms in on the most recent period, since these price developments cannot easily be seen in Figure 38.

[103] *Weighted average is most likely higher, due to generally higher prices at moments of higher demand.*
[104] *Full data for BE Zeebrugge, AT Baumgarten, DE Gaspool, DE NCG, FR PEG Nord, IT PSV, UK NBP, NL TTF*

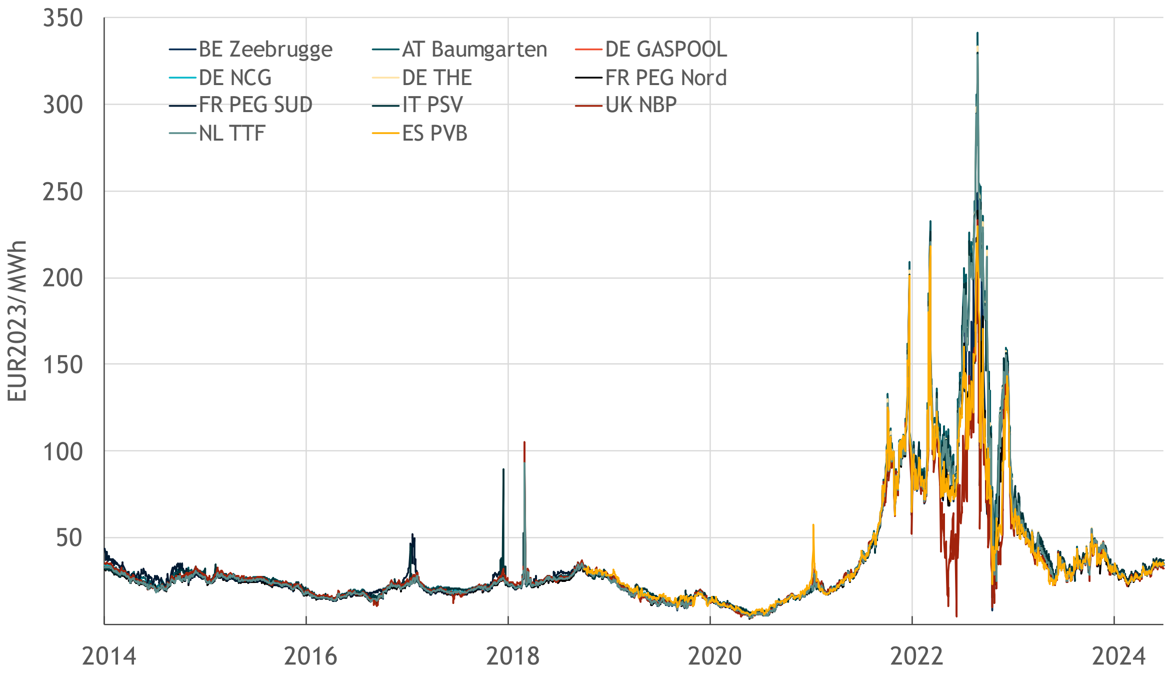

Figure 38: Daily day-ahead prices at selected gas hubs from 2014 to 2023. Zoom in on prices during the 2021-2023 period can be found in the following figure below.

Source: S&P Platts

In Figure 39 the daily wholesale prices in the 2021-2024 period are displayed. **High absolute price levels and high price volatility can be observed at all selected market platforms** within this period, with short peaks in December 2021 and end of February 2022 (Russian invasion in Ukraine). The whole summer period of 2022 – as mentioned before – saw continuously increasing day-ahead prices until their peak on the 26th of August 2022. After this peak, spot prices continuously decreased, with a rebound peak again in December 2022, mainly due to the cold weather. In the next period, between March 2023 and February 2024, continuously decreasing spot prices could be observed, with values not exceeding 50 EUR_{2023}/MWh. The average spot price in this time period, however, was **still about twice as high as the average during the 2014-2020** period (35 EUR_{2023}/MWh compared to 17 EUR_{2023}/MWh).

When looking at differences between hub prices, the average price during the high price period between July 2021 and July 2023 was 78.5 EUR_{2023}/MWh. Price differences between hubs were larger than during the period before 2021: the highest average prices were observed in France (92.5 EUR_{2023}/MWh, PEG SUD hub), Germany 77.5 EUR_{2023}/MWh; THE hub[105]) and the Netherlands (78 EUR_{2023}/MWh; TTF hub). The lowest wholesale prices could be seen in the UK at 59.6 EUR_{2023}/MWh (NBP hub) during this period, with similar differentials in France (66.2 EUR_{2023}/MWh; FR PEG Nord) and Spain (65.1 EUR_{2023}/MWh; ES PVB) compared to the TTF price. The main driver for the lower price levels is the relatively large access to LNG regasification capacity in these markets, which has become a major driver of prices since the Russian pipeline supply has dwindled. The relatively high price differentials also show that there were substantial pipeline constraints to transport gas within Europe; according to an ACER study, congestion on the gas grid tripled in 2022 to unprecedented levels following tight market conditions and the need to reroute gas flows away from historical east-west routes to predominantly west-east routes.[106] Though difficult to see in the figure, similar price

[105] *For the average in Germany, before 2021 the average of the Gaspool and NCG hubs were used, while since its inception in 2021 the THE hub price is used.*
[106] *ACER (2023). 10th ACER report on the congestion in the EU gas markets and how it is managed*

differentials compared to the TTF – the European gas hub with the highest traded volume – could be observed in 2023, albeit smaller.

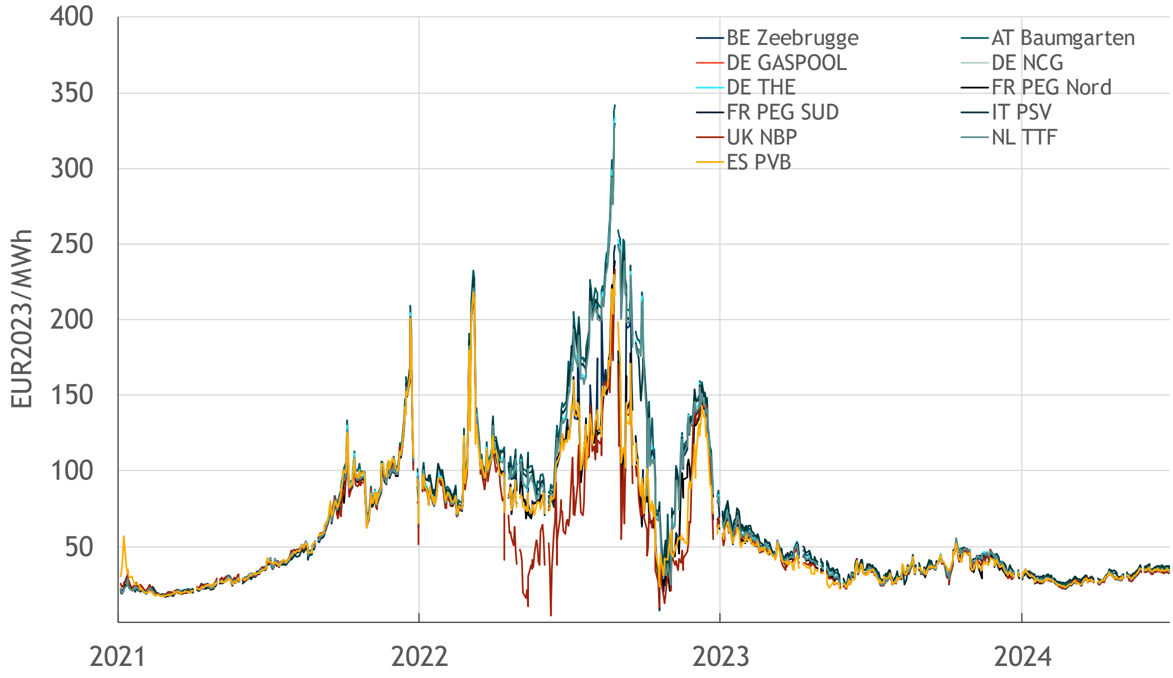

Figure 39: Daily day-ahead prices at selected gas hubs from 2021 -2024 June.

Source: S&P Platts

Figure 40 illustrates the difference between the S&P Platts North West Europe Gas Contract Indicator (GCI) and the Dutch Hub price (TTF). The GCI serves as a theoretical index reflecting a gas price entirely linked to oil, thereby helping to compare gas hub and oil-indexed contracts. From 2010 to 2020, GCI prices typically maintained a premium over gas hub-based prices, prompting a transition from less favourable oil-indexed contracts to hub-based pricing within the EU. However, since 2021, the premium has transformed into a significant discount, driven by the slower growth of oil-indexed contracts compared to gas hub priced contracts. In 2022, the average discount of oil-indexed contracts reached 93 EUR_{2023}/MWh, peaking at 197 EUR_{2023}/MWh in August, when gas hub prices peaked. Notably, while crude oil price changes have a few months lag before impacting oil-indexed contracts, TTF hub prices respond very promptly to market dynamics, further amplifying the difference between hub and oil-indexed contracts in 2021 and 2022.

Along with the fast decrease of gas hub prices since August 2022, the price difference also quickly decreased: between its peak in August 2022 and February 2023 the prices almost converged at a level of 5 EUR_{2023}/MWh. Since then, on average in 2023 oil-based contracts were 1.4 EUR_{2023}/MWh lower.

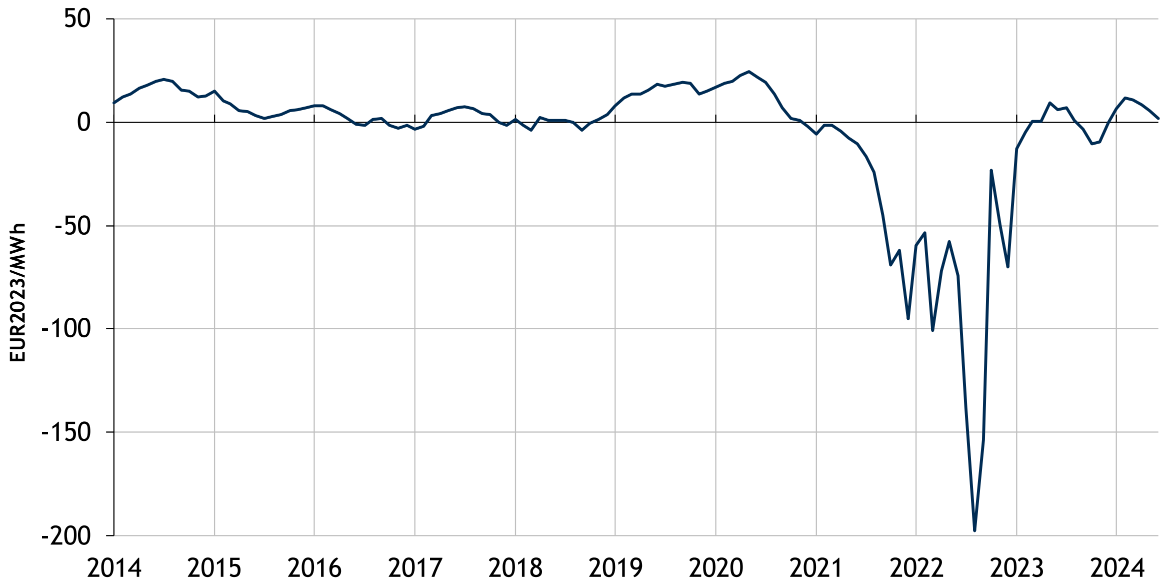

Figure 40: Difference between the S&P Platts Northwest Europe Gas Contract Indicator (GCI) and the Dutch gas hub price (TTF). Example: a negative difference of -50 EUR/MWh means the GCI price is 50 EUR/MWh lower than TTF.

Source: S&P Platts

3.1.2. Factors impacting wholesale gas prices

The wholesale natural gas prices are influenced by a number of factors such as temperature (through the heating demand), development of industrial activities and availability of intermittent energy generation (through the industrial and power generation demand, ancillary services, etc.), filling activities and levels of gas storage facilities, pipeline and LNG imports, or the ETS, oil and coal prices.[107] This section takes a closer look at some of these factors impacting wholesale gas prices.

Oil price developments

Figure 41 shows the correlation between crude oil prices and gas hub prices (TTF hub). Until the energy crisis in 2021, hub prices typically were impacted by the oil price (and to some extent the other way around as oil can serve as a substitute for gas in electricity production[108]). This reflects the close relationship between the gas market and the wider energy system, as well as the macro-economic situation. Normally oil prices are higher than gas on an energy content basis. However, during the energy crisis, from 2021 to the beginning of 2023, gas became significantly more expensive than oil. The temporary spike in oil prices mid-2022 can be explained by the increased natural gas price – after which the oil price started to decrease in tandem with the gas price. By Q2 of 2023, oil and gas prices have moved back to their 'historical' ratio where gas had a lower price – but both prices settled on a significantly higher level than observed prior to the crisis. The longer term oil price increase can be explained by the ban of Russian import to Europe (sanctioned by the EC since 5 December 2022, coinciding with the historical peak, as seen on Figure 41, and the subsequent replacement of it by (generally more expensive) US sourced oil and petroleum products. The relative weakness of the Euro against the US dollar also contributed to the oil price increase within the same period.[109]

[107] *D. Hulshof et al. (2016). Market fundamentals, competition and natural gas prices*

[108] *European Central Bank (2022). Energy price developments in and out of the COVID-19 pandemic - from commodity prices to consumer prices*

[109] *U.S. Energy Information Administration. (2022). Short-term energy outlook*

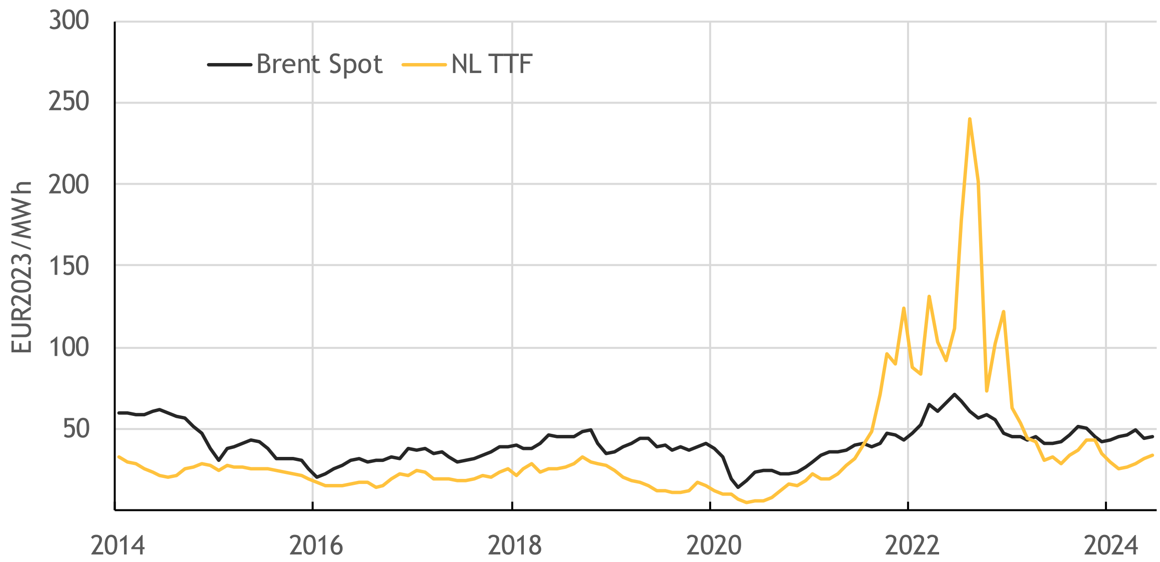

Figure 41: Daily spot prices of oil (Brent) and gas (at the Dutch TTF hub) both in EUR_{2023}/MWh.

Source: S&P Platts. Conversion rate from oil to energy: 1 toe = 11.63 MWh (IEA).

LNG developments

Figure 42 shows the composition of weekly natural gas imports by source country (both pipeline gas and LNG) in 2020-2024. Russian pipeline gas import shrank dramatically due to the consequences of the Russian invasion in Ukraine: from 45-50% of the EU's total gas imports in 2021 to about only 10% 2 years later. The dashed line shows the share of LNG in the overall imports, doubling between 2021 and 2023 (from 15-20% to 40-45%). Hence, the supply gap has mainly been filled by increased LNG imports, in combination with lower gas consumption in the EU.

While until 2024 Russian LNG import levels to the EU stayed stable, early 2024 EU lawmakers started to take action restricting LNG transhipments.[110] Reducing Russian LNG imports had been deemed difficult in a tight gas supply market – although recent research suggests cutting Russian LNG imports is economically and technically feasible on the medium-term.[111] The EC previously committed to terminate all Russian fossil fuel imports by 2027, as part of the REPowerEU plan. To enable this, the EU has been making arrangements with US partners – among others – to expand their LNG deliveries to the EU. Green Deal policies and the related objective to significantly reduce fossil fuel use in the EU are also expected to significantly lower the demand for gas on the medium and long-term.[112]

Overall natural gas imports also declined by about 7% (from average 7 bcm weekly in 2021-2022 to average 6.5 bcm weekly by 2023-2024), resulting from both a mild winter in 2023, high energy prices and continued expansion of renewable energy generation, as well as the already mentioned efficiency measures (substitution of gas) put in place in Member States. The clear 'winner' of the crisis is the LNG sector, which delivers a significantly larger share of the EU's natural gas imports than it did 3 years ago, both in absolute and in relative terms.

110 Reuters. (2024). EU Parliament approves legal option to block Russian LNG imports

111 S&P Global. (2024). Europe is set to continue to rely on Russian LNG in short term

112 European Commission. (2022). Joint statement between the European Commission and the United States on European energy security

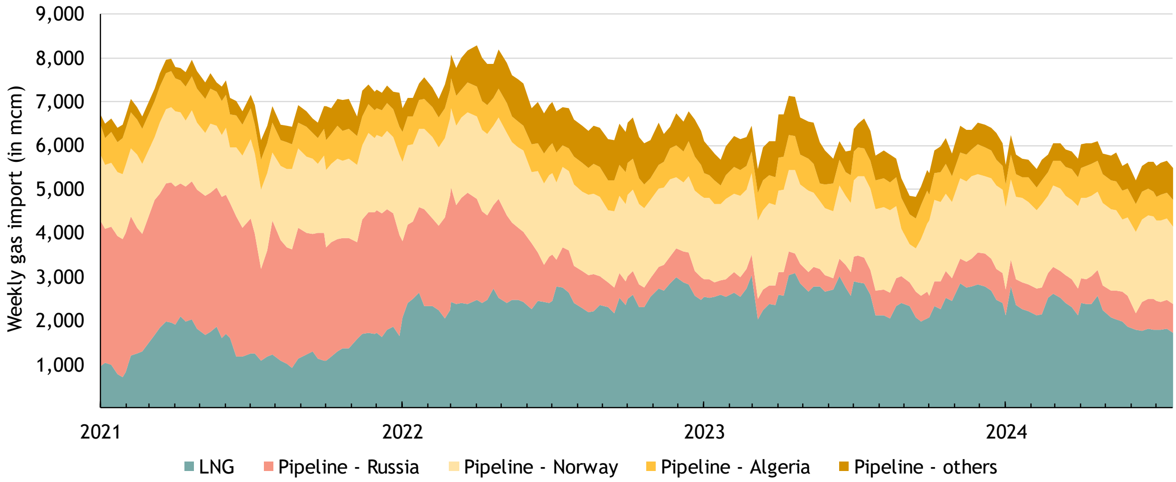

Figure 42: Weekly natural gas imports into the EU from 2021 to 2024 July.

Source: ENTSO-G

The Russian invasion of Ukraine and subsequent impact on pipeline gas deliveries from Russia to the EU, had a fundamental effect on the global LNG market. Hence, in this edition a more detailed picture on the LNG market compared to previous editions is provided.

Before the invasion, Russian pipeline gas was the EU's main source of imported natural gas representing a 40% share (in 2021). This share has in 2023 shrunk to 8% due to restrictions on both sides.[113] The decoupling of the EU energy system from Russian fossil fuel was achieved partially via demand-side reduction, backed by the growth of renewable energy generation and energy efficiency measures – while the still remaining gas supply gap has been bridged via increased LNG imports to the EU. This section focuses on the recent developments of the LNG market, including the changes of the LNG import share over time, the sources of imported LNG, and EU-member states' initiatives to build additional infrastructure for LNG imports.

Figure 43 below shows the relationship between the EU LNG imports, both in absolute terms and as a share of the total gas import and consumption. In the first decade of the 2000s, LNG imports in the EU showed a significant increase thanks to the new LNG infrastructure coming online in many European countries (e.g. Spain, Italy, France, UK, Netherlands and Belgium) – more than doubling the available import capacities that have been built up until that point, in the 40 years prior.[114] The limited priority to invest in LNG infrastructure until 2000 can partially be assigned to Russian pipeline gas' competitiveness over LNG[115], and the abundantly available European supply coming from the Netherlands (up until 2023 when the operation of the largest Groningen gas field was suspended) and Norway, both reducing the need for LNG.[116]

As can be seen on the figure below, the LNG imports have been in a slight decline in the first half of the 2010s, and only started to increase again between 2014 and 2019. This can be attributed to the Fukushima incident and the consequent switch from nuclear electricity generation to natural gas in Japan[117] - which created significant competition on the LNG market, driving the LNG exporters to Asia, in particular in Japan, where they could find higher prices than in Europe all throughout the 2010s up until 2019 (see Figure 43), stalling the development of the sector in Europe.

[113] European Council. (2024). Where does the EU's gas come from?
[114] Gas Infrastructure Europe. (n.d.). LNG database
[115] Baker Institute for Public Policy. (2023). Why is Europe not replacing Russian pipeline gas with long-term LNG contracts?
[116] Gas Infrastructure Europe. (n.d.). LNG database
[117] The National Bureau for Asian Research. (n.d.). Energy mix in Japan - before and after Fukushima

Over the mid-2010s, due to the shale gas development, the US emerged as a significant natural gas exporter on the world stage[118],[119] and became the largest source of imported LNG in Europe in the following decade[120] overtaking Qatar and Russia (as seen in Figure 44). This global supply expansion, combined with a mild Asian winter in 2019 created an oversupply and, therefore, a price drop for LNG, which (facing the lower demand in Asia) diverted more to the European markets, creating an import jump on the European continent (as observed on Figure 43).

Between 2019 and 2021, net LNG imports into the EU declined slightly (from 86 bcm to 73 bcm), which is partially related to the decreased economic activity due to the pandemic. The European gas crisis that started to unfold already in late 2021[121] created a political need to quickly move away from the Russian (pipeline) natural gas sources, and consequently generated a large demand for LNG[122]. The year 2022 brought a large (75%) jump in LNG imports in Europe. This is due to the geopolitical developments in early 2022, and the subsequent political actions of the European Commission and EU Member States against the Russian Federation, enabled by several successful LNG infrastructure projects both in the US (on the export side) and in the EU (on the import side, as detailed later and seen on Figure 44 and Figure 45). The 2023 LNG imports into the EU again exceeded expectations surpassing the 2022 import level at 132 bcm.[123]

The US natural gas markets proved to be significantly more resilient over the crisis in 2021-2023 owing to the significant domestic gas supply in the US due to the shale gas development[124], and its spare capacity to increase its LNG exports, making US LNG a competitive option on the European natural gas markets. This aided the US in taking about half of the LNG import market of Europe over by 2023.[125] The sharp increase in LNG demand on the EU market is, however, expected to peak in 2024 due to the EU's declared energy and climate goals, which would lead to a marked gas demand decline, settling at approx. 40% of the current demand by 2030 (based on the REPowerEU projections).[126]

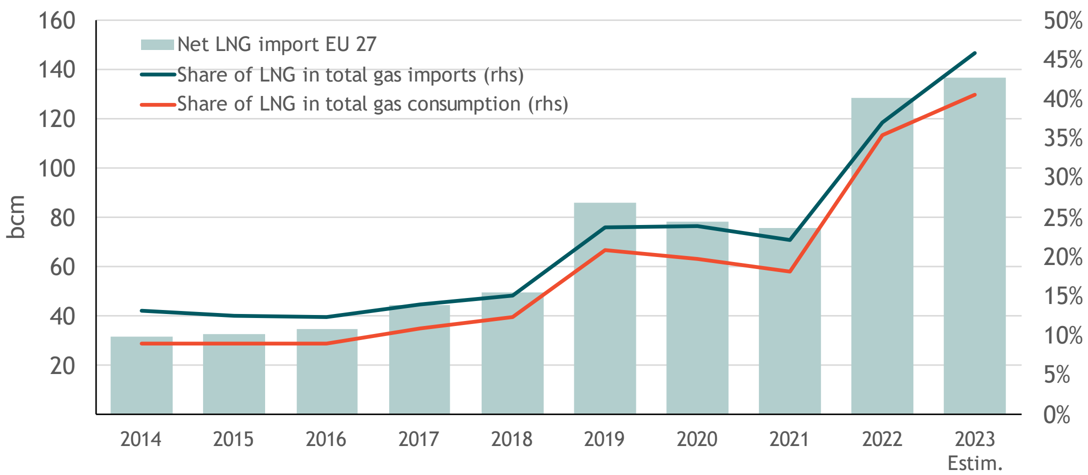

Figure 43: LNG imports and their share in the EU-27 total gas imports and consumption.

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[118] *ACER. (2024). Analysis of the European LNG market developments - 2024 Market Monitoring Report*

[119] *IEA. (2020). LNG exports for selected countries, 2015-2025*

[120] *U.S. Energy Information Administration. (2024). The United states remained the largest liquefied natural gas supplier to Europe in 2023*

[121] *CEPR. (2024). The European energy crisis and the consequences for the global natural gas market*

[122] *ACER. (2024). Analysis of the European LNG market developments - 2024 Market Monitoring Report*

[123] *ACER. (2024). Analysis of the European LNG market developments - 2024 Market Monitoring Report*

[124] *K. Aruga. (2016). The U.S. shale gas revolution and its effect on international gas markets*

[125] *U.S. Energy Information Administration. (2024). The United states remained the largest liquefied natural gas supplier to Europe in 2023*

[126] *ACER. (2024). Analysis of the European LNG market developments - 2024 Market Monitoring Report*

Note: 2023 volumes are estimated by Enerdata based on extrapolation of monthly data for 2023.. New data from a 2024 ACER report[127] suggests the 2023 estimation is close to the final numbers.

Figure 44 below shows the evolution of Europe's LNG import dependence on the different global exporters over time. Notably, the overall LNG import volume doubled from 60 bcm in 2010 to 120 bcm in 2023. Another noteworthy development is the aforementioned expansion of US-sourced LNG in the import mix, especially since the drastic reduction of Russian (pipeline) gas imports. As the Russian LNG import shows no significant reduction over the past 5-year period (between 2018 and 2023), and the overall EU gas consumption shrank rather significantly due to measures reducing gas demand put in place to establish strategic independence from Russia[128], it can be concluded that the additional demand for LNG is mainly driven by the reduction of Russian pipeline gas supply rather than by other market forces.

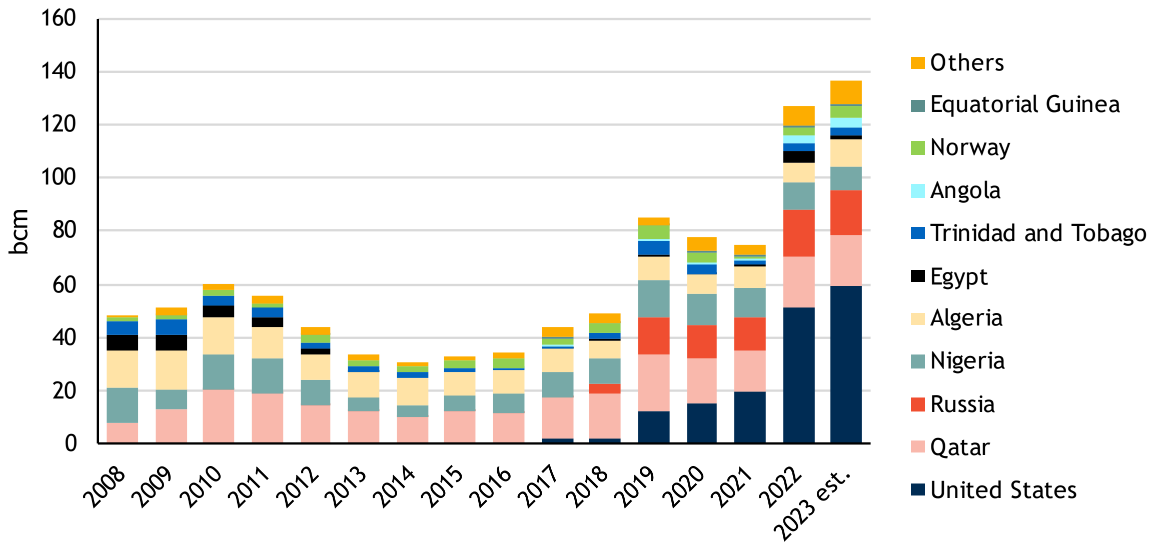

Figure 44: Main sources of imported LNG to the EU from 2008-2023

Source: Eurostat.

Note: the provided number for 2023 is an estimated value based on monthly import volumes in the first months of 2023.

Figure 45 shows the evolution of the LNG import capacity of the EU in 2008-2023. The first European LNG terminal was built in Spain, and is operational since 1969. LNG import capacity was greatly expanded in the early 2000s due to very similar reasons as today – high energy prices, concerns over security of gas supply, doubts about the reliability of Russian pipeline gas delivery[129] – but development stalled between 2010 and 2020 due to the LNG demand generated in Japan by the Fukushima disaster, and lack of competitiveness of LNG against Russian pipeline gas import.

The disruption of pipeline gas supply from Russia in 2022 provided an immediate and important push to the expansion of LNG import capacities in the EU, to ensure security of gas supply. In total, regasification capacity in the EU increased by 12% in 2022 and another 15% in 2023.[130] LNG import capacity increased the most in Germany (representing ¼ of the overall capacity increase in the EU), where several floating LNG terminals came online since 2022 and with further plans to expand capacity towards 2030. In the EU, the overall regasification capacity increased to 220 bcm, with an additional 120 bcm capacity in development (planning stage or under construction) until 2030.[131] The

[127] ACER. (2024). Analysis of the European LNG market developments - 2024 Market Monitoring Report
[128] Bruegel Institut. (2024). European natural gas demand tracker
[129] JRC. (2009). Liquefied Natural Gas for Europe - Some Important Issues for Consideration
[130] ACER. (2024). Analysis of the European LNG market developments - 2024 Market Monitoring Report
[131] Gas Infrastructure Europe. (n.d.). LNG database

EU Member States with major LNG regasification capacities are Spain, France, the Netherlands, Italy, and since 2023, Germany – but 9 other Member States also have LNG terminals. The EU's overall capacity grew by 40 bcm in 2023 alone, and is expected to expand by an additional 30 bcm in 2024.[132]

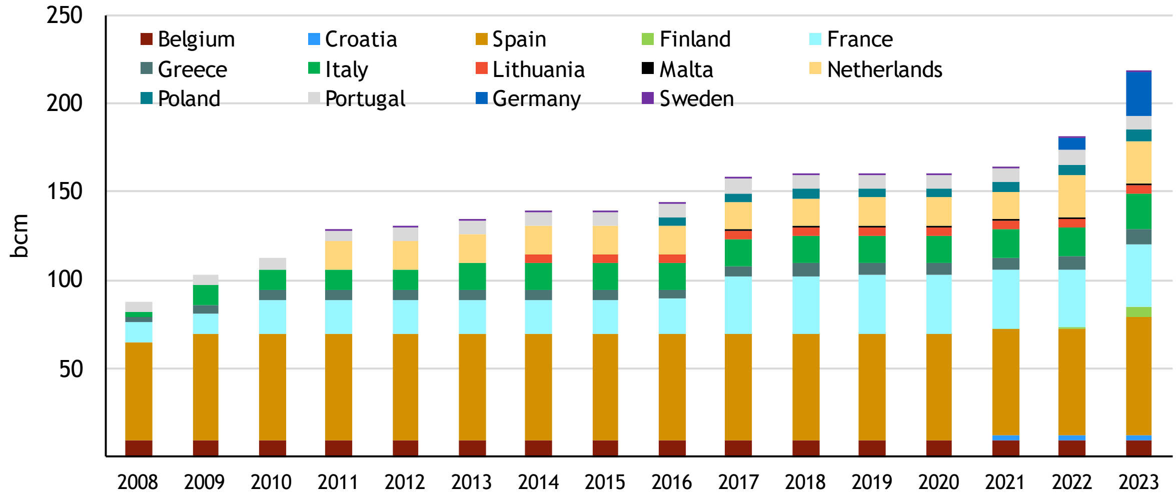

Figure 45: LNG import/regasification capacity of EU member states in 2008-2023.

Source: Enerdata EnerMonthly

Notwithstanding the short-term benefits of additional LNG import capacity, there is also a risk for overcapacity in the medium term, taking into account the stream of recently completed and planned new terminals. While ample capacity is positive for security of supply in the EU-27 and is seen as 'a strategic insurance policy for unexpected events' by ACER[133], it also decreases the business case of existing import pipelines and terminals and creates additional incentives to longer rely on fossil gas. Figure 46**Error! Reference source not found.** shows the utilisation rate of LNG terminals in 2023. Although the utilisation rate in 2023 was the highest in recent years, the figure shows there was still sufficient flexibility and capacity to import LNG. However, the utilisation of LNG import capacity was in 2022-2023 also constrained by physical or contractual congestion on gas pipelines within the EU. Most spare LNG import capacity is situated in Spain (utilisation rate of only 34% in 2023). Some experts estimate that LNG demand will shrink towards 2030 while LNG import capacity will further increase, leading to lower utilisation rates.[134]

[132] *Council of the European Union. (2024). Liquefied natural gas infrastructure in the EU*

[133] *ACER (2024). Analysis of the European LNG market developments*

[134] *Institute for Energy Economics (2024). European LNG tracker.*

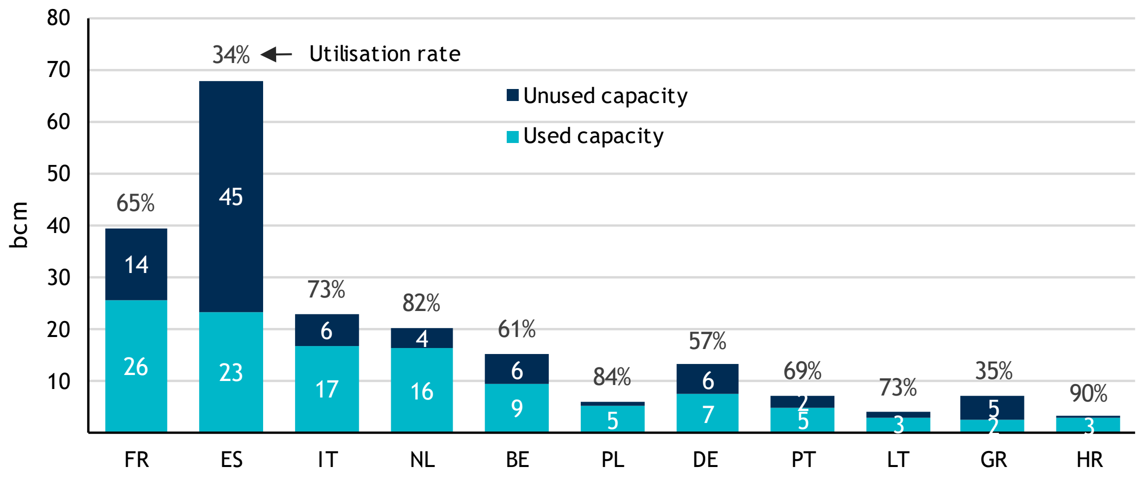

Figure 46: LNG terminals' capacity and utilisation rate breakdown by EU-27 country for 2023.

Source: ACER (2024 Market Monitoring Report) and ALSI GIE.

Figure 47 shows an overview of representative global LNG export (FOB) and import (CIF) prices. The figure shows that LNG import prices were structurally low and did not exceed 40 EUR_{2023}/MWh between 2016 and 2021. Similar to all gas price indexes, LNG import prices (CIF) increased throughout 2021 up to all-time high levels in 2022, with prices peaking at 200 EUR_{2023}/MWh in the EU, Japan and Korea; during 2022 import prices were structurally above 100 EUR_{2023}/MWh. The NL TTF import prices benchmark compared with the LNG FOB prices of major exporters, it can be seen that until 2021 EU hub prices – for a large part trading also pipeline gas supply – were lower than LNG FOB (and certainly CIF) prices. However, during the energy crisis in 2022, LNG FOB prices from the US or Australia were relatively lower compared to the TTF benchmark. As of 2023, US export LNG prices have decreased again to levels similar to before the energy crisis at around 25 EUR_{2023}/MWh.

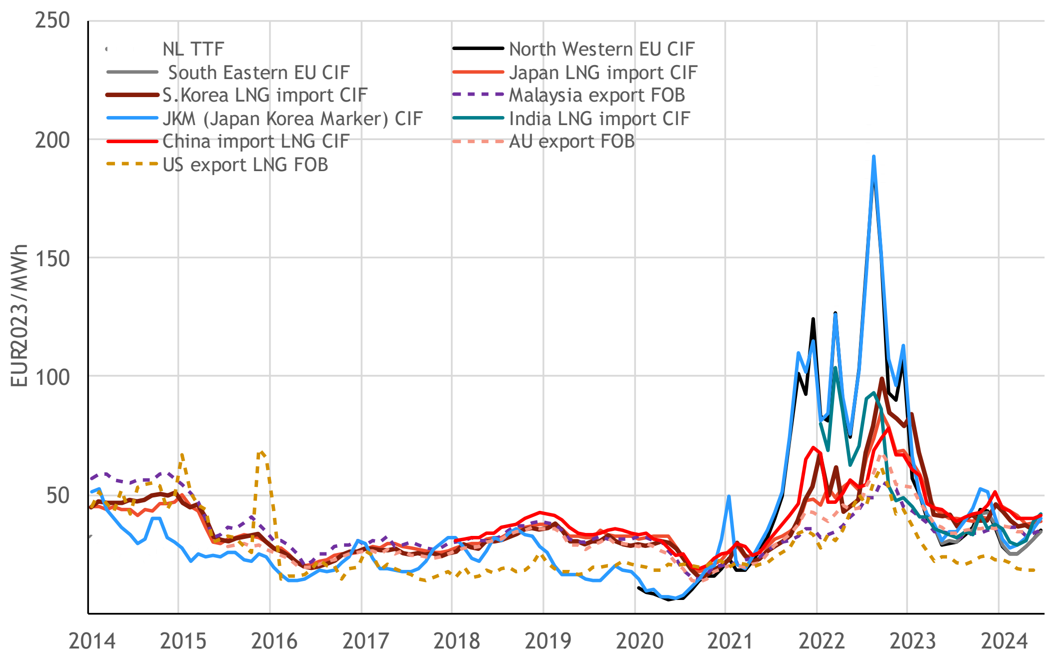

Figure 47: Overview of wholesale LNG prices in global regions in EUR_{2023}/MWh. Note that the figure both displays FOB (Free on Board) prices with dotted lines and CIF (Cost, Insurance, Freight) prices. CIF prices include more costs and hence are higher. The Dutch NL TTF benchmark price is also shown for comparison.

Source: S&P Platts, Enerdata EnerMonthly

3.1.3. International comparison of wholesale gas prices

This section presents an international comparison of wholesale natural gas prices. Such a comparison of the prices in the EU and its main global trading partners provides important insights into the competitiveness of European industry, and especially the competitiveness of energy-intensive sectors where the energy related costs form a large share of their final production costs.

Figure 48 shows (proxies for) day-ahead wholesale gas prices in the EU and its major trading partners. The figure shows that in general gas prices in the US have been lower than in other regions mainly due to its increasingly significant domestic production including the shale gas development. Prices in Japan and Korea generally were higher than in the EU because of their lack of domestic production, and the consequent reliance on LNG instead – their geographical position also ruling out (cheaper) pipeline supply, making Japan the second largest importer of LNG globally. Chinese gas prices were relatively high until 2021 but price increases during the energy crisis have been significantly lower in China than in other regions. A partial explanation for the lower prices in China (and India) can be found in the fact that gas demand in these countries generally is more price-sensitive than in the EU or Japan, where there is a lot of inelastic demand from household consumers. In contrast, China and India back away from expensive spot deliveries due to their higher price elasticity; as they mainly use gas in industry and for power generation. During high prices gas-to-coal switching for power can relieve demand and industrial production can temporarily ramp down or shut down.

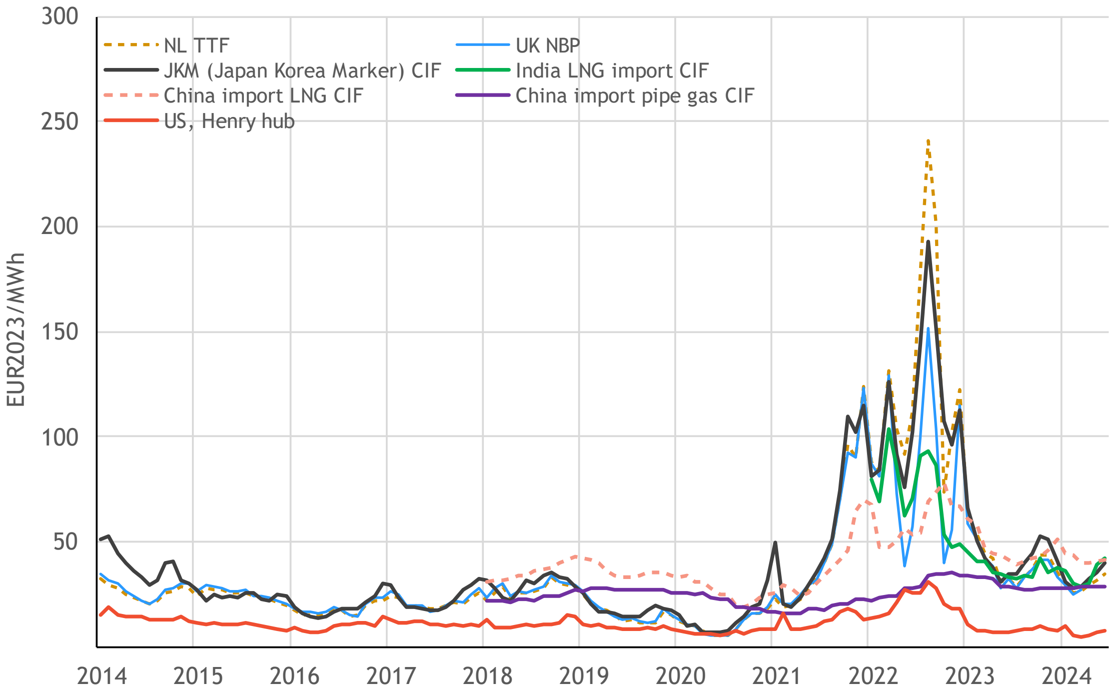

Figure 48: Day-ahead wholesale gas prices in the EU (NL TTF) and its major trading partners – China, Japan/Korea, India and the US in EUR_{2023}/MWh. For Japan/Korea, India and China LNG CIF prices are used as proxy.

Source: S&P Platts, Enerdata EnerMonthly

For completeness, Figure 49 also shows wholesale gas prices in other G20 countries, such as Indonesia, Brazil, Russia, and Canada. LNG spot prices in Indonesia and Australia are similar to the EU, while (significantly) lower price levels can be observed in recent years in large gas producers such as Russia, and Canada.

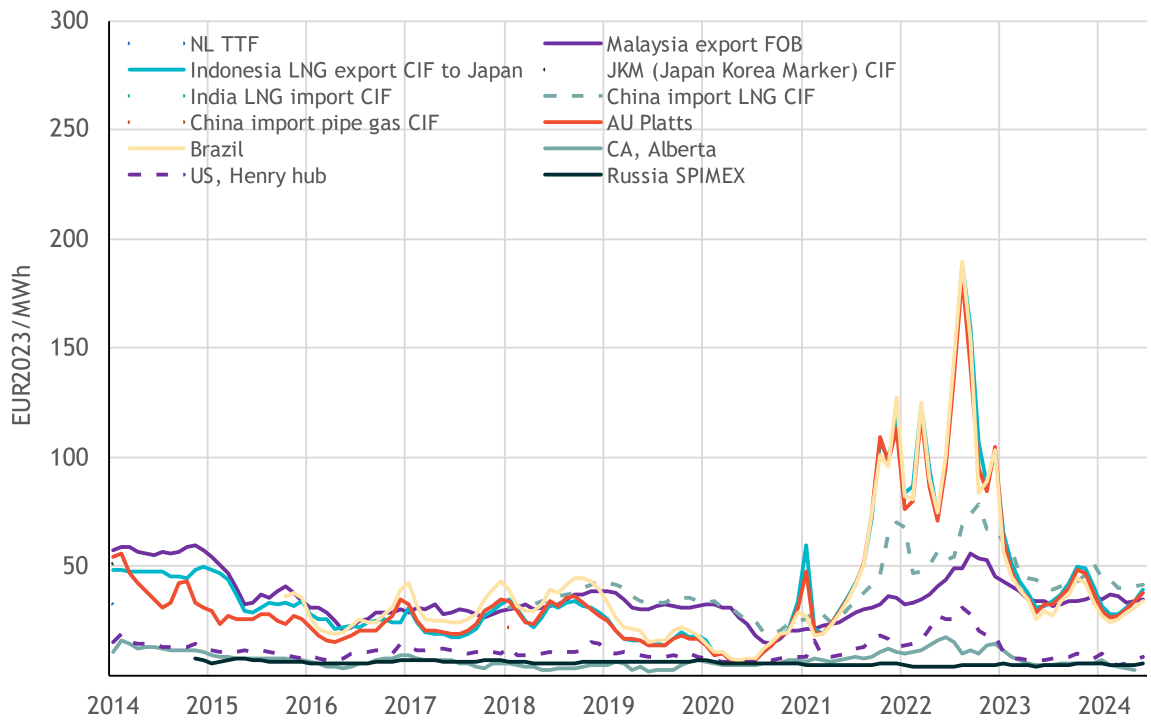

Figure 49: Day-ahead wholesale gas prices in the EU (NL TTF) and other G20 countries, such as Indonesia, Brazil, Malaysia, Australia, Canada and Russia. Part of the data overlaps with the previous figure: new data is presented with solid lines, while data already showed in the above figure has dashed lines in this figure.

Source: S&P Platts, Enerdata EnerMonthly[135]

Figure 50 provides a closer look into on how EU gas prices compare to prices in major trading partners the US and Japan. Pre-2020 European prices generally were lower than in LNG-dependent Japan. On the other hand, in the same period, the US gas market (albeit with much more significant fluctuations) displayed significantly lower natural gas prices than its European counterpart owing to the abundant domestic supply and limited export capacity. In Q1 2020, the combination of lockdown measures, the abundance of renewable energy and LNG supply (also thanks to the growing US export capacity), and the mild weather conditions brought the European gas prices down by 40-50% year-on-year.[136] This resulted in the EU gas prices (EU TTF) reaching parity, and even dipping temporarily below the US levels (Henry Hub), and way outperforming the Japanese markets. However, the correction came immediately, and the gas supply crisis of 2021, followed by the energy crisis of 2022 pushed European gas prices to peak levels never observed before. In 2021-2022, European gas markets traded at a higher price than the Japanese counterparts for the first time since at least 2008. Since 2023, gas prices stabilised in the EU and are now very similar to Japanese prices, showing the shift in Europe from cheap pipeline supply to price formation driven by LNG, similar to Japan.

[135] Note: the type of price indices differs per country; for some there is data on import CIF prices, some reflect export FOB prices, while some other present hub prices (NL TTF, Henry Hub).

[136] *European Commission (2020). Quarterly Report on European Gas Markets.*

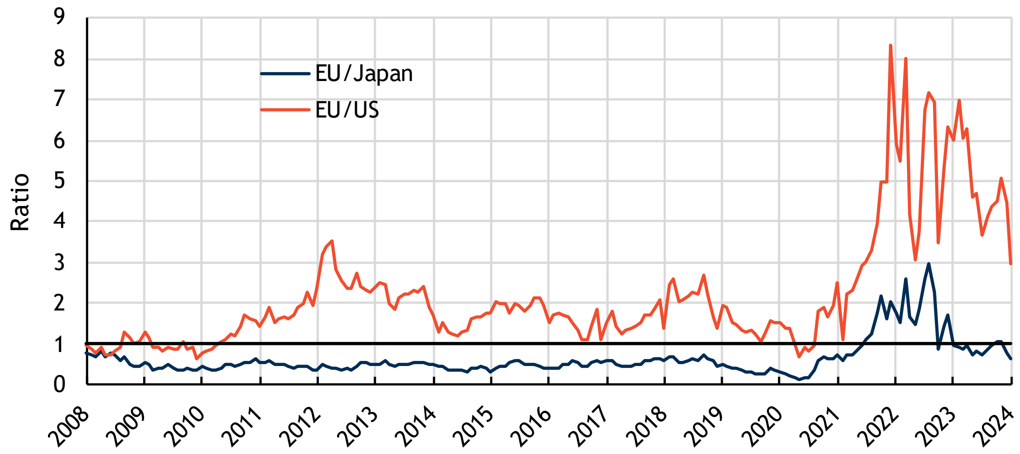

Figure 50: The ratio of European versus US and Japanese day-ahead wholesale gas prices (nominal).

Source: S&P Platts, Enerdata EnerMonthly

3.2. Retail prices

Main Findings

Natural gas retail prices are largely the result of wholesale gas price developments – but the pass-through rate from wholesale to retail prices depends on many factors, such as region and market segment, and other retail market characteristics. This section mainly provides an analysis on average annual retail prices, which means some trends and their impacts on individuals or even groups of gas users are not emphasised to their full extent, as they do not form a core part of the analysis.

Households

- In parallel with the large increase in wholesale prices in Q4 of 2021 and 2022, **average retail household prices** in the EU started to increase from their earlier level at around 70-80 EUR_{2023}/MWh in 2021 to a price level of 125 EUR_{2023}/MWh in August 2022. Surprisingly, after this price peak, the average EU-level retail price component stayed very constant at a level of around 105 EUR_{2023}/MWh. However, behind this average, significant differences between Member States and between consumers are hidden. **Household gas prices, further increased** from 100 EUR_{2023} /MWh in 2022 to 112 EUR_{2023}/MWh in 2023. However, prices were highest from Q3 2022 to Q2 2023, after which they entered into a decreasing phase, but annual averages do not fully reflect this trend. Prices have been stabilizing since Q3 2023 in all Member States, although at levels almost twice as high as pre-crisis (100 EUR_{2023}/MWh instead of ~60 EUR_{2023}/MWh).
- The energy crisis resulted in **significant differences in household gas prices** both between and within Member States. Big differences can be observed **between Member States**, due to differences in retail market characteristics and national crisis measures and their consequences for the pass-through rate. Retail prices in 2023 were highest in Sweden and the Netherlands (~205 EUR_{2023}/MWh) and lowest in Romania, Croatia and Hungary (all lower than 55 EUR_{2023}/MWh).
- **Differences for households within Member States can also be observed**, due to the prevalence of supply contracts at fixed price, the price increase for individual households depends significantly on the moment that their supply contracts have to be renewed or when new prices are set within contracts (for variable price contracts).
- Notably, most Member States implemented far-reaching **temporary measures** aimed at preventing very high price levels for (certain) households. This had a **significant mitigating impact on retail price levels** throughout the EU, albeit at a large financial cost for governments. As examples, some MS froze retail prices at low levels (e.g. Hungary), while other MS implemented price ceilings (e.g. the Netherlands) or lowered the VAT rate (e.g. Belgium, Germany). Gradually

in 2023 most of these temporary relief measures have been removed, thereby creating upward price pressure at a time that wholesale prices decreased. Partially due to these relief measures, the average tax component decreased from 23 EUR_{2023}/MWh in 2021 to 21 EUR_{2023}/MWh in 2022 and 2023.[137] Network costs averaged 19 EUR_{2023}/MWh in 2023. Despite the temporary measures, the impact of the energy crisis on the gas expenses of individual households has been very high in some cases.

- Compared with other global regions, **EU retail gas prices have historically been relatively high** (though different per MS), also due to relatively high network costs and taxes in the EU and large subsidies in other regions. This was not different during the energy crisis, although household prices also significantly increased in many other regions, such as the US.

Industry

- In this report both the end-user gas prices for the I3 consumption band (representative for medium-sized industry) and I5 (energy-intensive industry) band are analysed.
- During the energy crisis, **average gas prices for the I3 consumption band almost doubled** from 40 EUR_{2023}/MWh in 2016-2019 to 74 EUR_{2023}/MWh in 2022 and 76 EUR_{2023}/MWh in 2023. For the I5 band, prices surged from 39 EUR_{2023}/MWh in 2021 to 87 EUR_{2023}/MWh in 2022 but reduced more quickly to 59 EUR_{2023}/MWh in 2023.
- Compared with households, **relief measures were not implemented on the same scale** for industry. This contributed to larger average price increases for industry compared to households. Tax levels and network charges are also generally lower for industry: for medium-sized industry taxes were 7 EUR/MWh (7% of total gas price) and network charges 6-7 EUR_{2023}/MWh (6-7%). For large industry taxes accounted for 3-4 EUR_{2023}/MWh (3-4%) and network charges 2-3 EUR_{2023}/MWh (2-3%). For both market segments, network charges have stayed relatively stable in the past 10 years, although this differs per MS. Taxes stayed at the same level during the crisis, even without VAT being taken into account, as this is recoverable for businesses.
- The significant increases in gas prices for industry have had a **substantial impact on European industry**: it has led to large cost increases especially for energy-intensive businesses resulting in an industrial gas demand reduction due to industrial facilities limiting or halting their production (sometimes permanently). The higher gas price levels decreased the competitiveness of European industry compared with competitors such as the US and China, where prices were substantially lower. The Green Deal Industrial Plan aims to support existing and new key industrial activity in the EU, partially addressing the lower EU competitiveness in this respect.

3.2.1. Household natural gas prices

The following chapter compares natural gas prices paid by household consumers across the EU in the consumption band 'D2' (falling in the range of 20 to 200 GJ annually, as defined by Eurostat[138]. This is the most representative consumption band in most of the EU countries, according to Eurostat.

Evolution of household gas prices

Household gas prices remained relatively stable in the period 2014-2021, with an average of 82.7 EUR_{2023}/MWh in real terms during this period, as shown in Figure 51. Then, in 2022, following the global wholesale market trends (see above), and in response to the supply crisis, household retail gas prices also rose significantly – with an increase of 25% from 80 EUR_{2023}/MWh in 2021 to 100 EUR_{2023}/MWh in 2022. The acute gas supply crisis lasted until the second half of 2023, reflecting in a (more moderate) increase of the yearly average price in 2023. However, as of Q3 and Q4 of 2023, the prices have been showing a decreasing pattern.

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[137] *Some relief measures impacted the 'energy and supply' price directly and did not impact the taxes/levies category.*
[138] *Eurostat (2024). Bi-annual gas price data method.*

Composition of household gas prices

A closer look at the composition of household gas prices, illustrated by Figure 51 below, shows that the real-term composition has gradually shifted over time. The most significant fluctuations are observed in the gas supply price component, which accounts for a substantial portion of the overall household gas prices. This component represented about 34-44% of the total price between 2014 and 2021, and increased to 61% and 72% in 2022 and 2023, respectively, as the retail gas prices soared to 61 and 72 EUR$_{2023}$/MWh over the same period. Taxes and levies also fluctuated during this period, with the most noticeable reduction occurring in 2022 when many Member States temporarily reduced taxes and levies on energy products to mitigate the impact of soaring market prices on households. This is reflected in both an absolute reduction (from 27 EUR$_{2023}$/MWh in 2021 to 22 EUR$_{2023}$/MWh in 2022) and a declining share of taxes/levies in the total price, which fell from 34% in 2021 to 22% in 2022. Network-related costs have remained relatively stable, hovering around an estimated 18-20 EUR/MWh from 2014 to 2023 in real terms – but with the sudden increase in energy prices, the relative share of the network costs in the overall household gas price has declined significantly in 2022.

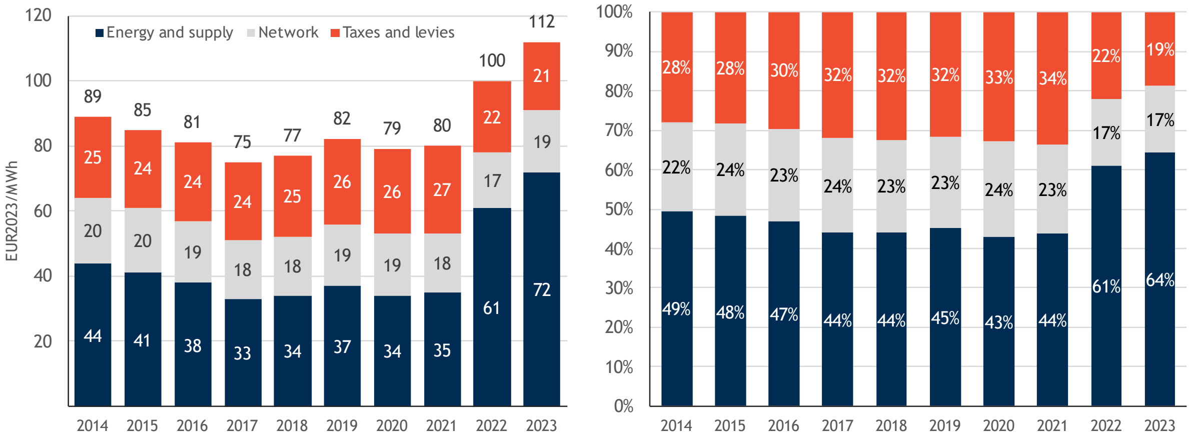


Figure 51: Composition of the EU household gas price in EUR2023/MWh (D2 consumption band).

Source: Eurostat

Situation in individual Member States

In 2023, the highest retail household gas prices in the EU were observed in Sweden (210 EUR$_{2023}$/MWh), the Netherlands (206 EUR$_{2023}$/MWh), and Lithuania (169 EUR$_{2023}$/MWh). These high prices are partially due to the higher tax components in these member states, with taxes/levies comprising 33% (70 EUR$_{2023}$/MWh) of the total price in Sweden and 40% (81.7 EUR$_{2023}$/MWh) in the Netherlands. In comparison, the taxes/levies in the EU represented 18% of the total price on average.

In Sweden, a carbon tax – aimed at reducing greenhouse gas emissions – combined with a limited gas network tariff contributes to comparatively high taxes and levies price. Network charges are also high in Sweden. In the Netherlands, high household gas prices are mainly driven by high tax rates on natural gas consumption. However the Netherlands has a fixed tax refund on the energy bill for electricity, reducing overall tax expenditure per households significantly; during the energy crisis this fixed refund was increased.[139] In Lithuania, the high household gas prices are primarily due to high energy and supply costs (highest among EU Member States), which accounted in 2023 for 74% (124.7 EUR$_{2023}$/MWh) of the total retail gas prices. As Figure 52 shows, Member States such as Hungary, Croatia, and Romania in 2023 had the lowest household gas prices in the EU, well below the EU average of 112 EUR$_{2023}$/MWh. In 2023, Luxembourg had the lowest relative tax level, with subsidies and allowances leading to a 'negative' tax level of 42.7 EUR$_{2023}$/MWh (Figure 53 and Figure 54), which

[139] *Tax Authority Netherlands (2024). Energiebelasting en opslag duurzame energie- en klimaattransitie*

means temporary price mitigation measures led to a price lower than the energy and supply price, which is reflected in the data as a negative tax and levy level.

Figure 52 below shows the tax components in the household gas prices and the changes in taxation of household gas consumption in 2023, compared to 2021. Almost all components of taxes/levies appear to have increased – with the notable exception of the 'Other' category of taxes, which became negative due to relief measures applied by most EU Member States in response to the very high energy prices. Overall, 2023 sees lower overall taxes compared to 2021 (21.2 vs 23.1 EUR/MWh).

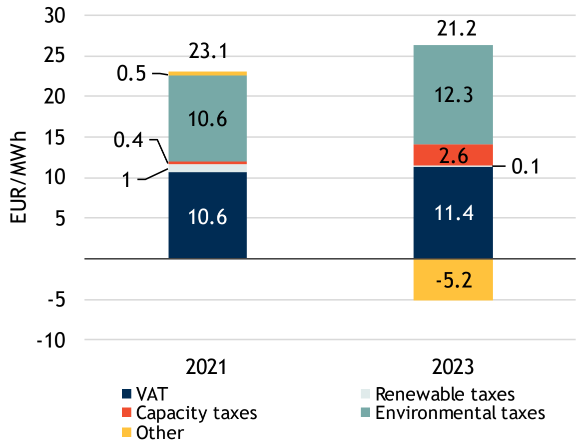


Figure 52: Composition of EU taxes and levies on household gas prices in 2021 and 2023. Note that the 'other' category is negative due to relief measures adding up to a 'negative' tax in some cases.

Source: Eurostat

Figure 53 shows the average household gas prices by EU Member States in 2023. The highest prices were observed in Sweden, closely followed by the Netherlands. Household gas consumers in these countries were paying almost twice as much than the EU average. On the other end of the scale, the lowest price was observed in Hungary, where strong government intervention has kept the retail gas prices artificially low since 2012 – to the detriment of e.g. energy efficiency goals. This policy – which included a blanket price cap for all consumers (households and industry, until 2022 when most industrial consumers were excluded) of (among others) electricity and natural gas – was found to be favouring the higher income households, and resulting in a substantial over-consumption of energy resources over the years leading up to the energy crisis.[140] The strongly increasing energy prices in 2022 rendered the measure untenable, forcing the Hungarian government to limit it to the portion of consumption corresponding to a calculated 'average' consumption – basically excluding industrial and institutional consumers from the measure, and keeping it to (a part of) household consumption only.[141] Also, household consumers in Luxembourg were in 2023 subsidised significantly, resulting in a negative taxes and levies component in the total price. Figure 54 shows the composition of household gas prices per EU Member State in 2023. The data shows a big variation in the composition of prices between Member States.

[140] Cs. Weiner, T. Szép. (2022). The Hungarian utility cost reduction programme: An impact assessment

[141] Magyar Közlöny (2022. július 21.)

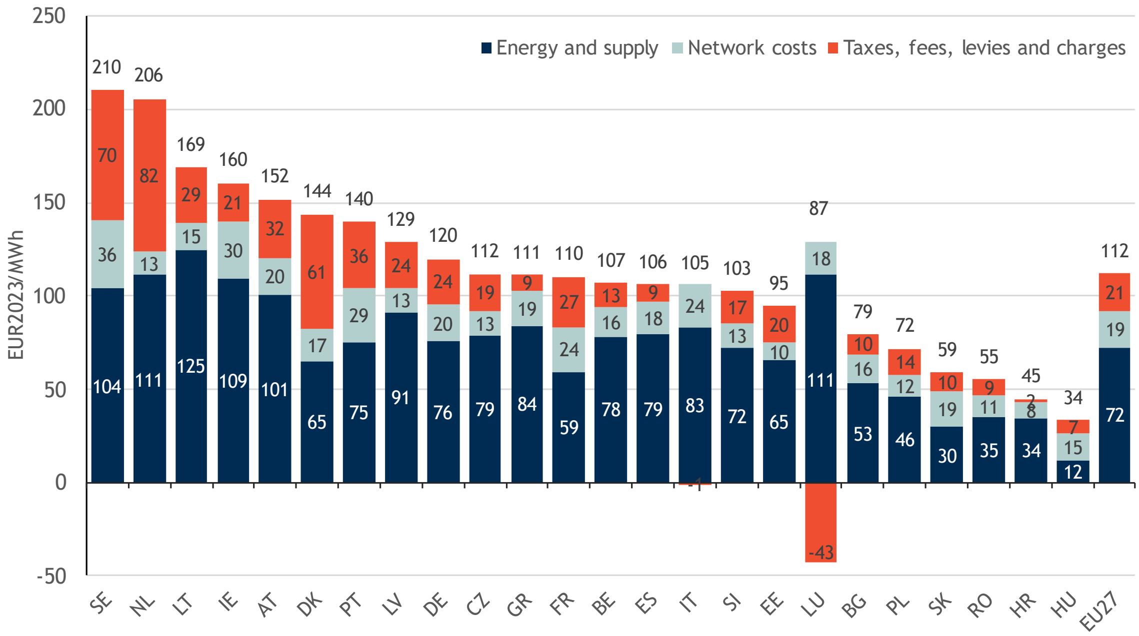


Figure 53: Average household gas prices in EU Member States in 2023 in the D2 consumption band in EUR_{2023}/MWh.

Source: Eurostat[142]

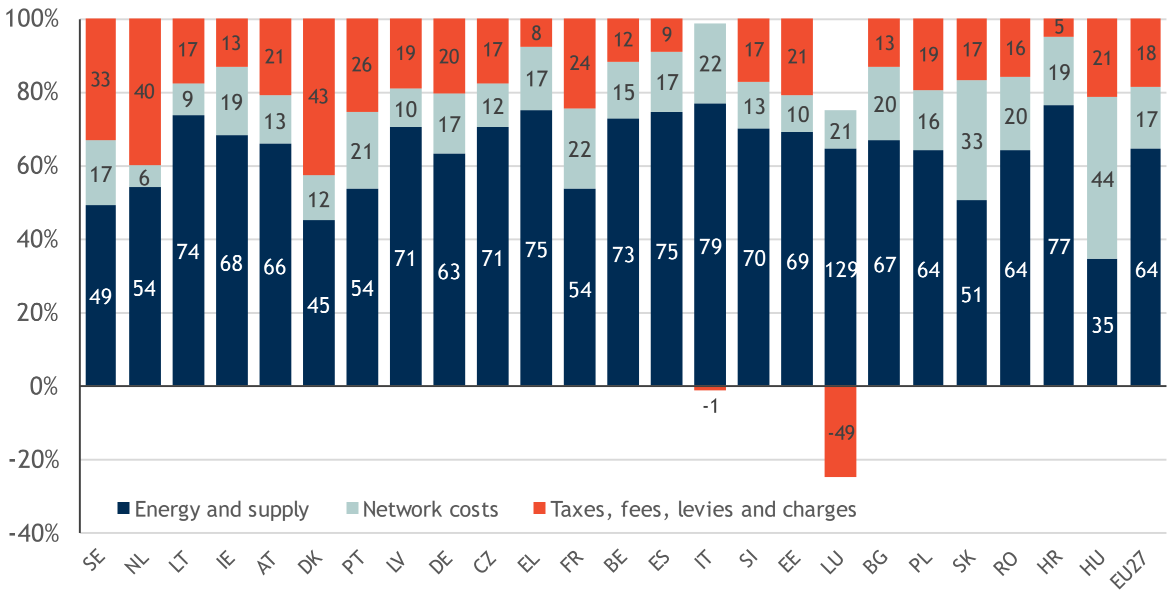


Figure 54: Average composition of household gas prices in EU member states in 2023.

Source: Eurostat

Figure 55 shows a more detailed picture of the evolution of household gas prices over the period between 2019 and 2023. The figure clearly shows that while the yearly average price in 2023 further increased (as observed on Figure 51 above), the monthly prices have been trending downwards in all Member States – especially in the second half of the year.

[142] Note: Luxembourg had a retail price cap of 87 EUR/MWh and Italy had a temporarily regulated price scheme that led to virtually negative tax rates This is reflected in the figure with tax rate of 0 and adjusted through a lower 'energy and supply' price.

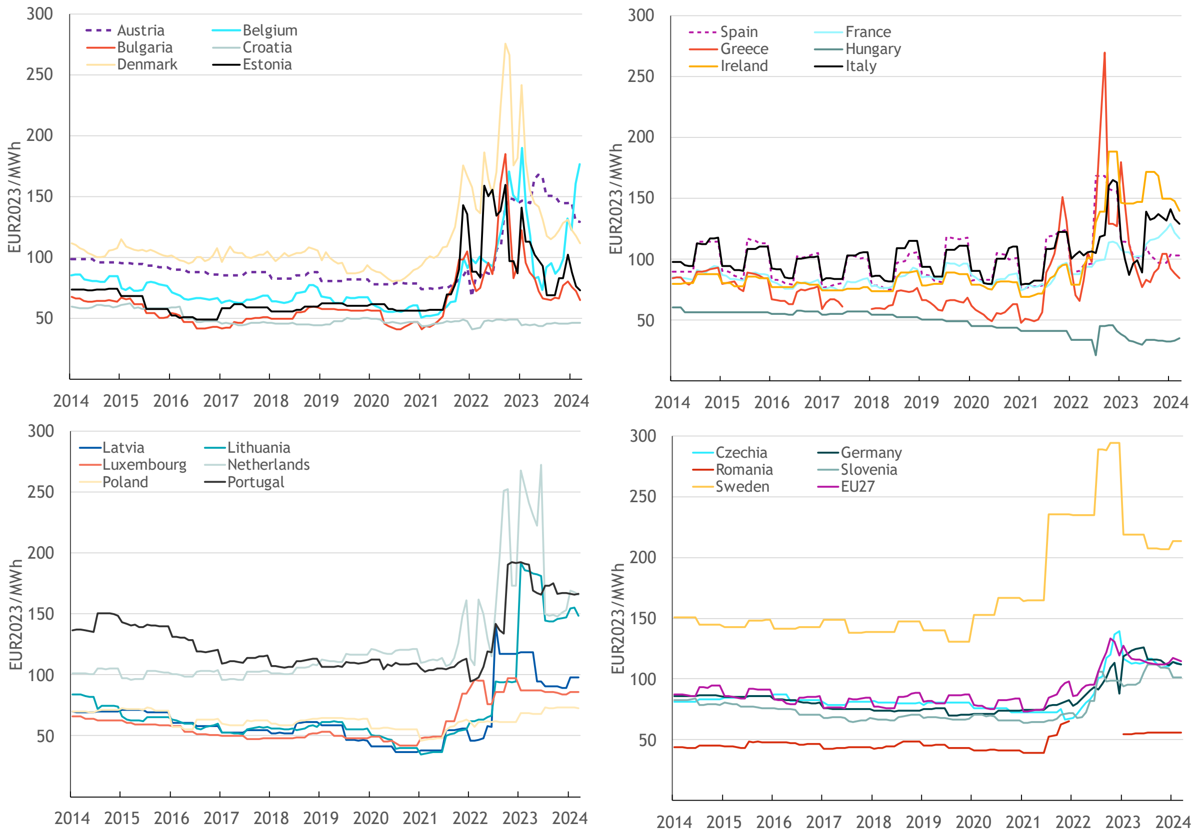


Figure 55: Average household retail gas prices in the EU-27 in EUR_{2023}/MWh from Jan 2019 - June 2023.

Source: Eurostat

International comparison of household retail gas prices

Figure 56 shows the development of household prices in the EU (on average) and in some of its peer international trading partners – the US, the UK, and Japan between 2014 and 2024.

The EU average household gas prices increased significantly during the gas supply crisis, trending from around 80 EUR/MWh in 2021 to 130 EUR/MWh in October 2022. 2023 brought less volatility and stabilising prices for household consumers – but still at a high price level just below 120 EUR/MWh. These prices have not notably decreased by Q1 of 2024 either.

The EU gas prices – the EU being heavily import dependent – are and have been trending consistently (about 60%, pre-crisis) higher than the US gas prices, showing the largest intra-year volatility, but the most perennial stability even during the 2021-2022 energy crisis thanks to its domestic production and consequently low reliance on import. While the energy crisis had some comparatively minor effects on the US market too, it eventually increased the gap between the US and the EU average prices to 240% (from the 60% pre-crisis level).

While the average EU household consumers experienced a significant price increase in 2022, UK consumers (although from a lower baseline, from around 60 EUR/MWh, taxes and levies included) witnessed a more significant increase in their gas bills compared to the EU average. At the height of the crisis (autumn 2022), the UK gas household prices reached as high as 175 EUR/MWh (taxes and levies included). Prices also 'normalised' somewhat slower than the EU average, the UK market displaying significantly higher prices all throughout 2023 (between EUR 140 and 160 for the most part). The UK's vulnerability – compared to the EU average, but not necessarily compared to all EU

Member States individually – to the gas crisis can be explained by its higher dependence on natural gas (39% of its energy mix[143], compared to the 27% European average[144]), combined with a low production of the North Sea gas fields in the same year, and therefore an increasing import (by 10%, year-on-year[145]). The UK also has very little natural gas storage capacity[146] compared to its reliance on gas, meaning that the UK prices are more dependent on the short-term market developments, and therefore prone to volatility, which was also a contributing factor for the remarkable price spike in 2022. But by 2024, the UK prices basically closed this gap, and joined the EU price levels at around 120 EUR/MWh.

Historically, the natural gas market of Japan tended to clear on the highest price levels among the four markets analysed. From 2014 to 2022 Japanese household gas prices averaged between 120 and 140 EUR/MWh (while the EU prices averaged at 80 EUR/MWh). The unfolding energy crisis pushed the Japanese market over the EUR 140 barrier, to be quickly followed by a sharp price decrease below both the EU and UK levels in 2023 and 2024. This tendency was accelerated by the steadily declining Japanese domestic natural gas consumption (supported by a change in the energy mix and the demographics of the country)[147, 148, 149], which is expected to create a long-term oversupply of LNG in the country because of the existing long-term contracts[150], and therefore a possibly lower price for the domestic consumers in the coming decade(s). Europe's expected long-term reliance on LNG imports rather than (Russian) pipeline gas means that the EU is losing its favourable position and historical competitive advantage over Japan – a trend depicted in the figure below. Chapter 5 on industrial energy costs zooms in further on costs and competitiveness of the EU industry.

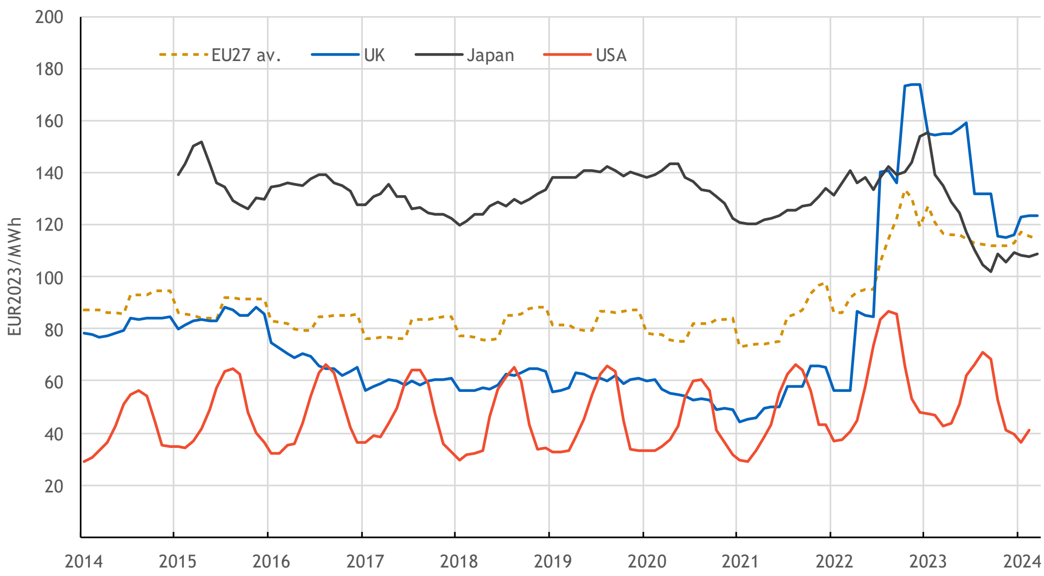


Figure 56: Household gas retail prices in EUR_{2023}/MWh in the EU, Japan, US and the UK.

Source: Eurostat, Enerdata EnerMonthly

[143] IEA. (n.d.). Countries&Regions - United Kingdom

[144] IEA. (n.d.). Countries&Regions - Europe

[145] Department for Energy Security and Net Zero. (2024). Digest of UK Energy Statistics (DUKES), Chapter 4

[146] ENTSOG. (2021). Security of supply - Storages

[147] Institute for Energy Economics and Financial Analysis. (2024). Japan's declining gas demand will leave utilities with persistent LNG oversupply through 2030

[148] U.S. Energy Information Administration. (2023). Countries - Japan

[149] IEA. (2023). Gas Market Report Q2-2023

[150] Institute for Energy Economics and Financial Analysis. (2024). Japan's declining gas demand will leave utilities with persistent LNG oversupply through 2030

Figure 57 shows the evolution of household retail gas prices in the rest of the G20 (where data is available) compared to the EU average in the period 2014-2024.

Russia, being an export-oriented country with regulated domestic energy prices, the household gas prices, just like the wholesale gas prices (see above), do not follow any international/global (market) trends, and the Russian domestic market tends to clear on the lowest, artificially suppressed price levels. The Russian household gas prices are subsidised through heavy regulation, and set by the state at a much lower level than the export netback price of Russian gas. State-owned Gazprom, which has a monopoly in the export of Russian natural gas, remains the largest producer and supplier on the domestic market. Only about 10% of the domestic gas market is traded at an unregulated price.[151] Furthermore, residential gas prices are typically set lower than industrial gas prices (even though transportation costs are usually higher for residential consumers, meaning industrial cross-subsidisation of the residential sector, partially explaining the low price levels on the figure below). Gazprom was given permission by the anti-monopoly agency of Russia to introduce an 8% gas price increase in 2023, with another 8% price increase in 2025, to finance the expanding export infrastructure (in the direction of China).[152] This is following a decade of price increases not surpassing inflation.

Canadian gas prices move together with the US gas prices – displaying the same dynamics, but at a lower, 20 EUR/MWh cheaper level. This is not surprising given the 'continental' nature of natural gas markets – gas being harder to ship than oil, and limited LNG capacities being historically a constraint. The US-Canadian natural gas markets are also coupled through extensive pipeline infrastructure.[153] Similarly to the US, the natural gas prices in Canada also proved to be resilient to the 2022 crisis, thanks to the country's limited dependence on import[154] (and being actually a net exporter). Furthermore, countries, like Türkiye or South-Korea experience a generally lower gas price than the EU average, and were hit less by the energy crisis too.

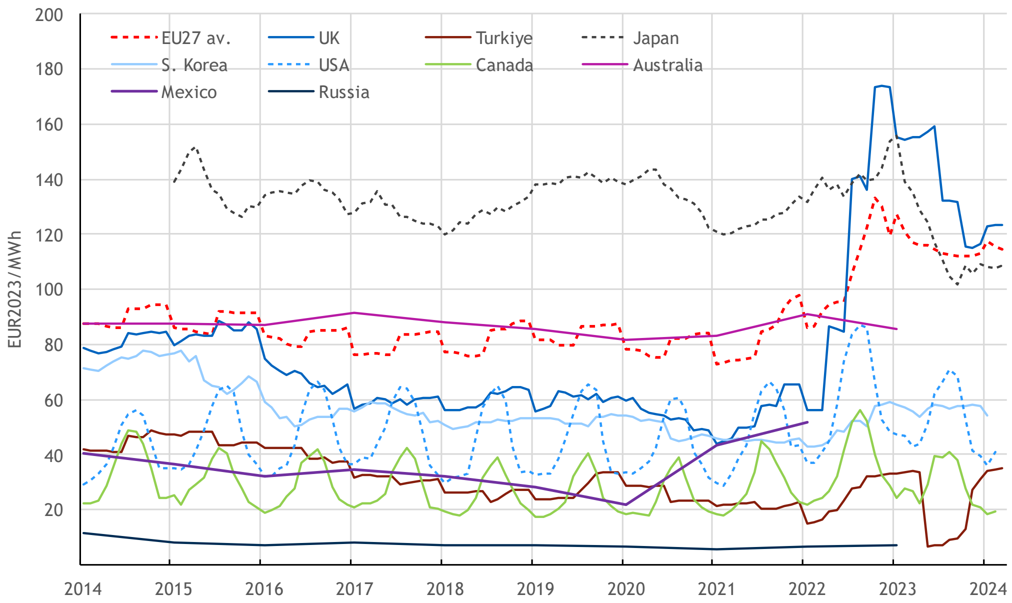


Figure 57: Household retail natural gas prices in EUR2023/MWh in the EU-27 and major G20 trading partners from 2014 to 2024.

Source: Eurostat, Enerdata EnerMonthly

[151] World Bank Group. (2021). Energy subsidies in Russia

[152] Upstream. (2023). Russia approves big hikes in Gazprom's domestic gas prices

[153] Canadian Energy Centre. (2021). Circling the Earth 11 times: Key facts about the Canada-US energy pipeline network

[154] Canada Energy Regulator. (2018). Market Snapshot: Why does Canada import natural gas, while being a major exporter?

3.2.2. Industrial natural gas prices

This section compares the evolution of natural gas prices paid by industrial consumers within the medium ('I3', 10.000-100.000 GJ annual consumption) and large ('I5', 1-4 million GJ) consumption bands, as defined by Eurostat. See the methodological section (page 27 of this document) for more details.

Generally, the overall industrial gas prices (all components included) showed a sharp increase in 2022 due to the gas supply crisis resulting from the disruption of Russian pipeline gas supply. Prices for consumers in the 'I3' band, as reported by Eurostat, doubled from EUR_{2023} 35 per MWh to a historical high at EUR_{2023} 71 per MWh (excl. the mostly recoverable VAT) within one year (2022). A similar (and an even more extreme) trend could be observed for the 'I5' consumption band. Then, in 2023, the market cooled somewhat down – however more for the large industrial consumers in the 'I5' band than for the smaller consumers in 'I3'.

Composition of industrial gas prices

Figure 58 shows how the natural gas price paid by medium-sized ('I3' band) industrial consumers changed over time. The composition of the natural gas price paid by industrial consumers in the different bands ('I3' and 'I5') has experienced significant fluctuations between 2014 and 2023. While the network tariffs and the taxes/levies components (without the recoverable VAT) remained stable in the past decade (and therefore their share decreased gradually as the natural gas prices increased noticeably in two steps; first in 2018, then in 2022), the price components changed significantly over the years. Between 2014 and 2021 the energy price component in the overall end-user prices – still remaining by far the largest portion – showed a significant decrease compared to the network tariff and taxes/levies components. Energy supply costs for the industry increased significantly in 2018, as the average EU emission allowance price increased threefold that year.[155] The 2022 natural gas price increase, however, can be attributed solely to the increased gas commodity price' (the cost of the sourced energy), as the network costs and the taxes and levies remained stable (on average, and again, excluding VAT).

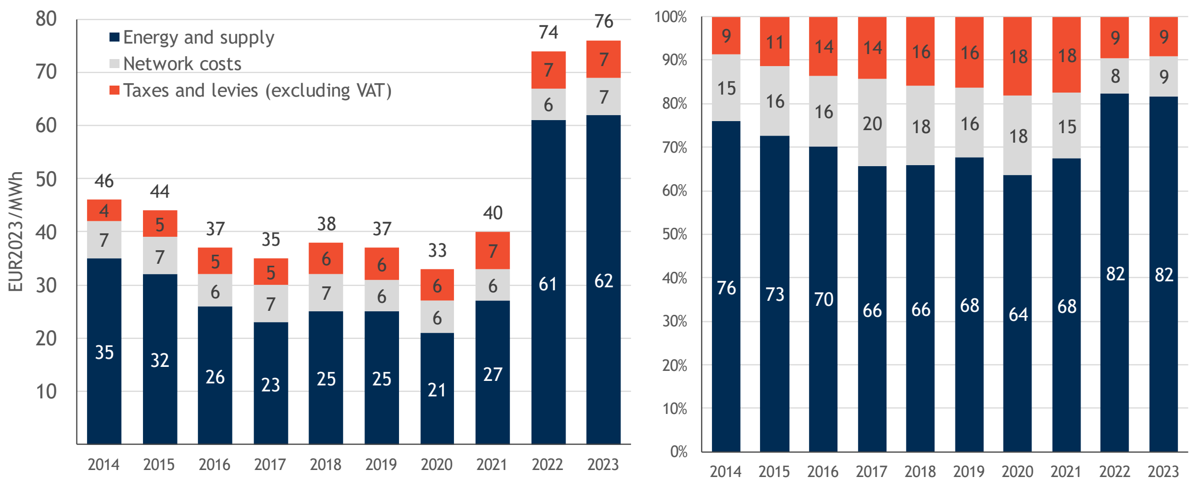


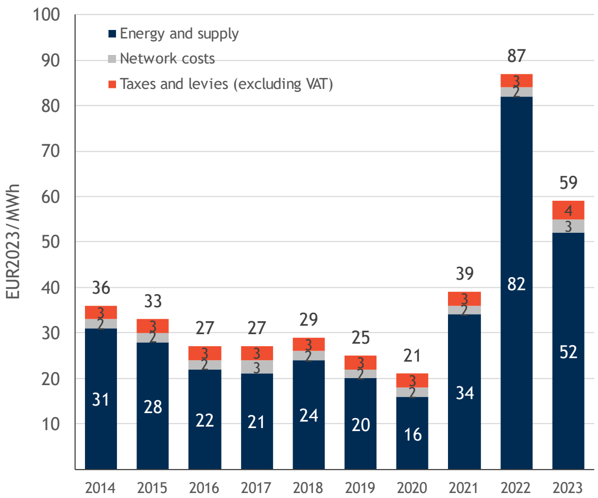
Figure 58: Composition of EU prices for medium (I3) industrial gas consumers (excl. VAT).

Source: Eurostat

Figure 59 shows the evolution of natural gas prices paid by large industrial consumers (in the 'I5' band, as defined by Eurostat). Similar to medium-sized consumers, large consumers experienced a price hike in 2018 – but a more sudden and significant one, followed by a gradual decrease until 2021, during

155 European Central Bank (2022). The role of speculation during the recent increase in EU emissions allowance prices

the pandemic when gas demand was lower due to reduced industrial activity. The gas supply crisis then pushed prices back up, and Russia's invasion of Ukraine in 2022 further increased the uncertainty about future Russian pipeline gas supply, leading to historically high market prices. While the 2022 spike was higher for large consumers than for medium ones (87 vs. 74 per EUR_{2023}/MWh, excl. VAT), the market prices also decreased in 2023 more rapidly for large consumers (although from a higher base), who paid significantly less than medium-sized consumers (59 vs. 76 EUR_{2023}/MWh) for their natural gas needs in 2023.



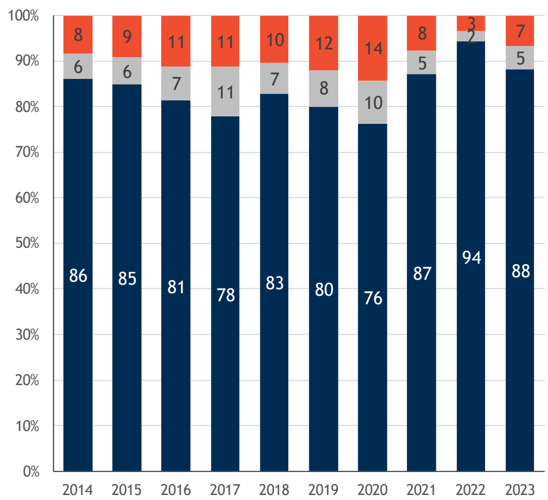


Figure 59: Composition of average EU prices for large (I5 band) industrial gas consumers (excl. VAT).

Source: Eurostat

The taxes/levies component in the end-user prices of natural gas is generally lower compared to electricity prices, as industrial consumers benefit from exemptions and reduced tax rates in most Member States and can recover VAT. Since 2019, however, the rate and share of taxes/levies on industrial gas use have steadily increased. Figure 60 illustrates the composition of the 'taxes and levies' component of natural gas prices for medium and large industrial consumers over the past five years. The taxes/levies component of the retail price in both bands grew due to increases in various tax components such as capacity taxes, and environmental taxes (i.e., excise duties).[156] More important is the significant year-on-year increase in the capacity component[157] of taxes paid by industrial consumers within the EU – which increased from 0.6 EUR_{2023}/MWh to 1.7 EUR_{2023}/MWh between 2022 and 2023. This increase of the EU average results of the tax increase implemented in a few specific Member States – notably Germany, Greece and Belgium.[158] Environmental taxes also represent a significant portion of the tax component and have steadily grown over the years.

[156] *VAT makes up more than half of the taxes/levies component and has significantly increased from EUR 6.1 per MWh to EUR 9 .7 EUR/MWh for the I3 band and from 3.9 per EUR2023/MWh to 7.2 per EUR2023/MWh for the I5 band within the period 2019-2023 – but it is not displayed on the figure below and does not form a core part of this analysis, as it is recoverable for industrial consumers.*

[157] *Capacity components include taxes, fees, levies or charges relating to strategic stockpiles, capacity payments and energy security; taxes on natural gas distribution; stranded costs and levies on financing energy regulatory authorities or market and system operators.*

[158] *Eurostat. (n.d.). Gas prices components for non-household consumers - annual data*

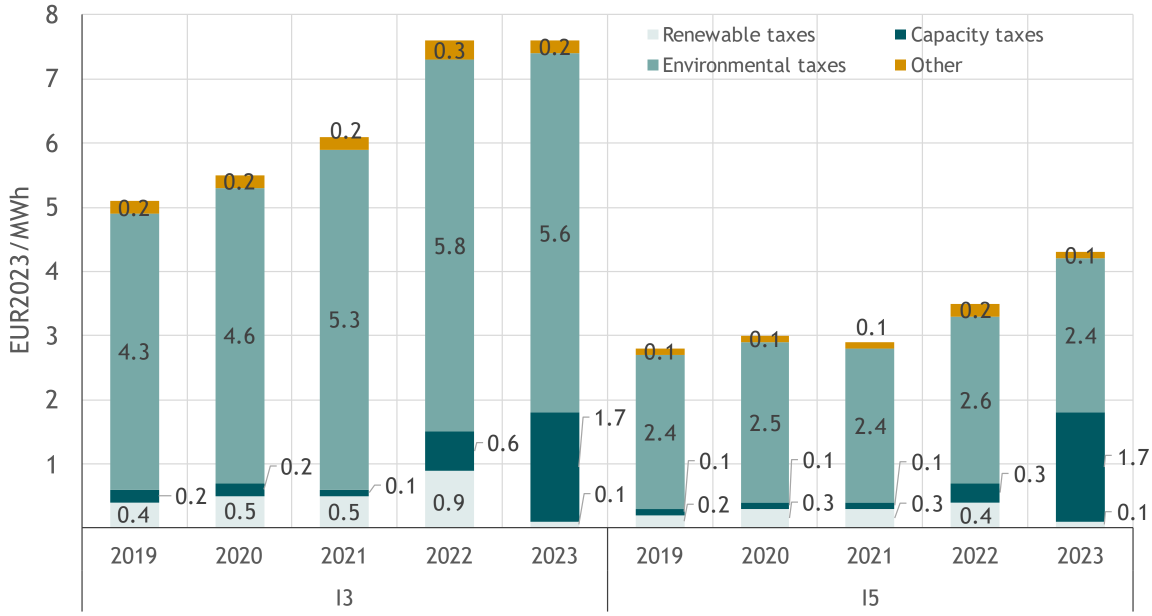


Figure 60: Composition of the taxes/levies structure of the EU end-user gas prices for medium (I3) and large (I5) consumers in 2019-2023 in in EUR_{2023}/MWh, excluding VAT.

Source: Eurostat

Situation in individual Member States

The supply price of natural gas, also known as the 'energy component', constitutes a significant portion of the overall industrial end-users gas prices, meaning end-user prices are heavily influenced by wholesale gas markets. As shown on Figure 37 and Figure 38, the COVID-19 pandemic slowed down the economic and industrial activity and the related gas demand, causing wholesale gas prices – and subsequently retail prices – to drop throughout 2020-2021. By late 2021-2022, wholesale prices recovered as global economic activity resumed, and later soared further as geopolitical tensions rose, leading to gas supply tensions - as described in Section 3.1.1. ., and illustrated in Figure 37 and Figure 38. In 2023, industrial consumers paid significantly lower gas prices than in 2022, in line with the lower wholesale price.

Figure 61 shows the variation of industrial end-users gas prices (and their composition) for the two bands of industrial consumers across EU member states, while Figure 58 and Figure 59 show the proportional composition of these prices (broken down to commodity price component, network costs, and taxes/levies). As can be seen, the 'I3' band pays a larger premium compared to 'I5'. For both consumption bands, a slight price convergence can be observed across the EU, although in some countries the difference remains significant, such as Sweden and Finland, which impose significantly higher taxes/levies than other countries; around 46 – 58 EUR/MWh compared to the EU's 10.9 – 16.8 EUR/MWh.

The Hungarian industrial gas prices were in 2023 on the higher end in the 'I3' consumption band, and – by far – the highest in the 'I5' band among all Member States. While Hungarian household consumers enjoyed the lowest prices in the EU during the crisis (Figure 53**Error! Reference source not found.**) owing to the government's policies and state imposed price cap on household energy bills (for consumers within a pre-calculated average consumption band), industrial consumers – in contrast with other Member States, like Germany, aiming to shield their industrial production instead – did not get such support in Hungary. Therefore, the industrial consumer prices moved in Hungary more along the free market trend, and were naturally higher in 2022-2023.

Furthermore, it is worth noting that the post-pandemic global inflation crisis hit Hungary the hardest among the EU Member States in 2022 with a staggering 25% inflation rate.[159] In response, to stabilise the economy, the Hungarian National Bank started an interest rate hike not seen since 2008.[160] As a result, the local currency (HUF) reached a relatively strong position against the EUR in 2023.[161] The prices of natural gas expressed in EUR are, therefore, even moderated somewhat by a stronger than usual local currency.

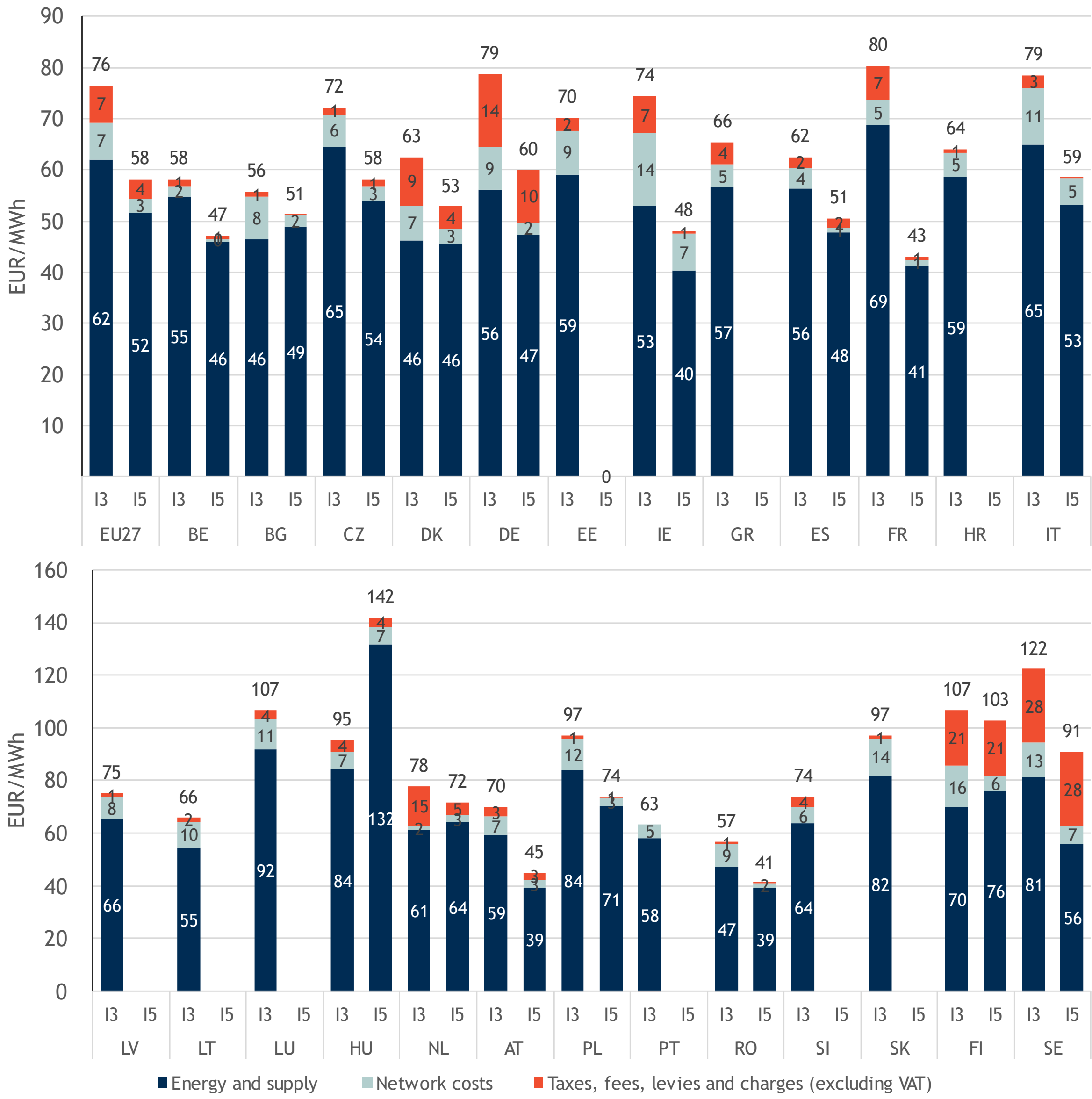


Figure 61: Comparison of Medium (I3) and larger (I5) consumer industrial gas prices in 2023 per Member State.

Source: Eurostat

Figure 62 and Figure 63 show the average end-user gas prices in 2014-2023, paid by industrial consumers in the 'I3' and 'I5' bands, respectively, in the EU member states. Among the mid-size industrial consumers (falling within the 'I3' band), Swedish and Finnish consumers were hit the

[159] Eurostat. (2022). Annual inflation down to 9.2% in the euro area

[160] Magyar Nemzeti Bank. (n.d.). A jegybanki alapkamat alakulása

[161] European Central Bank. (n.d.). Statistics - Hungarian Forint (HUF)

hardest by the energy crisis, and seemed to be an outlier in this regard in 2023 too – as already stated above. Latvian and Hungarian industrial consumers were also experiencing a high price increase nearing the Swedish prices during the height of the crisis in 2022, but in 2023 the gas prices seem to have consolidated more in these two Member States, closing the gap to the rest of the EU.

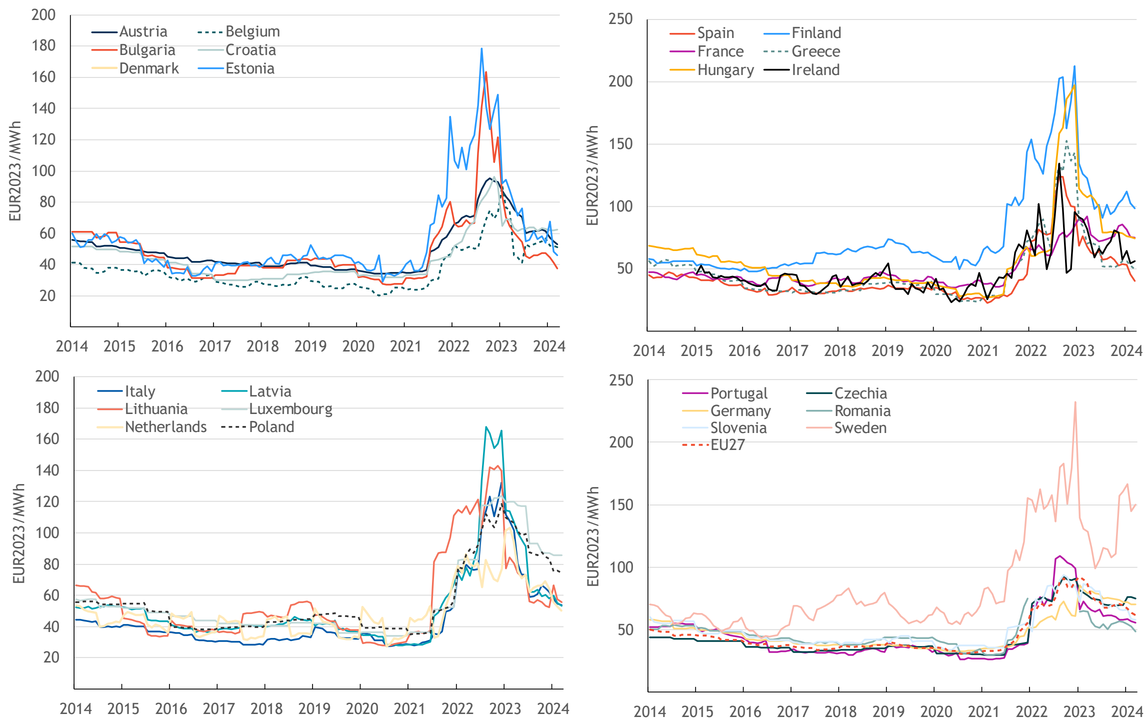


Figure 62: Average industrial end-user gas prices (Band I3) in the EU-27 in EUR_{2023}/MWh, Jan 2014-2024.

Source: Eurostat

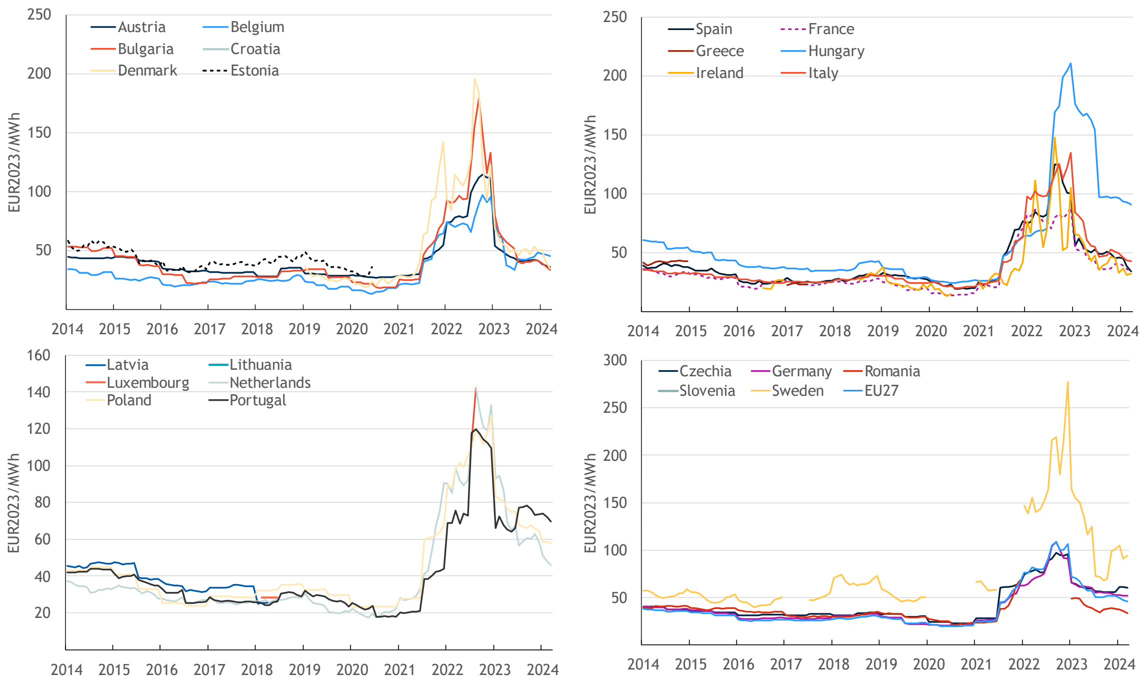


Figure 63: Average industrial end-user gas prices (Band I5) in the EU-27 in EUR2023/MWh, 2014-2024

Source: Eurostat

Figure 64 shows the correlation between the wholesale and end-user electricity and gas prices development, both for industrial and household consumers. The figure concentrates on the period between 2020 and 2024, highlighting the dynamics of the 2022 energy crisis in Europe. The correlation between the wholesale gas and electricity prices has been pointed out and explained in Section 2.1 of this report. The figure below illustrates to what extent the wholesale spot electricity prices correlate with the wholesale gas prices; given the EU's reliance on gas-fired power plants to cover (peak) electricity demand, natural gas is still often setting the clearing price in the merit order. The wholesale gas prices peaked in August 2022 at a level 17 times higher than the 2019 average (not shown on the figure below), whereas the electricity prices reached in August 2022 9.5 times their 2019 average level. With a slight delay, the industry end-user gas prices followed a similar trend, and eventually displayed a more significant price increase (compared to the 2019 average) than end-user electricity prices. For household end-user prices, relatively speaking the overall prices (all components included) decreased the least, due to the larger share of taxes/levies and network costs, as well as the type of retail contracts (as most households have fixed price contracts for e.g. a 1 year period, wholesale price increases were passed through to retail users with some delay). Still, impacts of the energy crisis on individual households could be significant, which is discussed in more detail in chapter 6 on household energy expenditure.

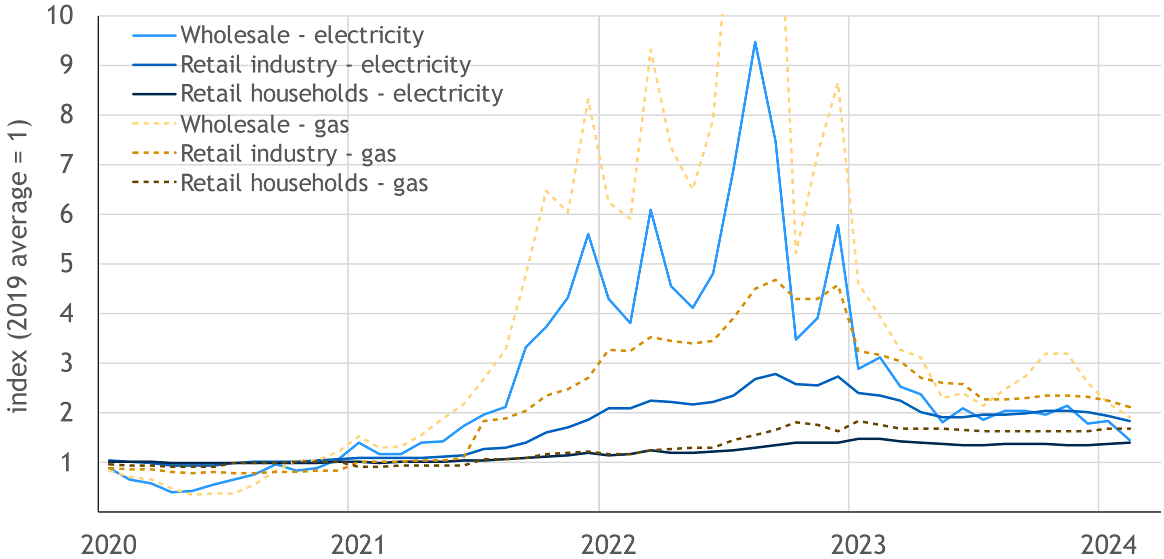


Figure 64: Indexed (2019 average = 1.0) price development since 2020 showing for electricity and gas the end-user prices for households and industry, as well as day-ahead spot wholesale prices (TTF for gas, EPB for electricity).

Source: Eurostat; S&P Platts

International comparison of industrial end-user gas prices

Figure 65 shows the development of industrial end-users natural gas prices in the EU and its major trading partners – Japan, the UK and the US. The trends observed in industrial gas prices are similar to the trends in household prices discussed above. The US prices cleared generally at the lowest level (going as low as EUR 8.7 in 2020, and averaging at 15.5 EUR/MWh in 2014-2024, even taking into account the 'crisis prices'), and were the most resilient to the crisis (experiencing only a comparatively minor spike in 2022, maxing at 33.4 EUR/MWh, at the same time as the rest of the world), whereas the UK/EU/Japan experienced generally higher prices (within the 20-50 EUR/MWh range) and a much more prominent price spike (the EU price topping the chart at 108.8 EUR/MWh, almost three-times as high as the US price) during the crisis. This has a clear consequence primarily on the competitiveness of US industry, compared to the rest of the world, including the EU.

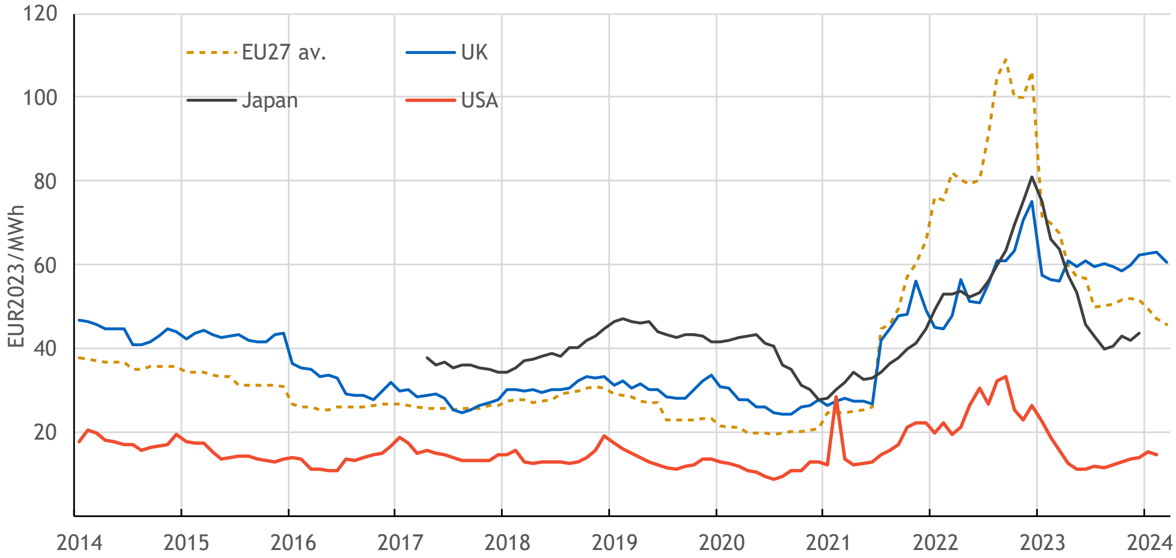


Figure 65: Industrial end-user (I5 band) natural gas prices in EUR_{2023}/MWh in the EU-27, Japan, US, UK

Source: Eurostat, Enerdata EnerMonthly

Figure 66 complements the figure above with the gas price development in (some of) the rest of the G20 countries. This figure illustrates especially well the effect of the 2022 energy crisis in Europe – the observed EU average gas price being far above most of its competitors/trade partners. Only South Korea observed a comparable price hike as the EU-27 (both in absolute and relative terms) – but from a generally higher price standard. The pre-crisis EU industrial consumer prices were already higher than most of the G20 but were comparable to the prices in Indonesia and Australia (and way below the aforementioned South Korea and Brazil). The crisis then pushed the EU average over the top, and this only mitigated somewhat in 2023 and 2024, with the EU prices closing the gap with the (also higher than pre-crisis) South Korean prices. Unsurprisingly, the oil and gas exporter Russia and Saudi Arabia are unaffected by the recent market developments, and while Canada (also self-sufficient natural gas producer) experienced some of the similar dynamics as the EU, prices remained on a much lower level – and by 2023 they returned to their pre-crisis standard.

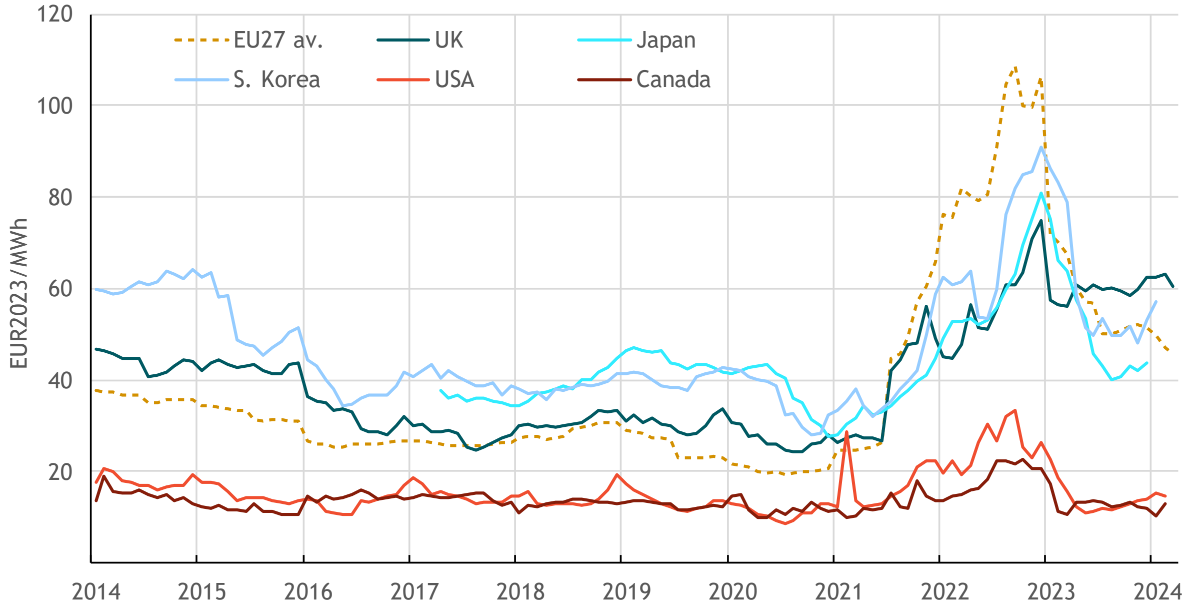


Figure 66: Industrial end-users (I5 band) natural gas prices in EUR_{2023}/MWh in the EU and major G20 trading partners.

Source: Eurostat, Enerdata EnerMonthly

4. Oil (product) and other fuel and key technology prices

Main findings

- Similar to the price trends for other energy sources, since 2020 **crude oil** prices have been notably volatile, mainly due to two major global events: the global Covid-19 pandemic in 2020 and the invasion of Ukraine by Russia in 2022. First, crude oil prices hit all-time low levels of 20 USD/bbl in the first half of 2020 due to the pandemic and the resulting sudden demand reduction among others. In contrast, after the Russian invasion prices peaked at very high levels at more than 130 USD/bbl in March 2022, after which prices reduced again to still relatively high levels. After turbulent years, since January 2023 relatively stable crude oil prices can be observed at around 80 USD/bbl again. Due to sanctions and the consequences of the Russian invasion, a discount on the global market now can also be observed for Russian crude oil (Ural and other blends). In reality, this discount is likely smaller due to 'shadow shipments'.
- For **coal** import prices, similar price trends could be observed, although coal prices did not plunge significantly during the pandemic in 2020. In 2022, coal demand and hence import prices – displayed by Australian and South African export prices - increased to continuously above 250 EUR/tonne until Q3 2022. Demand growth was mainly driven by gas-to-coal switching for power generation in Europe. As of 2023, coal use for power generation was comparable with pre-crisis (2019) levels, and subsequently prices reduced as well, although these seem to stay at structurally higher levels than pre-crisis.
- High crude oil prices resulted in high **oil product prices,** such as **diesel**, **gasoline** and **heating oil**, in 2022 and 2023. In these years, prices have been at the highest level since at least 2008, averaging in the EU-27 a pump price of 1.79 EUR/litre for gasoline and 1.75 EUR/litre for diesel. On top of the high electricity and gas prices during the energy crisis, these high fuel prices further increased the energy costs for households and businesses during the energy crisis. To reduce the price impact, many Member States temporarily reduced VAT and excise duty rates in 2022 and 2023. This intervention slightly mitigated the increase in pump prices and came at the cost of high government spending and subsidising fossil fuel consumption. At the time of writing in Q2 2024, oil product prices continue to be relatively high. Partially this is due to lower wholesale prices being counteracted by most temporary tax cuts being lifted in 2024.
- Diesel, gasoline, and heating oil retail prices historically have been higher in the EU-27 than other regions due to higher taxation. In the past years this been no different. Since price increases mainly were the direct result of higher crude oil prices, similar retail price increases could be seen in other global regions, though absolute prices stayed significantly lower in for example the US and China. Higher VAT rates in the EU-27 also led to higher absolute cost increases in the EU-27 compared with other regions.
- **Alternative fuels** includes biofuels such as bioethanol and biodiesel and LPG. These fuels generally follow similar price movements to diesel and gasoline prices, since they can be used (to a certain extent) interchangeably or are produced from crude oil (LPG). LPG prices increased to an 0.90 EUR_{2023}/litre average in the EU during the energy crisis, but reduced to an average of ~0.70 EUR_{2023}/litre in 2024. Compared with other trading partners, European LPG prices are average; they remain slightly lower than in the US. For bioethanol and biodiesel, prices were high in 2021 due to supply issues, such as bad feedstock harvests due to extreme weather and for bioethanol corn export disruptions from Ukraine. EU bioethanol export prices are consistently higher than other main production regions, while EU biodiesel prices generally were high compared to the US, except during 2023.

- This report also discusses price developments for several key energy sources and technologies for the global energy transition.
    - **EV charging** prices in 2023 in the EU-27 can diverge significantly per location/MS and time. On average prices are estimated at between 150-350 EUR_{2023}/MWh for home charging. Public AC charging prices are generally higher at 400-600 EUR_{2023}/MWh. Fast DC charging is most expensive at 500-700 EUR_{2023}/MWh. Compared to 2021, in general charging prices have increased, although it heavily depends on the time of charging, given that dynamic and off-peak tariffs are available in most EU Member States
    - For **battery storage** technology costs continue to decline -after a brief plateauing in 2022 -, driven by decreasing raw material prices and by a growing penetration of lower-cost LFP cathode chemistries, thus making battery storage solutions competitive for more applications in more circumstances. Reductions in battery costs also continue to make electric vehicles (EVs) more affordable, with China leading the way in most stages of the supply chain of batteries and EVs. Behind-the-meter storage benefit strongly from this cost reduction but remains concentrated mainly in Germany and Italy
    - Green **Hydrogen** produced with grid or renewable-powered electrolysis continues to be in an early development stage and is very uncompetitive with grey hydrogen (using Steam Methane Reforming). Grey hydrogen production costs have surged though due to increasing natural gas prices since the energy crisis, from lower than 2 EUR_{2023}/kg in 2019 to 6 EUR_{2023}/kg in 2022. However, these values were still lower than green hydrogen production costs that are estimated at above 10 EUR_{2023}/kg in most Member States. Also, green hydrogen investment decisions are not made based on cost comparisons for a single year such as 2022, but are based on price projections during a project's lifetime. With natural gas prices reducing again since 2023, the gap widens. Hydrogen prices at the pump for the few hydrogen vehicles in operation in the EU are between 8 and 25 EUR_{2023}/kg in selected EU countries, making it a very uncompetitive fuel currently compared with EVs, raising further doubts about the future market size for hydrogen vehicles.

4.1. Crude oil and coal prices

4.1.1. Crude oil prices

Oil price movements in recent years were characterised – similar to other fuels – by significant price fluctuations. Most notably, since 2020 oil prices were first at record-low levels due to Covid-19, followed by record-high levels due to e.g. the build-up to and eventual Russian invasion of Ukraine in 2022 and its consequences.

Figure 67**Error! Reference source not found.** shows there have been very significant price reductions between 2014 and 2016 to a low point of 26 USD/bbl in January 2016, mainly due to the shale oil boom in the US and weak demand.[162] As of 2016, prices slowly trended upwards until 2020, among others driven by restricted production by key producers (incl. OPEC) and events such as the US withdrawal from the Iran nuclear deal, which prevented Iranian oil from reaching global markets.

162 *World Bank (2018). What triggered the oil price plunge of 2014-2016*

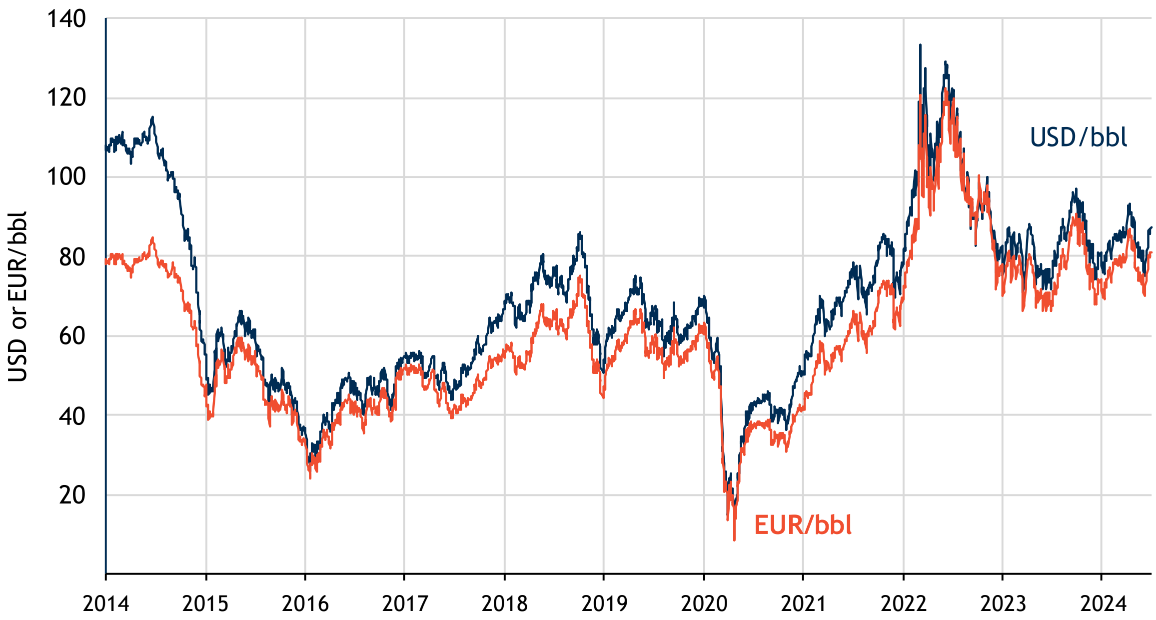


Figure 67: The daily Brent crude oil price (incl. Fuel Oil Barges/F.o.b.) from 2014 to February 2024, indicated by the Daily Europe Brent Spot Price FOB in both USD and EUR per barrel (nominal prices).

Source: S&P Platts

Due to the Covid-19 pandemic and subsequent lockdowns and quick demand reduction, the crude oil price crashed around March/April 2020 to 20 USD/bbl on average, with even daily prices reaching as low as 9 USD/bbl. Negotiations to adjust production within OPEC(+)[163] were not very fast, leading to adjustments later by May 2020, after which oil prices partially recovered to 40 USD/bbl. During 2020, prices stayed below 50 USD/bbl, though showing moderate growth throughout the year, among others due to growing demand in China after lockdowns were lifted and more optimistic economic outlooks. Absolute demand stayed low though due to global continuing lockdowns.

2021 also saw steady price increases from 50 USD/bbl in January to 80 USD/bbl by the end of year. Again, this was among others due to increasing demand due to Covid-19 restrictions being lifted. Upward price pressure also came from slow OPEC+ negotiations to increase supply again and fuel switching to oil due to gas and electricity exceptionally having higher prices on an energy content basis (Figure 41). As a result, crude oil prices in Q4 of 2021 reached their highest level since 2014.

Prices increased further in 2022 at the time of the Russian invasion in Ukraine to record-high levels of 133 USD/bbl in March 2022. Prices stayed at very high levels until July, with an average (unweighted) price of 114 USD/bbl between April and July. Though it is difficult to fully entangle price drivers, the invasion and the subsequent (voluntary) embargo on certain aspects of Russian oil exports contribute to high market uncertainty and hence upward price pressure.[164] There were attempts to stabilize the oil price, among others through large strategic stock releases from IEA countries - mainly the US - which had a downward pressure on prices.

In the 2nd semester of 2022, oil prices gradually decreased – albeit still at a high level with an average of 94 USD/bbl – among others due to further large releases of oil stocks of large oil-consumers led by the US and increased production from OPEC+. At the same time, demand stayed behind, for example since demand growth in China was lower than anticipated. Though prices were high, the oil market was relatively balanced.

163 OPEC+ is formed by the main OPEC states + 11 other oil producers, including mainly Russia (3rd largest global oil producer), Mexico, Kazakhstan and Oman.

164 See e.g. IEA monthly oil market reports for details.

One notable development was that Russian oil exports in retrospect did not structurally decrease after the invasion. While there was a supply glut directly after the invasion, due to (voluntary) embargoes and difficulties getting the oil on the market (e.g. insurance issues), over the course of a few months there were massive export shifts from Europe to other regions, and notably to India. India since 2022 has taken the place of the EU as the major importer of Russian crude oil, and it buys most Russian oil at a discount compared to the Brent price (see Figure 68).[165] The G7 price cap on Russian oil of December 2022 as well as other sanctions on Russian seaborne crude oil (products) also had limited effect on the crude oil price, though exports to the EU decreased further after these sanctions.[166]

Brent prices in 2023 averaged 82 USD/bbl and 2023 was characterized as a "stable year after three turbulent years" by the IEA.[167] Supply stayed high and is expected to stay high, according to the IEA, with planned supply capacity expansions in non-OPEC countries such as the US, Brazil and Guyana; global upstream investments in gas and oil increased by 11% in 2023. In contrast, on the demand side, the need for further global emission reductions and increased attention for energy security, drives the transition to renewable energy, creating downward pressure on oil demand. Still, it is estimated by the IEA that total global oil (product) demand has not reached its peak yet. In addition, OPEC+ applied a "pre-emptive", supply cut policy in 2023, with the aim to have consistently high and stable crude oil prices.

Since the invasion of Ukraine, several types of sanctions had an impact on Russian oil exports and prices. First, indirect sanctions and voluntary embargoes of consumers led to lower prices for Russian oil – shown above by the Russian Ural oil reference price. In 2022 several different sanctions came into effect with direct or indirect effects on Russian oil trade.[168] These mainly indirect sanctions were followed in December 2022 by a price cap of 60 USD/bbl on Russian oil by the G7 countries (including the EU and the US).

It should be noted that the price discount measured through Russian customs data of exports is (significantly) smaller than the discount of the Ural reference price. This difference implies that Russia is able to circumvent sanctions and can transport and sell oil above the price cap through unsanctioned *shadow fleet* shipments.[169] For example, customs data on China shipments shows oil is sometimes delivered for almost the Brent oil price. However, this is not the case for all Russian oil exports, where a large volume is still sold for the discounted Ural price.

With the above caveat in mind, Figure 68 shows that the invasion immediately led to a large negative spread for Russian Ural oil exports compared to Brent (and other major oil price references), with the spread in the first six months after the invasion being 24 USD/bbl on average, thereby having a large negative impact on Russian oil revenues. In the figure one can see that the price cap in December 2022 led to the biggest discount of Russian oil upon entrance to a price slightly below 60 USD/bbl.

Despite this spread, Russian oil revenues stayed significant and still profited from the higher oil price after the invasion. Analysis by CEPR notes that increased oil (products) prices led to 35 billion USD in additional revenues in 2022, although the lower volume and price due to sanctions shaved off at least 30 billion USD. Still, energy export revenues of Russia have never been higher than in 2022 : 333 billion USD in total, with crude oil accounting for 142 billion USD, oil products 83 billion USD and natural gas 142 billion USD.

From 2023 to February 2024, there has still been a significant discount for Russian oil compared to the reference Brent crude oil price, continuing to limit Russian oil revenues compared to global reference prices. In August and September 2023, the downward price trend reversed due to Saudi Arabia and Russia's voluntary production cuts, leading to crude oil prices climbing to about 92

[165] OIES (2023). *Global oil market update H2 2023.*
[166] ECB (2023). *Oil price developments and Russian oil flows since the EU embargo and G7 price cap*
[167] IEA (2023). *Oil in 2023; analysis and forecast until 2028.*
[168] See PIIE (2023). *Russia's war on Ukraine: A sanctions timeline*, for details on the sanctions timeline.
[169] CEPR (2023). *Assessing the impact of international sanctions on Russian oil exports.*

USD/bbl by October 2023.[170] Crude oil prices spiked after the 7 October Hamas attack on Israel, causing volatility due to fears of escalation. In mid-January 2024, after Yemen's Houthi forces attacked ships in the Red Sea and crude oil prices briefly increased over concerns of longer cargo journey times. The escalation of Middle Eastern tensions caused a rebound in crude oil prices in January 2024 again, marking the first monthly gain since September 2023.[171]

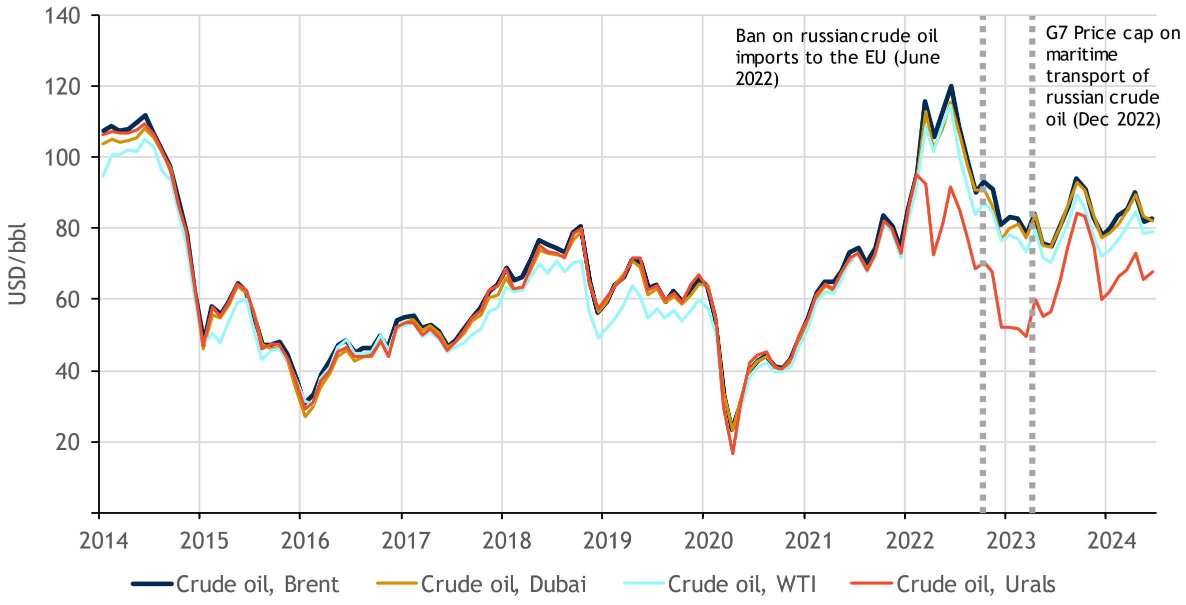


Figure 68: Crude oil price Russian Ural vs. Brent oil in USD/barrel (nominal prices).

Source: World Bank, OPEC.

4.1.2. Wholesale coal prices

Figure 69 the wholesale hard coal prices of Australia and South Africa are shown, two of the major global exporters of coal. Since Russian coal imports -the major supplier of coal to the EU in 2021 with around 45% - were banned in August 2022, both have become the main import regions to the EU.[172] These two price indices are generally representative of global hard coal import wholesale prices. Hard coal markets often are also (partially) local, leading to regional price variations. The EU is a net importer of hard coal with an import dependency of around 60%, indicating that a large portion is bought on the international wholesale market.[173] In contrast, lignite (brown coal) is often produced and consumed locally, and international trade is very low, leading even more to regional and untransparent price formation.

On the back of increased natural gas prices and subsequently electricity prices, coal became relatively attractive to use for electricity generation: dark spreads in European (and global) markets were high in 2021 and 2022 (see also Figure 12). This led to increased demand in the EU and other regions. Where hard coal and lignite consumption in the EU consistently decreased every year until 2020, there was increased demand in 2021 and 2022, although still at lower levels than in 2018 and before.[173]

Generally, coal supply chains are efficient but inflexible, which leads to high prices in response to high demand. As a result, in 2021 and 2022 import wholesale prices increased significantly. As an example, from July 2021 to July 2022 the average South African export prices were 200 EUR_{2023}/tonne, compared to an average price of 75 EUR_{2023}/tonne between 2014-2020.

[170] *IEA (2023). Oil Market Report – September 2023*
[171] *IEA (2024). Oil Market Report – January 2024*
[172] *Eurostat (2024). EU imports of energy products - latest developments*
[173] *See Eurostat (2024). Coal production and consumption statistics for details.*

Several global supply bottlenecks put upward pressure on prices in 2021 and 2022. Australian coal production was severely impacted by La Niña and associated heavy rainfall and flooding in 2022, especially in the region of New South Wales. In South Africa supply was lowered due to infrastructure issues. In addition, the EU's Russian coal ban in August 2022 temporarily reduced global supply as trade had to shift from the EU to other regions.[174] Coal price increases in the US were notably lower than in other examined regions.

During the second semester of 2022 South African prices moved downward, while Australian export prices stayed high. This is notable, since normally prices between these two exporters are more similar. The Australian price premium was the result of continuing supply bottlenecks and ample demand for high-quality coal from East Asia (e.g., Japan) for steel production. Indonesian prices were similar to Australia and Indonesian coal supply was at an all-time high in 2022 to profit from lower supply from other suppliers such as Australia.

As of 2023, coal prices reduced to lower levels in all markets with prices between 100 and 200 EUR_{2023}/tonne. Still, prices at the end of 2023 were notably higher than pre-crisis levels at around 125 EUR_{2023}/tonne for Australia, South Africa and Indonesia and slightly lower for the US. A major driver for the price reduction in 2023 was global coal-to-gas switching for power generation, now that gas wholesale prices also saw major reductions. For example, coal consumption for power generation in the EU reduced with 26% in 2023 compared to 2022, back to levels comparable pre-crisis.[175]

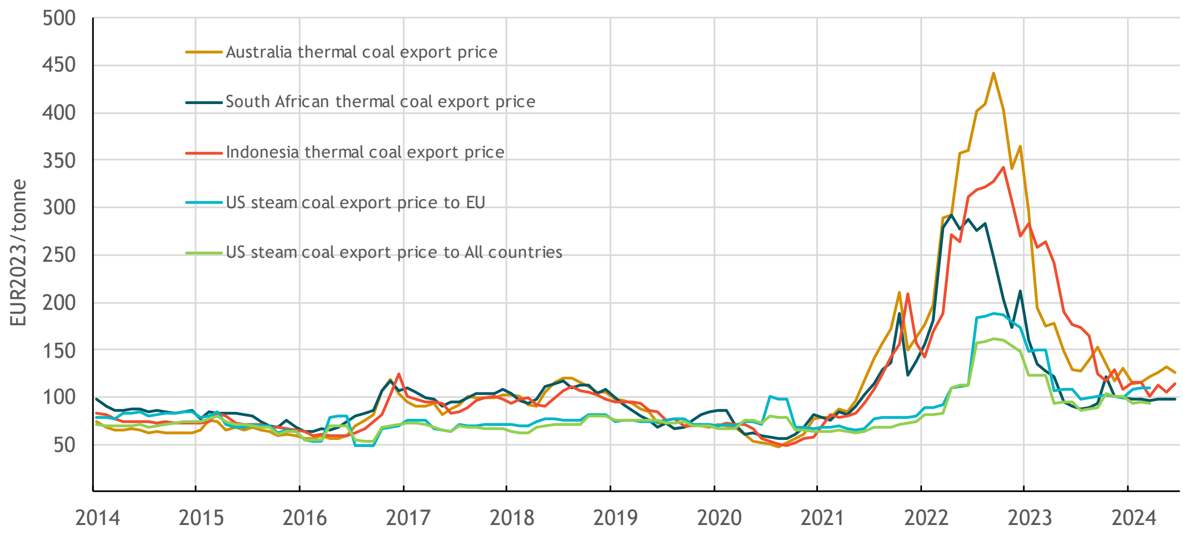


Figure 69: Wholesale hard thermal coal export prices (FOB) from Australia, South Africa, Indonesia and the US from 2014 to May 2024 in EUR_{2023}/tonne.

Source: World Bank

Figure 70 compares the (imported) coal prices *excluding* taxes in the EU and main trading partners Japan (major importer with very high import dependency) and the US (export country). It is relevant to note that the EU's consumption for 40% is covered by domestic production (for example in Germany, Poland and Czechia), often leading to lower prices than the import prices. Still, exposure to import price levels is large. Especially during the recent energy crisis coal prices in the EU increased relatively a lot compared to export regions such as the US. Import prices in Japan were similarly high to the EU.

The US has very low import dependency (importing less than 2% of its coal consumption[176]), producing most of its coal domestically. One can assume domestic US prices are below the export prices shown. The figure also shows that imported coal prices in the EU are relatively close to that of

[174] IEA (2023). Coal 2023.
[175] Ember (2024) European Electricity Review 2024.
[176] EIA gov (2023). Coal explained.

Australia's and South Africa's coal export price – which are the two main trading partners of the EU for coal.

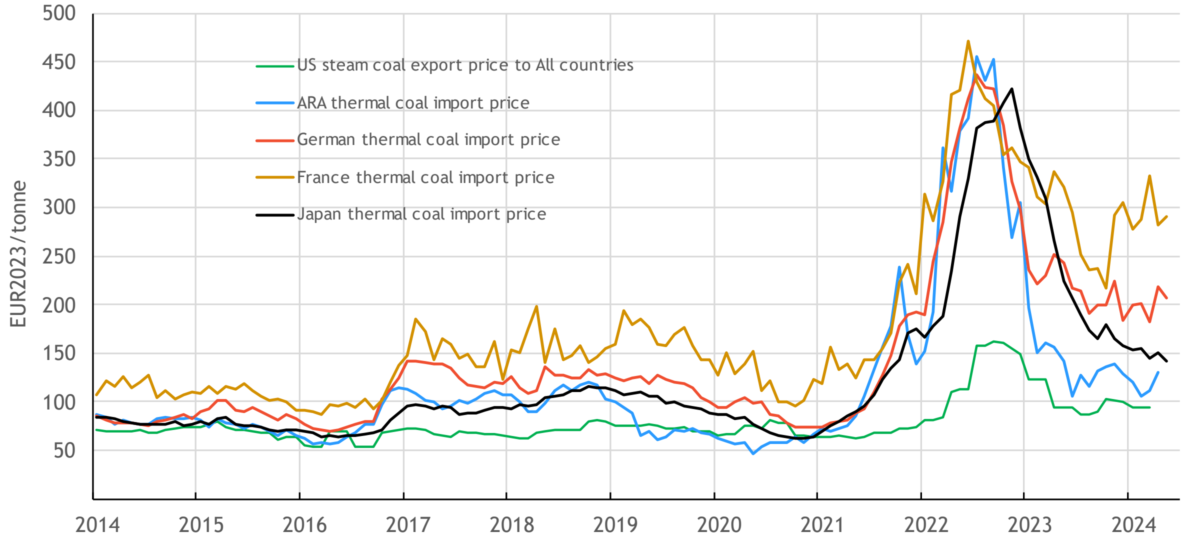


Figure 70: Annual average (imported) coal prices excluding taxes in several EU regions as well as Japan and the US from 2014 to May 2024 in EUR_{2023}/tonne.

Source: COMEXT (i.e. customs declarations), Eurostat, World Bank.[177]

4.2. Wholesale prices of oil-based fuel products

The prices of oil-based fuel products such as gasoline, diesel, and heating oil closely follow their main feedstock, crude oil. Figure 71 shows the wholesale prices of Brent crude oil and oil-based fuel products in Western Europe in real terms, converted to EUR_{2023}/litre instead of EUR/barrel. Additionally, Figure 72 illustrates the fluctuations in the wholesale prices of oil-based fuel products and crude oil by showing the crack spreads (the difference between the wholesale price of oil-based products and crude oil).

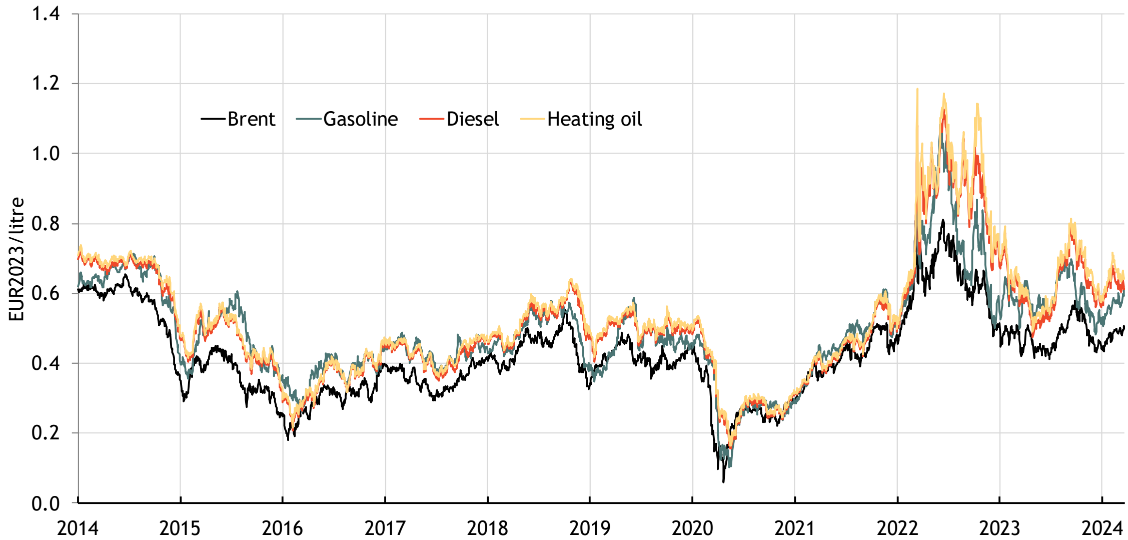


Figure 71: Crude oil (Brent) and European wholesale gasoline, diesel, and heating oil prices in EUR_{2023}/litre from 2014 to March 2024.

Source: S&P Platts, ECB (for exchange rates)

[177] *ARA = Amsterdam Rotterdam Antwerp price, a main price indicator for coal imports in the EU.*

The supply-demand dynamics of oil products are distinct, affecting their crack spreads. The COVID-19 pandemic initially widened crack spreads in spring 2020 due to plummeting crude prices but sustained low demand and ample supply later narrowed the spread. Post-pandemic economic recovery in 2021 along with the Russian invasion of Ukraine increased crack spreads, which soared to historic highs in 2022 due to rising crude prices and tight supply. By mid-June 2022, gasoline crack spreads fell, while those for diesel and heating oil remained high. From July 2022 to June 2023, crude oil prices continued to fall, reaching about 0.41 EUR_{2023}/litre (or 71 USD_{2023}/bbl) due to a waning global economic outlook, inflation, the energy crisis, and rising interest rates, despite OPEC+ production cuts in October 2022.[178,179] During this period, diesel and heating oil crack spreads narrowed initially until April 2023 before widening towards August 2023. Gasoline spreads fluctuated, generally widening until August 2023.

The volatility and declining investor sentiment in oil following the Hamas attack on Israel in October 2023 pressured prices lower towards the end of 2023, narrowing crack spreads for all products.[180] In mid-January 2024, following strikes from Houthis on maritime shipping lanes, widening crack spreads for oil products were observed next to more volatility in crude oil prices.

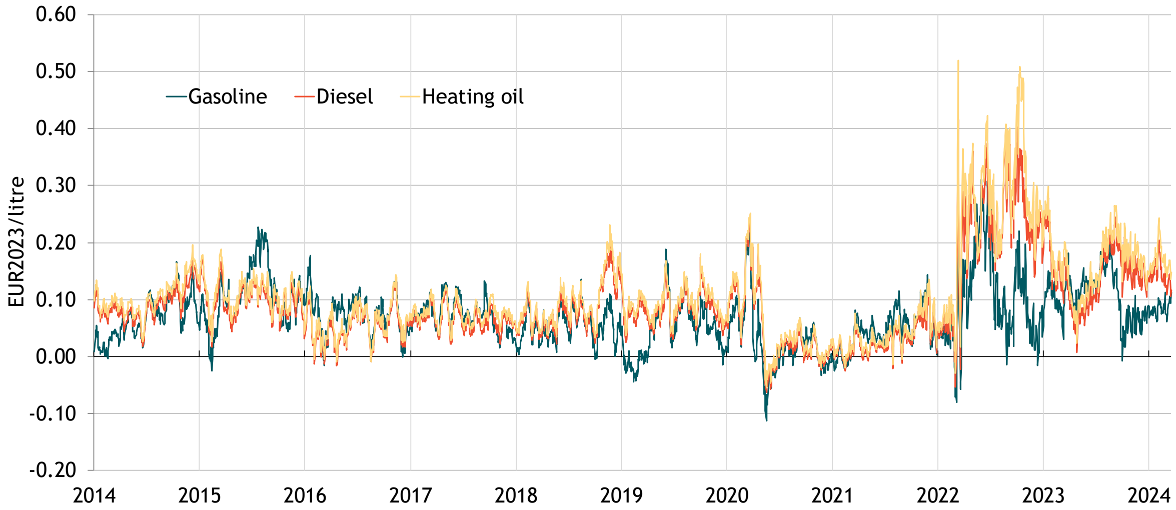


Figure 72: Crack spreads of gasoline, diesel and heating oil from 2014 to March 2024 EUR_{2023}/litre.

Source: S&P Platts, ECB (for exchange rates)

4.3. Retail prices of oil and oil products

Oil products constitute a significant portion of energy costs for both households and industry. Figure 73 below shows the total annual consumption of fuel products such as heating oil, kerosene, road diesel, and motor gasoline in the EU. As the figure illustrates, oil products are still mainly used as transport fuel, accounting for more than 50% of oil consumption in the EU, while the share of heating oil consumption has declined over the years. Oil products primarily fuel automobiles, airplanes, ships, and machinery (e.g. machinery with mobile engines). Additionally, industry (6%), residential (5.4%) and non-energy uses (17.3%) such as asphalt, engine lubricants and raw materials for plastics made up the remainder of oil consumption in the EU. [181]

Prior to the COVID-19 pandemic, final consumption of oil products in the EU kept increasing slightly each year, resulting in a total of 6.8% growth between 2014 and 2019. The COVID-19 related lockdowns

[178] *IEA (2022). Oil Market Report – August 2022*
[179] *IEA (2022). Oil Market Report – October 2022*
[180] *IEA (2023). Oil Market Report – November 2023*
[181] *IEA (2021). Oil, Europe.*

and travel restrictions severely impacted demand, resulting in a significant 15% year-on-year drop in oil product consumption in the EU. The consumption of kerosene-type jet fuel experienced the largest decline, with consumption halving due to the drastic reduction in air travel because of closed international borders, teleworking, and cuts in leisure air travel. To a lesser extent, demand for diesel and gasoline also dropped in 2020, dropping by 10 and 13% year-over-year, respectively.

Demand for oil products rebounded from 2021 onwards, in line with the recovery of mobility and economic activity. As the international aviation sector reopened, demand rose strongly in 2022 and 2023, approaching 2019 consumption levels. However, economic uncertainty and Europe's gradual transition to electric vehicles (EVs) moderated the oil demand growth, although the effect of EVs is still very small. in some countries, driven by 2020 EU CO2 standards[182,183] , battery-only EVs overtook diesel in shares of new sales in many Member States, including Sweden (34.5% vs 12.6%), Iceland (26.9% vs 16.4%), and the Netherlands (24.2% vs 1.5%), raising their share of the total number of passenger cars to 1.2% in 2022. [184] Overall, sales of passenger cars fuelled by alternative fuels have been rising, while diesel car sales have declined, with gasoline car numbers staying relatively constant. Petrol/gasoline-powered vehicles remain the most popular, with 24 Member States reporting that they have the highest share of new passenger car sales. [185] In heavy transport diesel is the main fuel and the transition to electric vehicles (or other low-carbon alternatives)is still in an early phase.

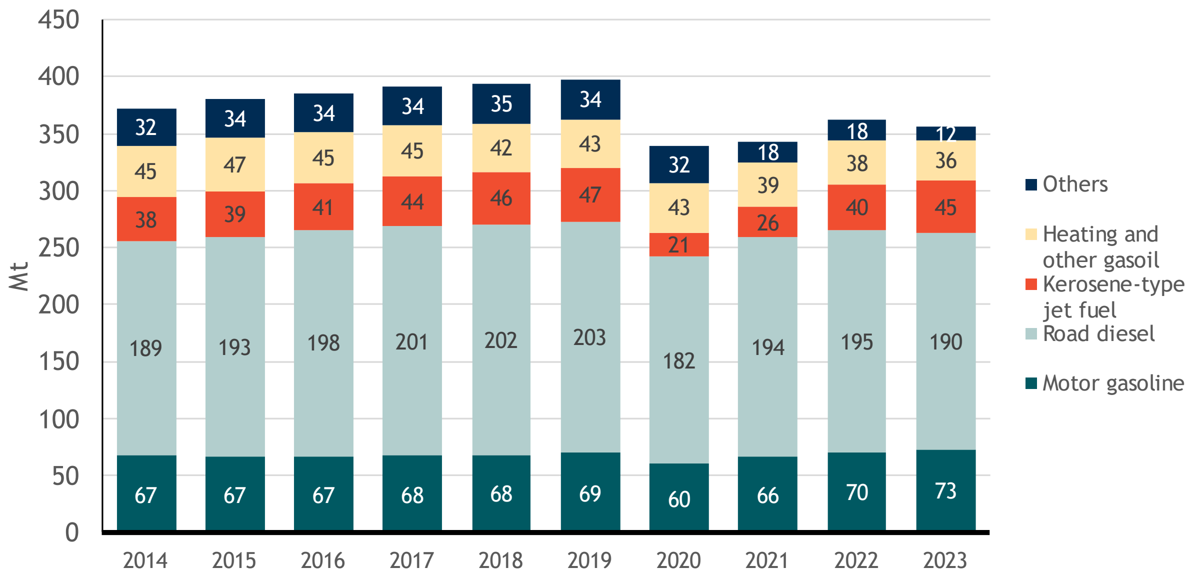


Figure 73: Final consumption of oil products in the EU.

Source: Eurostat

The retail prices of oil products, as discussed in the following sections, are influenced by several factors. Although changes in crude oil prices affect retail prices, the cost of crude oil often forms a small part of the final price. Crude oil is traded in US dollars, while the finished products are sold in euros or other national currencies, meaning exchange rate fluctuations also impact the crude oil component's cost, especially in regions without the Euro with currencies that show relatively large fluctuations against the dollar.

A considerable part of the retail price consists of taxes, such as excise duties, other indirect taxes, and VAT. Differences in prices between fuels and countries are mainly due to varying tax rates, which

[182] *IEA (2021). Oil 2021; Analysis and forecast to 2026.*
[183] *IEA (2020). Oil 2020*
[184] *Eurostat (2023). Passenger cars in the EU*
[185] *Eurostat (2023). Passenger cars in the EU*

contribute significantly to the tax revenue of Member States. For motor fuels like gasoline and diesel, taxes typically make up more than half of the final price. Excise duties are generally a fixed amount per unit (litre or kilogram), so they are not influenced by crude oil prices. VAT, however, is calculated as a percentage of the price (including excise duty), so changes in crude oil prices impact the absolute value of the VAT component.

Box C - 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 substantial portion of fixed taxes in the price serves as a buffer; fluctuations in the retail price of oil products (especially motor fuels) are considerably lower than those of crude oil prices. Exchange rate variations have a similar effect; the oil price and the value of the US dollar usually move in opposite directions: a strengthening dollar often coincides with decreasing oil prices, and vice versa. Consequently, changes in oil prices, whether increases or decreases, are moderated by the exchange rate, resulting in lower volatility of oil prices when expressed in euros compared to their volatility in dollars.

Moreover, although their share in total usage remains relatively limited, alternative fuels are contributing an increasing share to the energy mix in transport and other sectors, with their significance expected to grow in the future. Therefore, this report also includes price data for LPG, bioethanol, and biodiesel.

4.3.1. Methodology

The analysis in this section is mainly based on the data of the weekly Oil Bulletin, published on the website of DG Energy.[186]

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 2014 to 2023. For 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 to euro, using the ECB exchange rate of the day or yearly average 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.[187]

[186] European Commission (n.d.) Weekly Oil Bulletin.

[187] For all 2022 tax data, average tax rates in July 2022 are used, instead of an average over the first semester.

4.3.2. General findings

The retail price of oil products, as discussed in the following sections, is influenced by several factors. Crude oil prices are highly correlated with the different oil product prices, with the price difference mainly including refinery and transport costs.

Figure 74 shows the average annual net (excluding tax) retail prices of the main oil products in the EU. Fluctuations in these oil product prices are driven by changes in crude oil prices, as discussed in previous sections, explaining the high peaks observed in oil product prices in 2022 and 2023. As illustrated, oil product prices are relatively similar, with diesel prices on average being slightly higher than gasoline. However, when taxes are included, gasoline prices are typically higher than diesel prices (see 4.3.5. for more details).

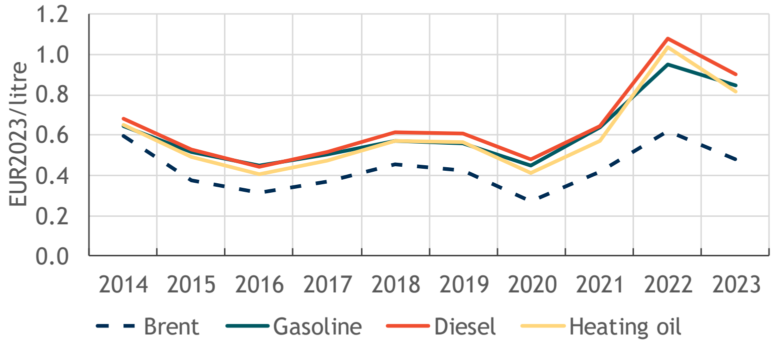


Figure 74: Average annual retail price of oil products in the EU-27 in EUR_{2023}/litre, excluding taxes.

Source: Oil Bulletin

Box D - 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[188]. 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[189]. In most Member States, however, heating oil is taxed at a lower level. Czechia is the only country that has subsidies for heating oil.

Figure 75 shows the average excise duty rates in the EU. As one can see, the tax levels have stayed very similar between 2014 and 2021 in nominal terms. However, more notable MS-level changes cannot be well observed in such EU-wide data. For example, Austria has had additional indirect taxes on fuel aimed at curbing pollution since 2010, a practice some other Member States have adopted in recent years (CY, ES, GR, HU, IE, LV, NL, PT, SI, SK). However, these indirect taxes are relatively minor compared to other taxes. Notably, the average tax level in the EU for gasoline and diesel in 2022

[188] I.e. gasoline excise > diesel excise > heating oil excise
[189] I.e. gasoline excise > diesel excise = heating oil excise

decreased significantly, due to temporary excise duty cuts to relieve cost increases for consumers during the energy prices crisis.

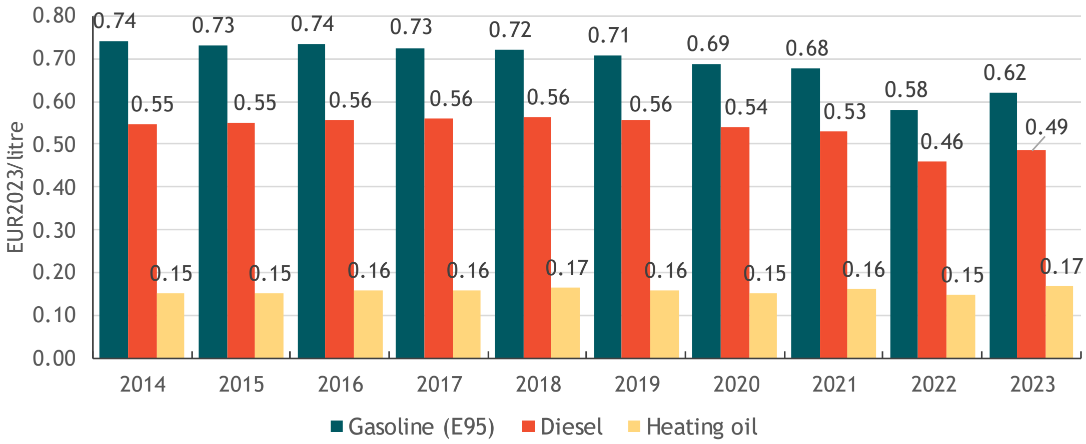


Figure 75: Average EU-27 excise duty rates for oil products in the EU, expressed in EUR_{2023}/litre.

Source: Oil Bulletin

4.3.3. Gasoline/petrol

Retail prices for gasoline/petrol, including and excluding taxes

Figure 76 shows the nominal average annual retail price of gasoline in the EU, both including and excluding taxes and VAT, with the range representing price variations among EU Member States. Gasoline prices have fluctuated in recent years. In 2022 -similar to other fuels - gasoline prices surged as energy markets faced significant challenges due to Russia's invasion of Ukraine. This lifted the gasoline price including taxes from a mean low of 1.28 EUR/litre in 2020 to 1.80 EUR/litre in 2022, marking a 43% increase over two years.

Consumers in Countries such as the Netherlands, Finland, Greece and Denmark were amongst those paying the highest price for gasoline, with an average price of around 2.09 EUR/litre, approximately 15% higher than the EU average of 1.80 EUR/litre in 2022. Conversely, Hungary, Poland, and Malta represented the lower end of the price range, with an average price of 1.30 EUR/litre. In 2023, the EU average gasoline price decreased as prices fell again in most Member States, reflected by the narrowing price range. However, countries such as Hungary, Poland, France, and Italy experienced a slight increase in prices.

As the price of crude oil surged in 2021-2022, so did the net price of gasoline: from a decade-low point of 0.45 EUR/litre in 2020 to 0.95 EUR/litre in 2022 (or approximately a 104% increase over two years). Other factors influencing the net price of gasoline include the source of supply (local refinery or import), transport costs, industry structure, and level of competition. During the surge in energy and fossil fuel prices, Malta reported the lowest gasoline price before taxes at 0.59 EUR/litre, due to its policy of freezing energy prices since the pandemic. Conversely, Germany reported the highest pre-tax gasoline price at 1.01 EUR/litre.

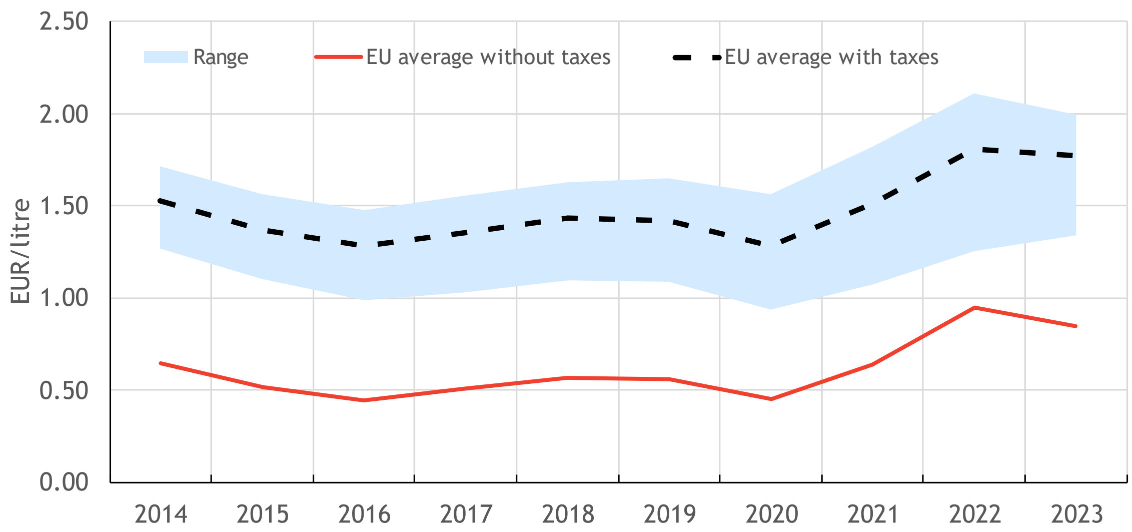


Figure 76: Average annual retail price of gasoline in the EU-27 in EUR/litre, including and excluding taxes and levies..

Source: Oil Bulletin

Excise duty for gasoline/petrol

These high fuel prices contributed to the financial impact of the energy crisis on (low-income) mainly households. As a result, a range of policy interventions aimed to mitigate the impact on consumers. In 2022, EU-wide subsidies for fossil fuel consumption increased to 123 billion euros, with a similar rate of 110 billion euros estimated for 2023.[190] Some significant interventions were the temporary reductions of excise duties in many EU Member States. Such measures were in some cases broad and not targeted to only reaching households in financial stress. The measures did contribute to lower total energy costs for all households in many Member States and were easy and fast to implement. Also given the high government costs of such a general excise duty cut, as of 2024 all temporary excise duty reductions have been lifted in Member States. To illustrate the cost of rate cuts, in 2022 excise duty revenue in the EU-27 was >20 billion EUR lower than 2021, mostly due to temporary rate cuts (and partially due to lower consumption). More details can be found in Chapter 8 on taxes and levies.

Figure 77 illustrates the development of excise duty rates in several EU Member States. The average excise duty rates in the EU have remained steady, going from 0.60 EUR/litre in 2014 to 0.61 EUR/litre in 2021 in nominal terms. In certain countries, like the Netherlands, the excise duty is indexed for inflation and therefore increases slightly annually. In others, such as Germany, the rate is not indexed and remains constant nominally, although other taxes related to CO_2 emissions have been increasing. As mentioned earlier, in 2022, several Member States temporarily reduced excise duties to alleviate the burden of the energy crisis on households. On average, excise duty fell by 6.7% year-on-year. Significant reductions were made in several Member States, such as Hungary (-26%), Italy (-25%), Portugal (-20%), and the Netherlands (-14%), while in some MS the excise duty was not temporarily decreased.

[190] EC (2023). Study on energy subsidies and other government interventions in the European Union – 2023 edition.

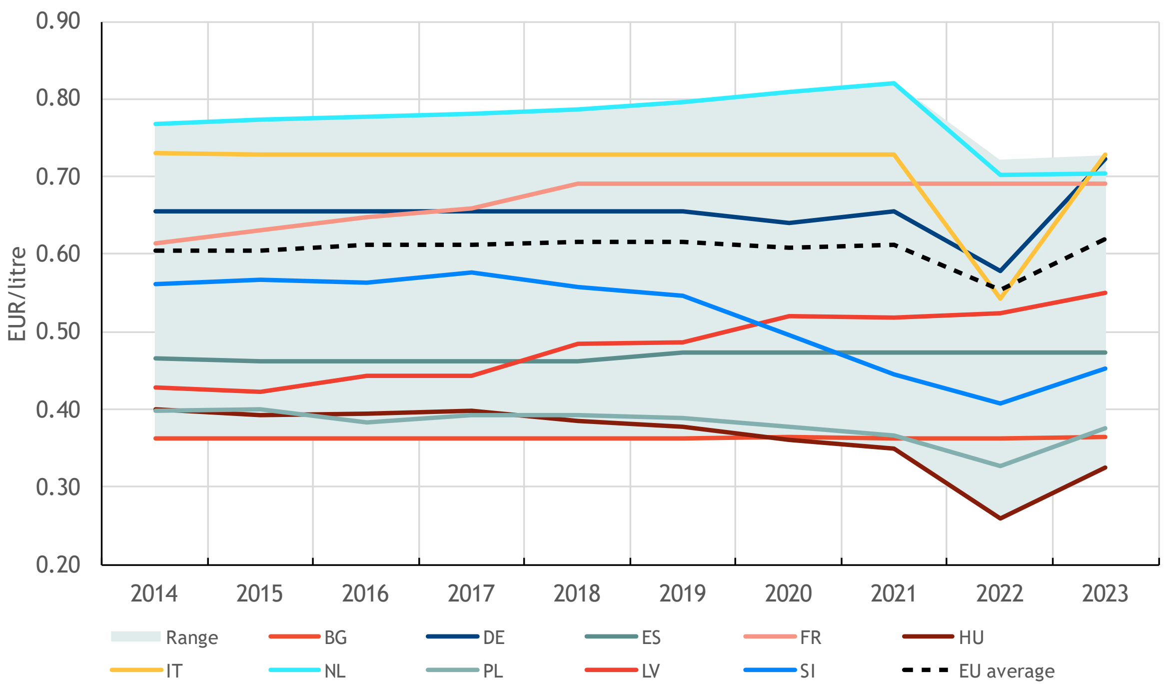


Figure 77: The excise duty rate of gasoline in several EU Member States in nominal EUR/litre.

Source: Oil Bulletin

Figure 78 shows the components (e.g., VAT, duties, and net price) of the retail price of gasoline. As can be seen, the crude oil price, reflected in the net price, is the main driver of total price volatility year-over-year. The average VAT rate in the EU gradually increased from 19.3% in 2005 to 21.5% in 2014. However, since 2014, the VAT rate in most of the Member States has remained unchanged, and the average VAT rate in the EU has stabilised at 21.5%, with slight variations across oil products and Member States.

Taxes on average account for 60% of gasoline prices. Although the VAT rate is constant, the effective VAT amount fluctuates based on the total price excluding VAT; the higher the price excluding VAT, the higher the VAT paid per litre. The share of taxes in the fuel price varies, but is typically 40-65% of the total, with lower shares in times of high net prices and vice-versa.

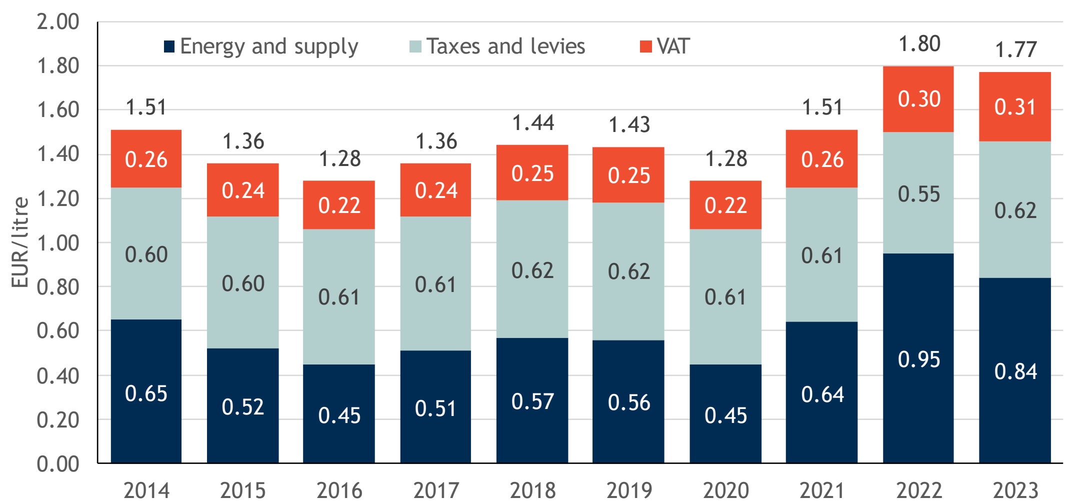


Figure 78: Average retail price of gasoline in the EU in EUR/litre by price component.

Source: Oil Bulletin

Figure 79 illustrates the composition of the average gasoline price in different Member States in 2023. As shown, retail gasoline prices are largely influenced by tax components, as the net price of gasoline is comparatively similar across Member States; with the exception of Malta, due to its policy of freezing energy prices. Complementing previous findings, countries such as Denmark, Finland, Greece, and the Netherlands have the highest retail gasoline prices, about 9-14% higher than the European average, while Malta, Bulgaria, and Romania are 21-24% lower.

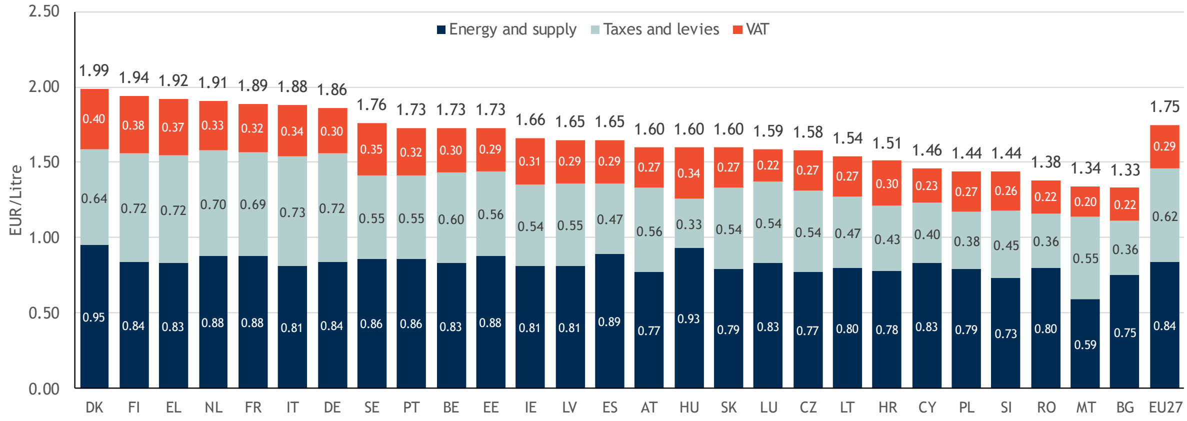


Figure 79: Average retail price of gasoline in 2023 by Member State in EUR/litre by price component.

Source: Oil Bulletin

4.3.4. Diesel

Retail prices for diesel, including and excluding taxes

As shown in Figure 80, diesel prices decreased in 2020 due to the pandemic-driven drop in crude oil prices, before increasing to relatively very high levels in the subsequent years (2021-2022) due to economic recovery and the energy crisis. During this period, diesel prices (including taxes) rose from 1.16 EUR/litre in 2020 to 1.81 EUR/litre in 2022, representing a 56% increase, which is a larger increase compared to gasoline's 41% rise over the same period. This increase is due to the strong demand of diesel and the tightening supply of diesel with sanctions in place against Russia, one of the world's largest producers and exporters of diesel.

The net prices of diesel rose from a low of 0.48 EUR/litre in 2020 to 1.08 EUR/litre in 2022. High net diesel prices were observed in countries such as Sweden (1.47 EUR/litre), Germany (1.21 EUR/litre), and Finland (1.20 EUR/litre), while the lowest prices were found in Malta (0.55 EUR/litre), Hungary (0.89 EUR/litre), and France (0.93 EUR/litre). The biggest outliers are Sweden's high diesel prices and Malta's low prices due to a policy intervention that froze prices.[191] Besides these extremes, the differences between EU countries are significantly smaller, indicating that diverging diesel retail prices in Europe are mostly driven by varying tax rates imposed by different Member States. Furthermore, in 2023, similar to gasoline, diesel prices also fell slightly, mainly reflecting a decrease in crude oil prices. However, prices in 2023 were still at a higher level than in the years pre-energy crisis.

[191] *IMF (2023). Malta: selected issues: Responses to the Energy Crisis in Europe and Malta.*

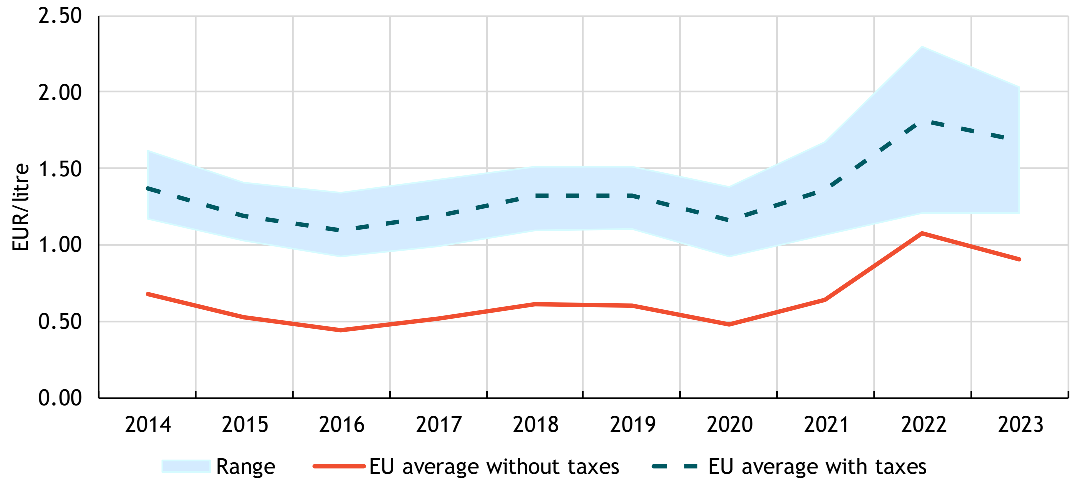


Figure 80: Annual average retail price of diesel in the EU-27, with and without taxes, expressed in EUR/litre

Source: Oil Bulletin

Excise taxes for diesel

The nominal excise duty rate for diesel has averaged around 0.43 EUR/litre from 2014 to 2021, illustrated by Figure 81 below. Historically, between 2010 and 2013, Italy's rate increased by 0.20 EUR/litre (40%), reaching 0.62 EUR/litre and then stabilizing. France’s duties rose significantly from 2014 to 2018 due to a new 'carbon' price component. Bulgaria, meanwhile, applies the minimum rate required by the Energy Tax Directive. In 2022, to offset the surge in energy prices, the average excise duty across EU Member States fell from 0.48 EUR/litre in 2021 to 0.44 EUR/litre in 2022, as Member States on average reduced their excise duty by 7%. Italy, which has the highest VAT, reduced its excise duty by 30%, from 0.62 to 0.43 EUR/litre, the most significant cut among the EU Member States.

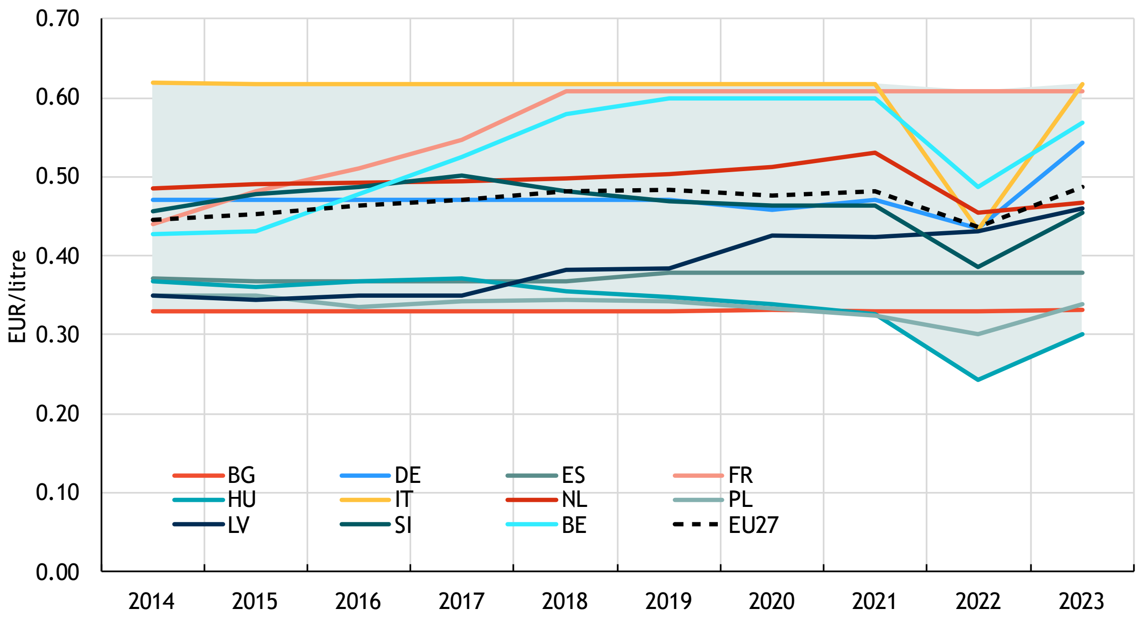


Figure 81: The average EU-27 excise duty rate of diesel in EUR/litre in selected EU countries.

Source: Oil Bulletin

The average VAT rate of diesel has gradually increased to 21.5% in 2016 and remained steady to 2021. In 2020, the average VAT rates fell slightly to 21% given temporary reduction of VAT in a couple of countries such as Poland (23% to 8%), Greece (24% to 20%) and Finland (24% to 21%) in the first half of 2022. Nonetheless, due to high crude oil prices, 2022 still sees the highest average diesel VAT since 2012 at 0.30 EUR/litre, as shown in Figure 82 below.

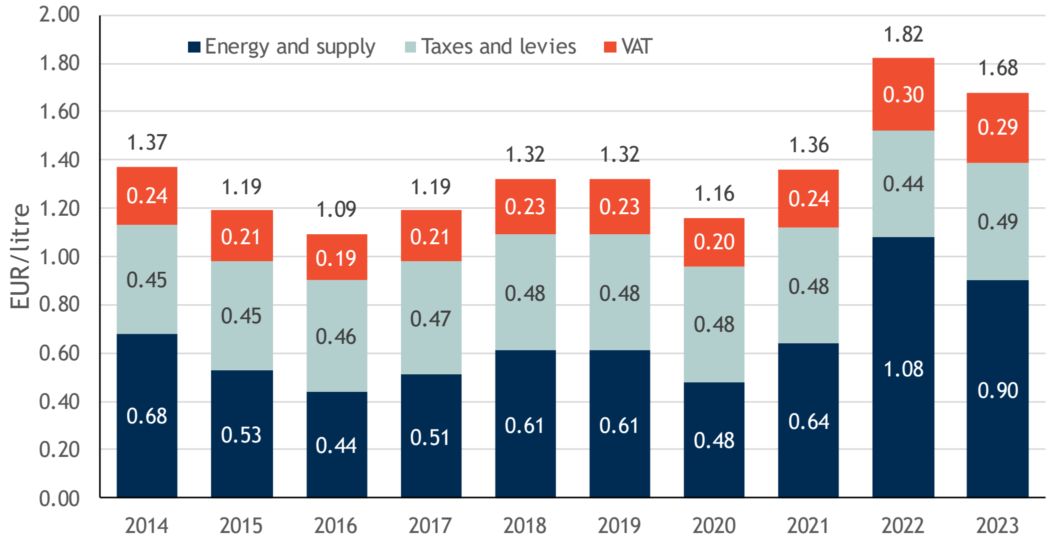


Figure 82: Average annual retail price of diesel in the EU in EUR/litre by price component.

Source: Oil Bulletin

With regards to price composition, as illustrated by Figure 83, the net price of diesel is relatively similar for most Member States apart from Sweden, Finland and Malta which represent the upper and lower extremes. When taxes and VAT included, Sweden had the highest diesel retail price at 2.04 EUR/litre while Malta had the lowest at 1.20 EUR/litre.

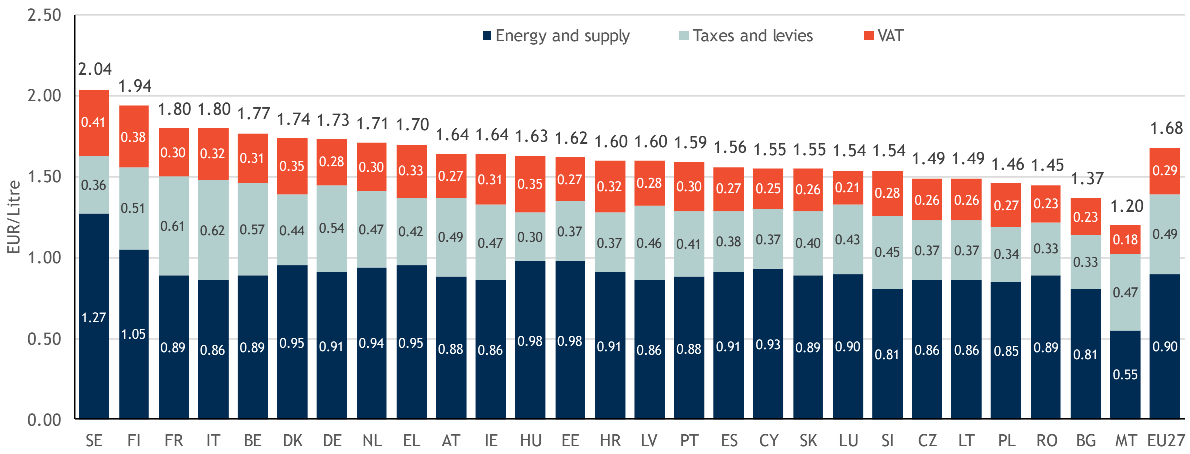


Figure 83: Average retail price components of diesel in 2023 by Member State in EUR/litre

Source: Oil Bulletin

Similar to gasoline, excise duties of diesel in Member States have changed in recent years mainly due to the energy crisis. From 2021 to 2023, excise duties across Europe have slightly increased, driven by rises in countries like Austria (19.5%), Denmark (14.9%), and Latvia (9.52%). Meanwhile, other countries, including France, Finland, and Estonia, have kept their excise duties unchanged. Some Member States, such as Portugal (-19.6%), Sweden (-20%), and Ireland (-12.9%), have temporarily reduced their excise duties in 2022. Italy reduced its excise duty by 30% in 2022, but it returned to the 2021 level in 2023 (see Figure 81), similar to other Member States such as Germany and Slovenia, while Portugal and Ireland, just to name a few, have raised their excise duty in 2023 though not to their 2021 level.

4.3.5. Gasoline vs. diesel

The previous sections have shown that although the wholesale price of diesel is typically higher than gasoline, the retail price tells a different story: gasoline prices are usually higher than diesel prices due to higher taxes. Figure 84 shows this difference. As illustrated, gasoline retail prices were on average higher than diesel prices by about 0.15 EUR/litre between 2014 and 2021. However, in 2022, the average retail price of diesel was equal for a few months at the start of the year, followed by a short period of higher diesel prices than gasoline. This was due to an exceptionally tight global refining market with high crack spreads especially for diesel (see Figure 84).

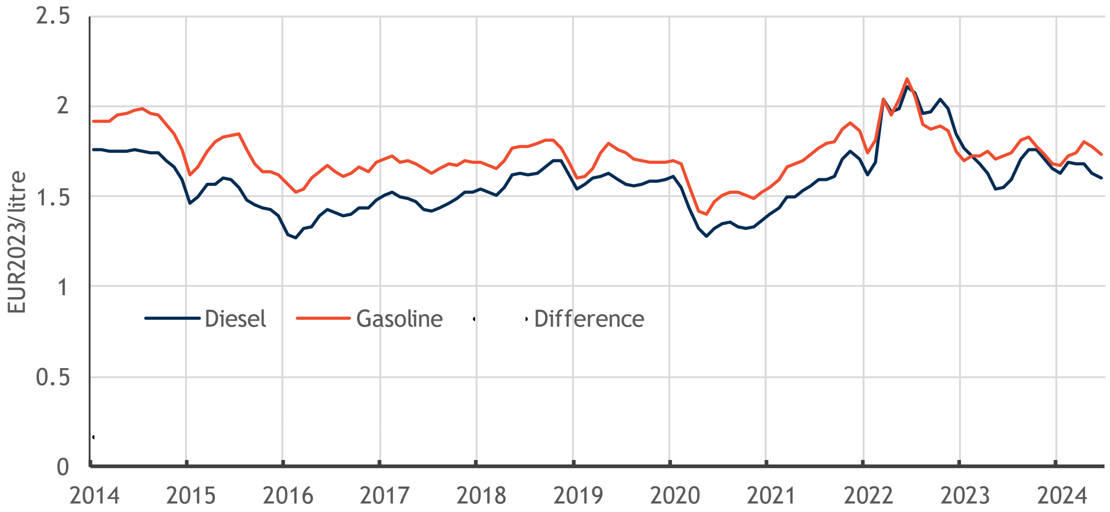


Figure 84: Average retail price of gasoline and diesel in the EU, with taxes, in EUR_{2023}/litre

Source: Oil Bulletin[192]

The average excise duty rates for gasoline, which have been around 0.60 EUR/litre since 2012, were on average 0.14 EUR/litre higher than those for diesel from 2014 to 2021, as shown in Figure 85. In 2022, the excise duty for both gasoline and diesel fell slightly as Member States implemented temporary tax reductions to mitigate the increased prices of these fuels, as elaborated in the previous sections.

[192] *Note that the above figure is in real prices, while majority of this chapter is nominal.*

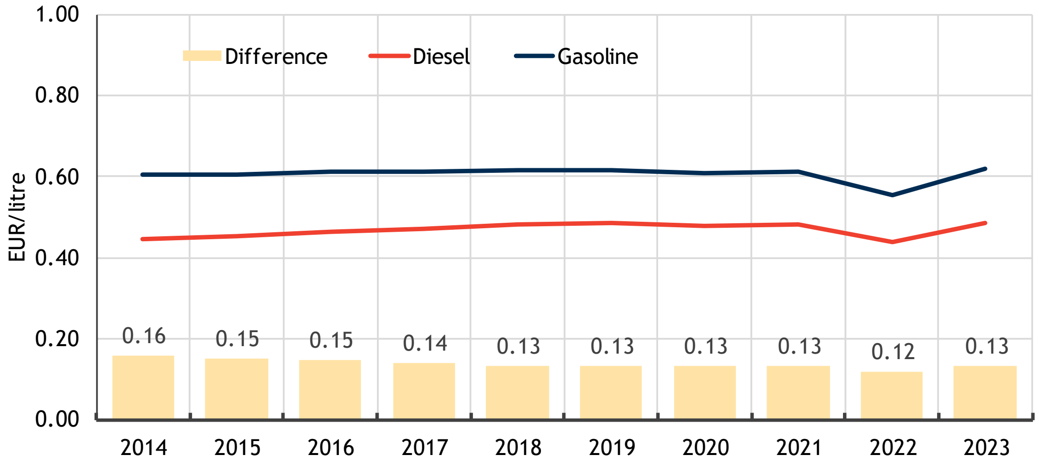


Figure 85: Average excise duty rates for gasoline and diesel in the EU in EUR/litre. Note this figure is nominal again, while above was in real EUR_{2023}.

Source: Oil Bulletin and DG TAXUD

4.3.6. Heating oil

Heating oil accounted for about 10% of the total oil product consumption in the EU in the past years. While its usage is declining in most Member States, heating oil remains prevalent for household heating in many countries. As shown in Figure 86, in relative terms, the largest relative share of heating oil in final energy consumption by households is in Ireland (41%) and Belgium, Greece and Cyprus (all 30%).[193] The largest absolute consumers in 2023 were Germany (140 TWh), Spain(60 TWh) and France (47 TWh).

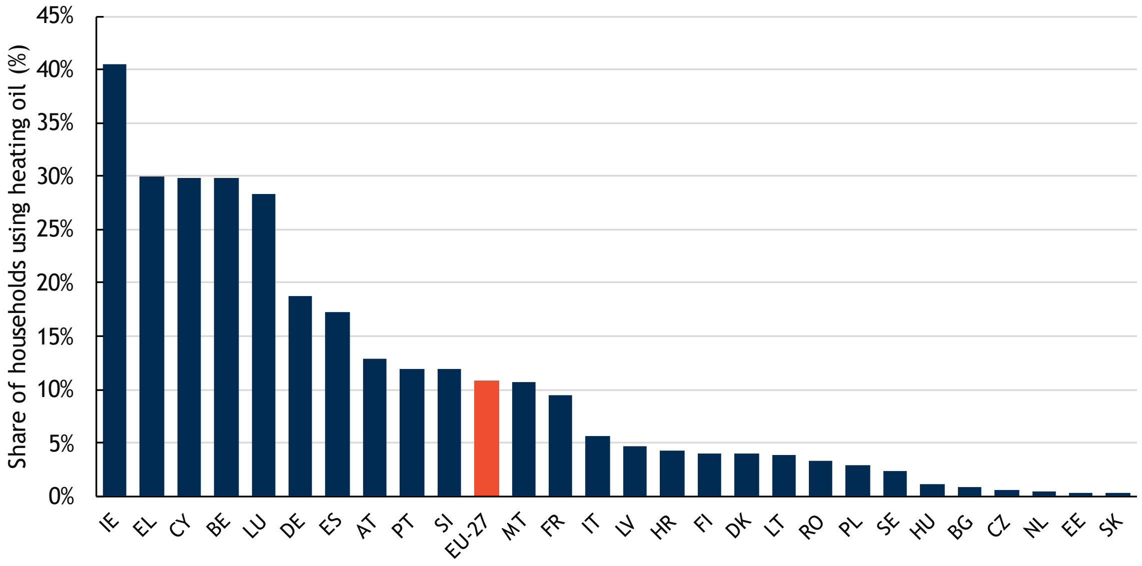


Figure 86: Share of households using heating oil for heating in 2023.

Source: Eurostat

As illustrated in Figure 87, in the first half of 2022, retail heating oil prices significantly increased across the EU, with the average price rising from 0.57 EUR/litre in 2021 to 1.04 EUR/litre in 2022, an 82% increase. Prices then fell to 0.82 EUR/litre in 2023, still marking an increase of 44% from 2021 to 2023.

[193] Eurostat (2023). Disaggregated final energy consumption in households 2022.

The highest prices in 2023 were recorded in Denmark (1.09 EUR/litre), followed by Hungary (0.98 EUR/litre), Finland (0.95 EUR/litre), France (0.9 EUR/litre) and Italy (0.88 EUR/litre). Germany, the largest consumer of heating oil in the EU, had prices close to the EU average[194]. Due to the relatively low heating oil prices in major consuming countries, the consumption-weighted average price in the EU remains close to the lowest price levels among Member States.

As illustrated, the range of price differences in net prices (excluding taxes) has grown gradually, increasing from about 0.31 EUR/litre in 2020 to 0.64 EUR/litre in 2022 and 0.48 EUR/litre in 2023. This widening gap is partly driven by the rising wholesale price of crude oil, but also by varying policy interventions, such as Malta's freezing of energy prices.

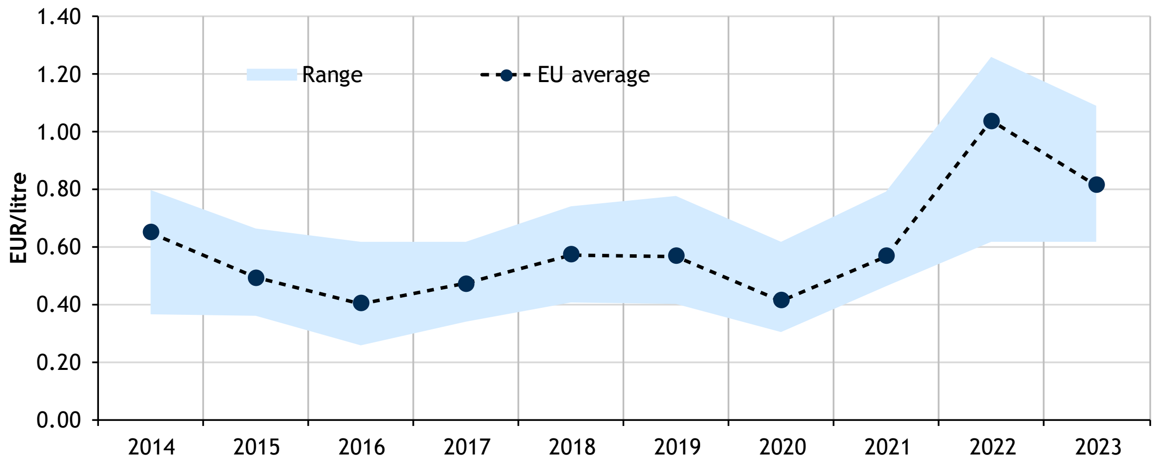


Figure 87: Weighted average EU retail heating oil price, excluding taxes, and price range in Member States.

Source: Oil Bulletin[195]

The average excise duty rate for heating oil in the EU, as shown in Figure 88, has gradually increased in nominal terms from 0.12 EUR/litre in 2014 to 0.17 EUR/litre in 2023. More details about excise duty rates can be found in Chapter 8 on taxes. Among EU MS with considerable heating oil consumption, Italy had the highest excise duty rate in 2023 at 0.40 EUR/litre in 2014 to 0.53 EUR/litre in 2021. Heating oil is not consumed on a wide scale in the Netherlands, Slovakia, and Bulgaria (and thus data was not available).

Sweden, Portugal, and Denmark have maintained some of the highest excise tax rates in the EU, ranging from 0.37 to 0.42 EUR/litre as of 2023. In France, a gradual increase in the carbon tax component from 2014 to 2018 has positioned the country's rate 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 in Belgium and Lithuania are also low at the minimum level set by the Energy Tax Directive (0.021 EUR/litre).

[194] Note that since it's a weighted-average, German price has large influence on EU average.
[195] Note: for 2023 heating oil prices in Bulgaria and Netherlands were not taken into account, due to doubts about data quality. In any case, heating oil consumption in Bulgaria and the Netherlands is negligible.

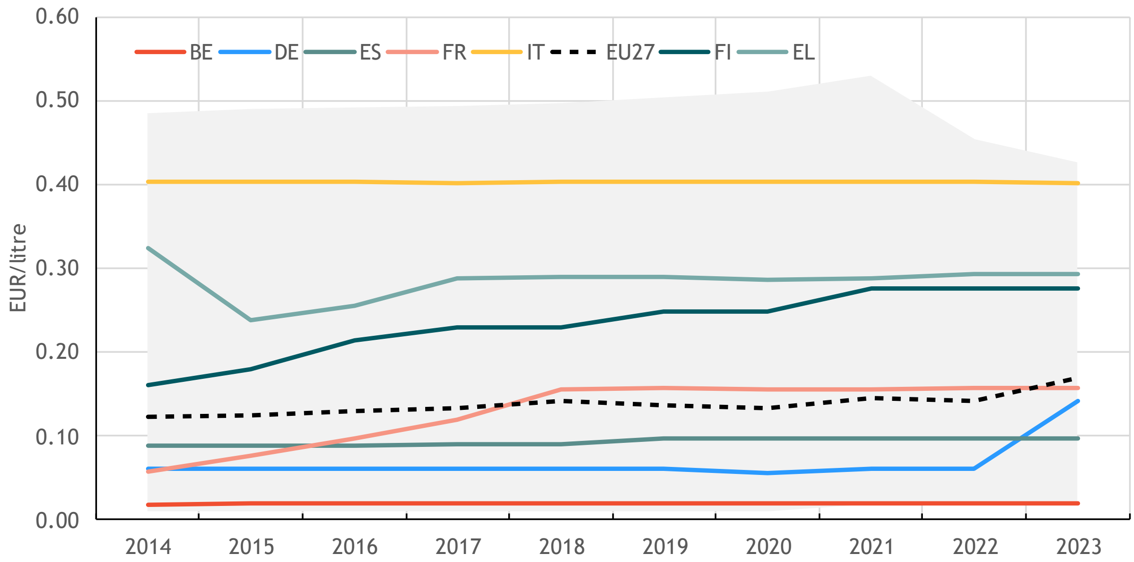


Figure 88: The excise duty rate of heating oil in the EU-27 (consumption-weighted EU average), and major heating oil consuming MS, in EUR/litre.

Source: Oil Bulletin

The average retail price of heating oil, like gasoline and diesel, is influenced by changes in wholesale crude oil prices. As shown in Figure 89, from 2014 to 2021, the tax component (including taxes and VAT) accounted for about 34% of the retail price of heating oil. In 2022, this share declined to 27% as the net price increased due to the increase in crude oil prices, which then represented 73% of the retail price of heating oil (1.04 EUR/litre). Additionally, similar to gasoline and diesel, the average VAT rate for heating oil has been gradually increasing from 19% in 2005 to 21% by 2021 and has remained stable since in most MS.

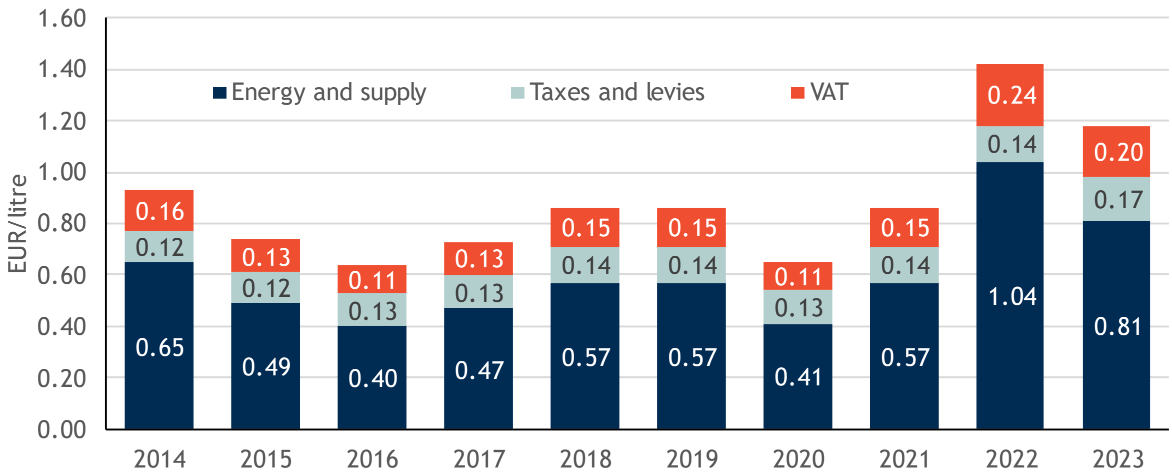


Figure 89: Average retail price of heating oil in the EU (consumption-weighted average) by price components (incl. VAT), in EUR/litre.

Source: Oil Bulletin

Complementing the findings from the previous figures, Figure 90 illustrates that the highest heating oil prices are found in Member States such as Denmark, Hungary, Portugal, Italy, and Finland. In contrast, countries like Bulgaria, Belgium, Lithuania, and Malta have comparatively low prices relative to the EU average.

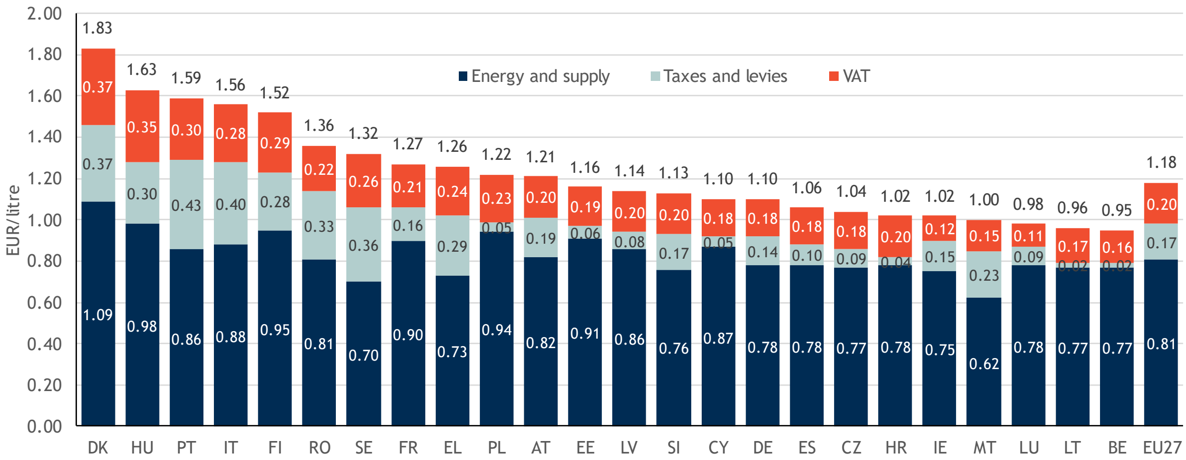


Figure 90: Average retail price of heating oil in the EU by Member States and price component in 2023, in EUR/litre

Source: Oil Bulletin[196]

4.3.7. International comparison

Gasoline/petrol

Figure 91 illustrates how retail gasoline prices in the EU compare to those in selected G20 countries in real prices, including taxes.[197] The EU average has consistently been higher than in other regions, except for the UK. Taxes are the main factor driving the price differences between the EU and other regions, since EU taxes on fuels are among the highest globally which results in high retail prices; explaining why gasoline prices in the EU are for example twice as high as in the US. Since 2008, taxes in the EU have averaged around 0.85 – 0.95 EUR/litre, while in the US (including federal and state taxes), they have been around 0.1 – 0.15 EUR/litre since 2015, with no changes to federal tax levels in over 30 years.

A consistent trend among G20 countries is the large increase in gasoline prices from its low point in 2020 during the Covid-19 pandemic outbreak, particularly in 2022 when crude oil prices skyrocketed. Notably, gasoline prices in Australia have gradually increased over the years and saw a significant rise from 2022 to 2024, marginally overtaking those in the EU, the UK, Japan, and South Korea. Some of the relative price movements can be explained by exchange rates, given that crude oil is mainly traded in US dollars.

[196] *Note: Data not available for Bulgaria, Netherlands, and Slovakia, since heating oil is not used on a large scale in these MS.*
[197] *In this edition we do not include an international comparison for prices excluding taxes, because it presents a skewed comparison, given that in many markets also the net price (excluding taxes) is heavily regulated and does not display all costs.*

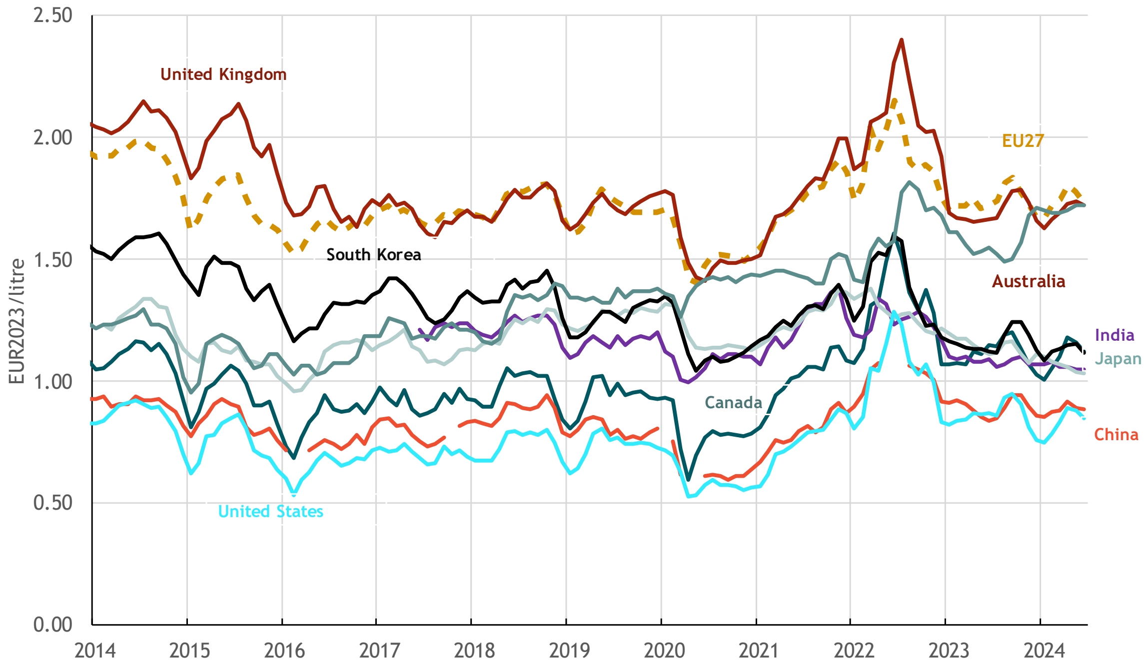


Figure 91: International comparison of retail gasoline prices in EUR2023/litre, including taxes.

Source: Oil Bulletin, DG Energy; Enerdata EnerMonthly

Diesel

The retail price of diesel follows a similar trend to that of gasoline, as shown in Figure 92. The EU average is the highest in the G20 countries, excluding the UK. This is more pronounced with diesel than gasoline prices. The high tax component, accounting for about 50% of the retail price, largely explains why diesel prices in the EU are significantly higher compared to other countries. For example, taxes in the US range from 0.11 to 0.16 EUR/litre, whereas in the EU, they range from 0.69 to 0.78 EUR/litre.

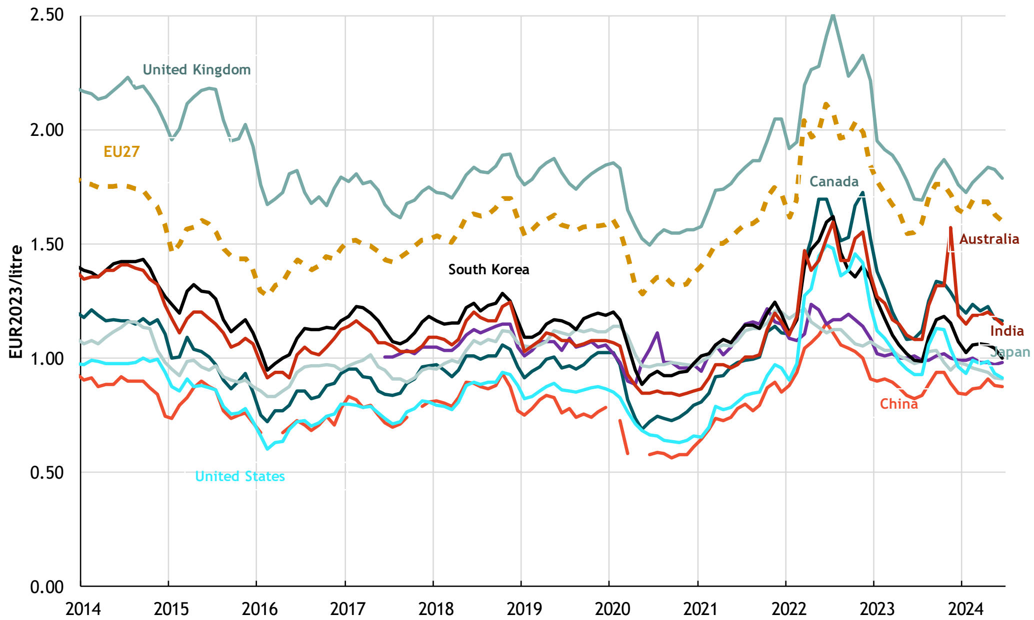


Figure 92: International comparison of retail diesel prices in EUR2023/litre, including taxes.

Source: Oil Bulletin, DG Energy; Enerdata EnerMonthly

Heating oil

Figure 93 below shows that EU-average prices for heating oil are relatively closer to prices in other G20 countries, due to the lower tax rate in the EU. Still, also average heating oil prices are relatively high in the EU. Until 2021, EU prices and prices in Canada, Japan, South Korea, and the US were similar due to similarly low tax rates and high influence of global crude oil prices. During the energy crisis, the price differential with South Korea and Japan grew, while prices stayed similar to the US and Canada. Prices in the UK were consistently lower than the other countries in the comparison.

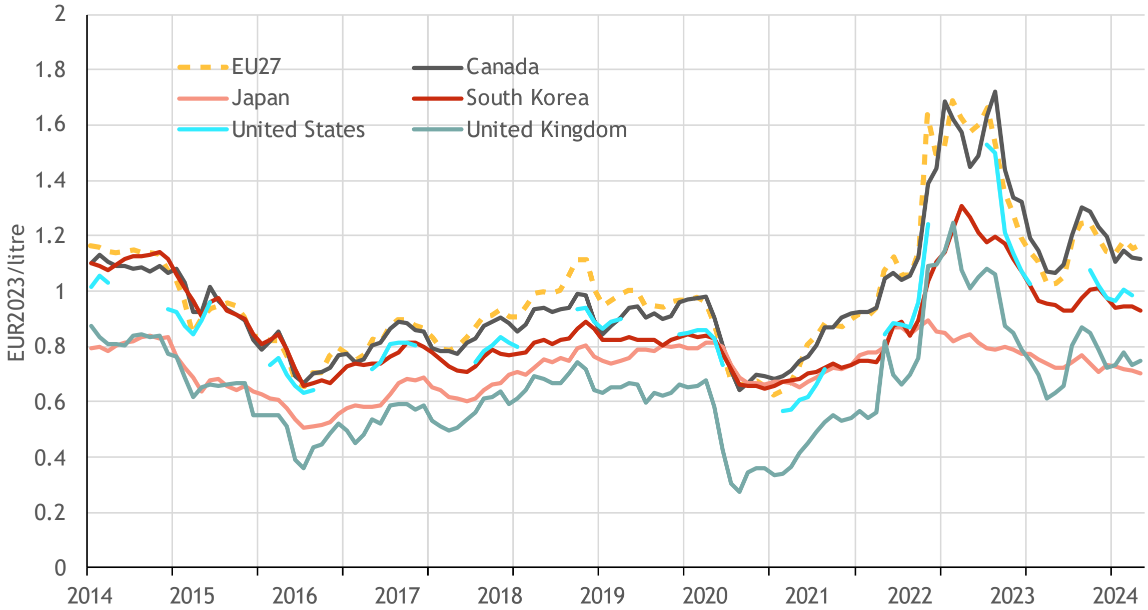


Figure 93: International comparison of retail heating oil prices in EUR_{2023}/litre, including taxes and VAT.

Source: Oil Bulletin, DG Energy; IEA; Enerdata EnerMonthly

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.

In Figure 94 heavy fuel oil prices have been comparable in the EU, US and South Korea especially in the 2018-2022 period. Between 2014-2018 prices have been consistently higher in the EU. Between 2022-2024 prices stayed high in the EU again, though US data is lacking for a comparison. Retail prices (including taxes) for heavy fuel oil are low (about half) compared to heating oil prices and even more so 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.

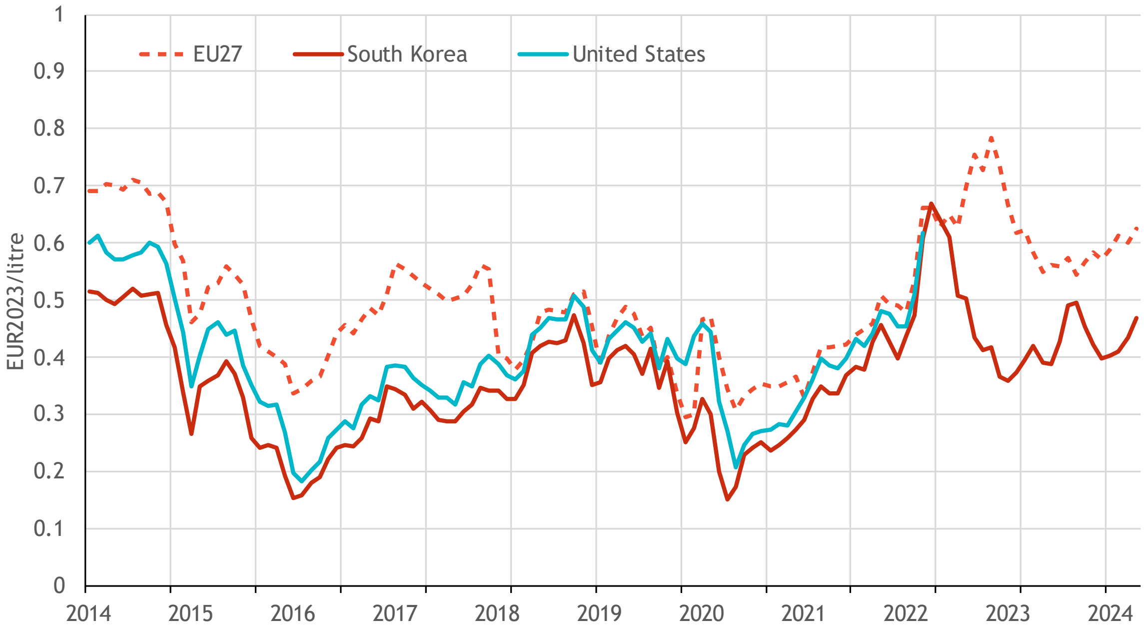


Figure 94: International comparison of heavy fuel oil prices in EUR2023/litre, including taxes.

Source: Oil Bulletin, IEA

4.4. Alternative fuels

In the following sections, analysis of the consumption and prices of several major alternative fuels is provided: liquefied petroleum gases (LPG), biogasoline (pure or blended), biodiesel (pure or blended), other liquid biofuels and biogases. The use of alternative fuels is promoted to substitute fossil oil-based fuels in the EU. Since most of these fuels are to some extent regional or global commodities, this section presents an international comparison for the prices for these alternative fuels.

4.4.1. Alternative fuels consumption

Figure 95 shows the total final energy consumption of the main alternative fuels used in the EU. Most of these alternative fuels are sustainable – when complying with EU sustainability regulations -while LPG is the main fossil alternative fuel. These fuels are mostly used in the transport sector, except biogas that can be used as a direct substitute for natural gas. The use of sustainable alternative fuels such as pure or blended biogasoline or biodiesel (and excluding LPG) has increased significantly since 2005, but still only represent a small fraction of total final energy consumption in transport at about 5% of final energy consumption. The share of LPG is at a similar level.

Especially the use of blended biofuels – mainly biodiesel – has increased significantly due to blending obligations. Pure biofuel use is marginal and has decreased since 2006. Biodiesel is mostly produced from vegetable oils and animal fats and is mixed with oil-derived diesel. The most commonly used blend in the EU is B7 (7% biodiesel). The use of biodiesel has gradually plateaued between 2020-2024. Biogasoline refers to mixing bioethanol with fossil gasoline. Most common blends for vehicles in the EU are currently E5 and E10 currently.

Next to biofuels, biogas also has seen a large increase in consumption since 2005.

Besides these sustainable alternative fuels, LPG is the main alternative fuel used in the EU-27. Since 2005, its consumption is gradually declining with about 15% between 2005 and 2022.

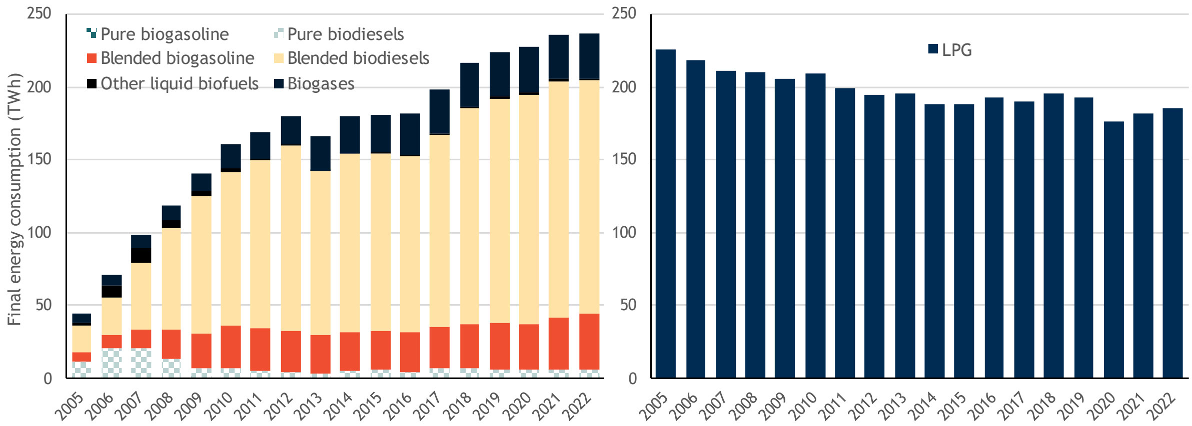


Figure 95: final energy consumption in all sectors combined for selected sustainable alternative fuels and LPG in 2022.

Source: Eurostat.[198]

Figure 96 shows most alternative fuels are used in the transport sector (255 TWh), followed by industry (40 TWh). Most 'other sector' consumption (123 TWh) is for heating and cooking as substitute for natural gas for households not connected to the natural gas grid.

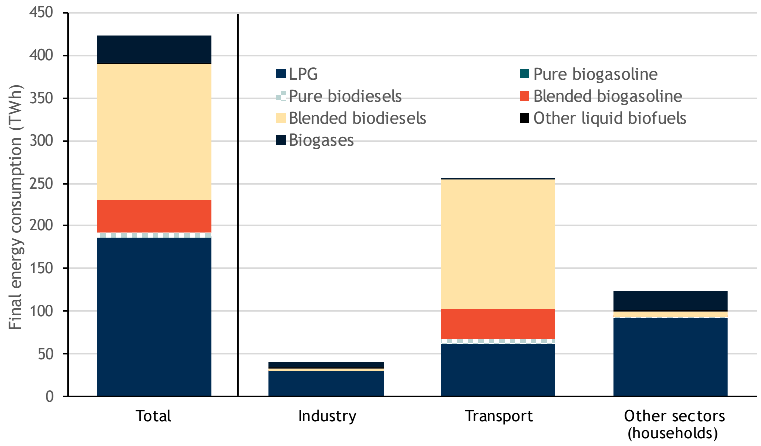


Figure 96: Final energy consumption per sector and in total for selected sustainable alternative fuels and LPG in 2022.

Source: Eurostat.

4.4.2. LPG for transport

In this section prices for LPG use as transport fuel are compared. Note that LPG prices as transport fuel can differ from LPG prices for other uses, such as cooking or heating, due to different tax regimes in many countries. In the case of LPG, EU average retail prices including taxes fluctuated within a range of 0.60-0.90 EUR_{2023}/litre. During the energy crisis, LPG prices increased – although substantially less drastic than other oil products – to 0.90 EUR_{2023}/litre. In 2023, prices reduced to around 0.71 EUR_{2023}/litre on average in 2023 and the first months of 2024. LPG price developments follow crude oil price developments, since the main feedstock for LPG production is crude oil. LPG prices also differ per Member State (see Figure 97): prices are below the EU average in Belgium and Poland, while prices have been traditionally high in France and recently also in Germany since 2022. Prices in the

[198] 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.

Netherlands generally are slightly above the EU average. Price differences are mostly the result from different tax levels. In some Member States temporary tax measures were implemented during the energy crisis to lower LPG price levels for consumers.

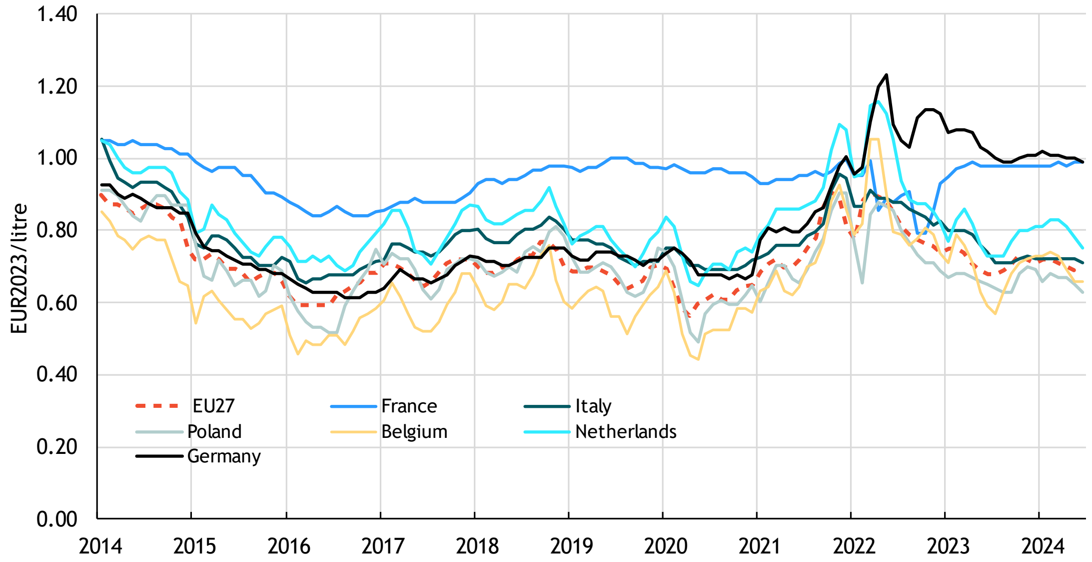


Figure 97: LPG (for transport) prices in the major LPG consuming Member States as well as the EU-27 average in EUR_{2023}/litre.

Source: Eurostat

Figure 98 compares the average EU LPG retail prices with prices for main trading partners, based on the most recently available data. Price trends are similar between countries, since wholesale prices are mainly driven by crude oil prices. Main differences are the result also from different taxation levels and/or subsidies. On average, prices in the US and South Africa are high for transport purposes (as example, LPG for heating is cheaper in the US due to lower taxes). EU prices are comparable with the price level in India and recently Japan and Brazil.

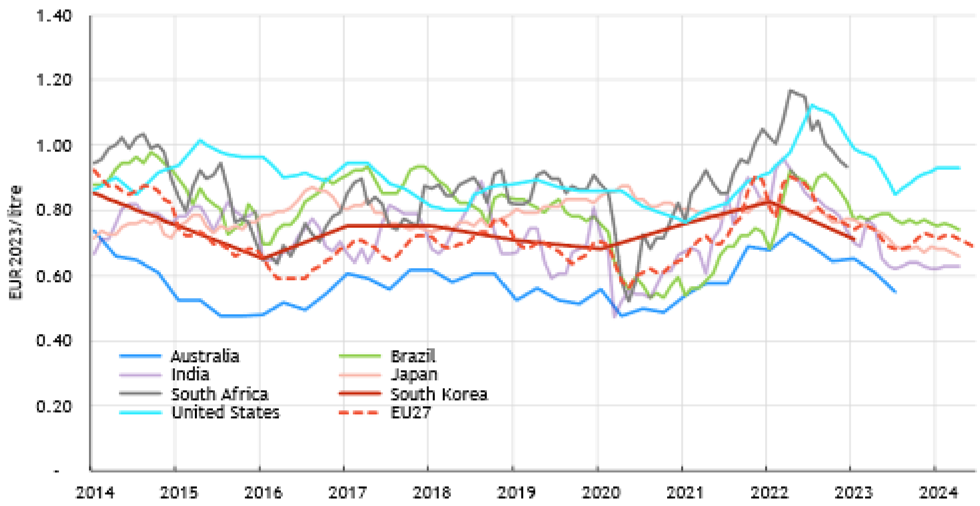


Figure 98: International comparison of LPG for use in transport retail prices including taxes in EUR_{2023}/litre.

Source: EU Oil Bulletin, Enerdata EnerMonthly

4.4.3. Biofuels

Bioethanol

Bioethanol is commonly blended with gasoline to produce blended biogasoline (see consumption data in Figure 99 under 'blended and pure biogasoline') and is one of the main alternative fuels used in the EU. In this section bioethanol prices of the main exporting regions are shown. Most of the bioethanol consumed in the EU is produced domestically. EU production is slowly increasing, but most of the growth in bioethanol consumption is driven by increased imports. Hence, export bioethanol prices have a growing influence on bioethanol prices in the EU.[199]

For the 3 main producers (US, Brazil, Europe), export wholesale prices until 2021 were lowest in the US at around 400 EUR/tonne. Prices in Brazil were between 500-600 EUR/tonne, while prices in the EU always have been usually higher. During the energy crisis, export prices significantly increased in all 3 regions, among others due to tight bioethanol supply due to corn (a major feedstock) export disruption from Ukraine and weather-related supply disruptions (La Niña in the US). Prices of the European ARA FOB reference price increased significantly and up until March 2024 bioethanol prices have been high and above 800 EUR/tonne.

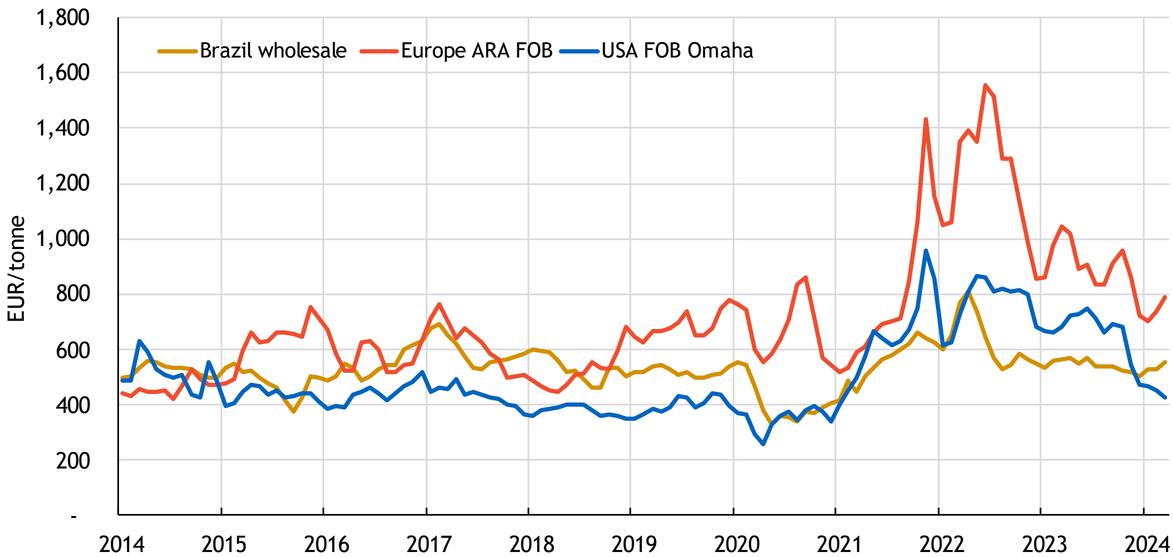


Figure 99: International comparison of bioethanol export prices via common reference prices for the three largest bioethanol producers: US, Brazil and the EU. Prices displayed in EUR/tonne.

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

Biodiesel

For biodiesel (see Figure 100) wholesale production prices for the EU (mainly rapeseed as feedstock) and the US were similar and lay in the 700-1000 EUR/tonne range between 2014 and 2021. Prices in Argentina and Malaysia were consistently lower at an average in the 2014-2021 period of 606 EUR/tonne for Malaysian exports (mainly palm oil) and 670 EUR/tonne for Argentina (soybeans).

Since 2021, biodiesel prices have increased substantially for all major producers (EU, US, Argentina, and Malaysia) due to increasing feedstock costs. Among others, there were several supply shocks in the agricultural sector in main producing regions (partially weather-related) and a large demand

[199] Note also that in this section prices per tonne are used, while the energy content for fuels can depend per tonne *between* biofuels, but also between the same biofuel type but from different regions; biofuels are less standardized than conventional fuels such as gasoline and diesel.

increase for corn and soy from China in 2021 increased feedstock prices.[200] Along with decreasing prices as of winter 2023 for other energy commodities, biodiesel prices have also gradually reduced, although prices in 2024 are still at considerably higher levels than pre-crisis.

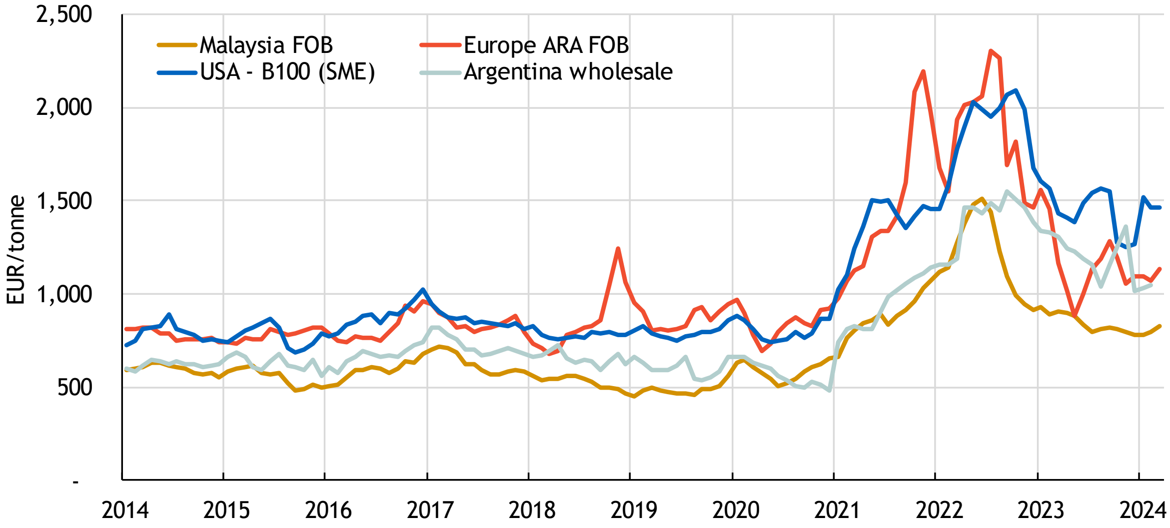


Figure 100: International comparison of biodiesel export prices (in EUR/tonne) via common reference prices for several of the largest biodiesel producers in 2017: EU (40% share global production), US (15%), Argentina (8%,) and Malaysia (2%) [201].

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). Residential tariffs specific to EV charging are still not widely available, and those tariffs are quite similar to dynamic tariffs (including peak and off-peak prices). Therefore, the main focus of the analysis are on these prices. An analysis[202] of the different tariffs available in the studied countries (see below EU-27 and non-EU-27 countries) shows that they all have specific peak and off-peak tariffs (see Table 5).

[200] *IEA (2022). Renewables 2021.*
[201] *IEA (2018). Share of global biodiesel output by country, 2017-2023.*
[202] *Overview for this selection of countries of the tariffs offered by the largest electricity suppliers in the country to identify the existence of dynamic tariffs.*

Table 5 Presence on off-peak tariffs among existing electricity offer in 2023

	Country	Presence of dynamic tariff
EU-27	France	YES
	Austria	YES
	Belgium	YES
	Germany	YES [203]
	Spain	YES
	Sweden	YES [203]
	Denmark	YES
	Finland	YES
	Italy	YES
Non-EU	Norway	YES [203]
	UK	YES
	China	YES
	Japan	YES
	South Korea	YES [204]
	Canada (Ontario)	YES
	USA	YES
	Australia	YES

Source: Enerdata

Figure 101 depicts average off-peak and on-peak tariffs dedicated to EV charging at home. Values are given for EU countries (blue) and non-EU countries (orange). 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 used for at-home EV charging vary 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, off-peak and on-peak tariffs are equal or lower than the average household electricity price, which make EV charging attractive.

In addition, in some countries (e.g. Canada, the USA, and Norway), subscribing to a preferential EV charging system "penalises" 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.

[203] *In Sweden, Norway, and Germany, utilities propose time of use prices. Only few customers choose this rate (the complexity of these tariffs still presents barriers to customers switching to it).*

[204] South Korea: Most prices are incremental prices, with seasonal prices. The only dynamic rates are for Electric Vehicles.

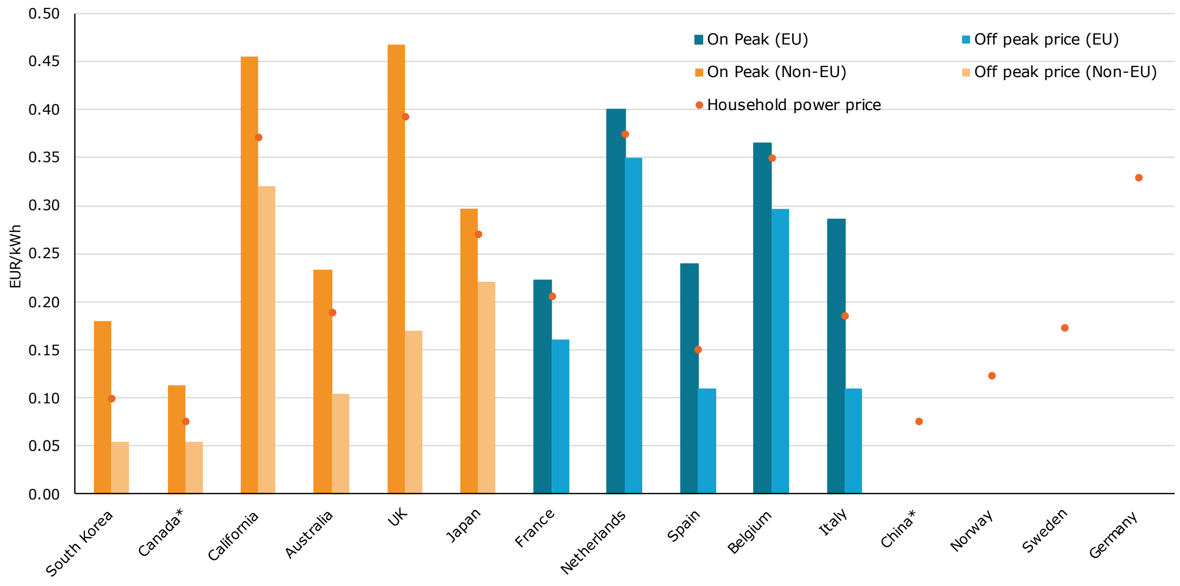


Figure 101: Examples of EV charging price at home in 2023 for both on peak and off-peak charging, as well as the household average electricity price.[205]

Source: Enerdata calculation based on Eurostat (2023) data and national sources *(e.g. selection of public offers from local electricity suppliers).*[206]

Public charging stations

Two types of public charging stations exist: Alternative Current (AC) and Direct Current (DC) charging stations. AC charging is generally slower than DC charging, but has lower cost (including production, installation, and functioning costs). It is preferred for long-term parking (>20mins) over DC charging and is the most common charging option currently on the market. These AC charging stations provide up to 22 kW of charging power and allow EV recharging within a few hours. "Fast" DC charging stations normally provide from 50 kW to 400 kW and are typically used for short periods of time, typically 30 minutes. Over 90% of the public charging points in the EU are AC chargers, though the DC share is increasing. [207]

Generally, the charging prices in the studied area have significantly increased from 2021 to 2024, with nearly +40% for AC charging and +16% for DC charging. This increase has been notable in certain countries such as Austria, where the average AC charging price has risen from 0.350 to 1.370 EUR/kWh (a change of +390%), and in Germany, where the average AC charging price has risen from 0.360 to 0.870 EUR/kWh (a change of +270%).

Public AC charging stations

Figure 102 shows the ad hoc[208] prices found at AC public charging stations and average 2023 household electricity prices in various countries. Lithuania, Portugal, Croatia, and Romania have the lowest public AC charging prices. Other countries such as the Netherlands and Romania also have average AC public charging prices lower than the average household electricity price (probably due to higher time and session fees).

[205] *Canada = Ontario Price*

[206] *Note: For each of the presented countries, there is no national statistic on average off-peak and on-peak price. This graph presents the average retail price and an illustration of dynamic tariffs based on a selection of existing offers, it is however, only an illustration.*

[207] *European Alternative Fuels Observatory (2024). Significant Milestone Reached: European Union Boasts Half a Million Public Recharging Points*

[208] *I.e., the price when no subscription is taken by the consumer.*

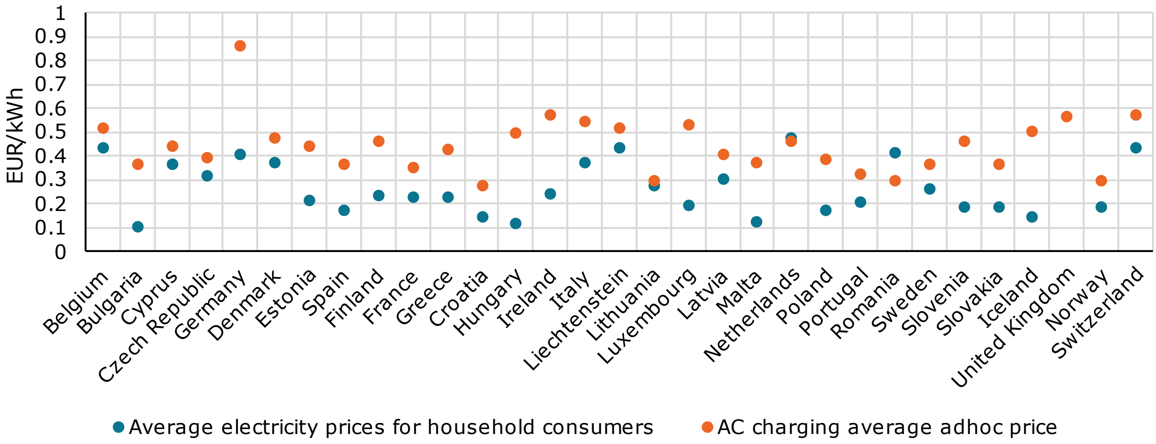


Figure 102: AC public charging price (energy component) in EUR_{2023}/kWh.

Source: Author's calculation from European Alternative Fuels Observatory (2023); Eurostat (2023) (household prices)[209]

Public DC charging stations

Figure 103 shows prices found at different DC public charging stations in various countries and the average EU-27 household electricity price. In average, DC charging prices are around 15% higher than those for AC charging. Croatia, Portugal, Romania, and Norway have the lowest DC charging tariffs.

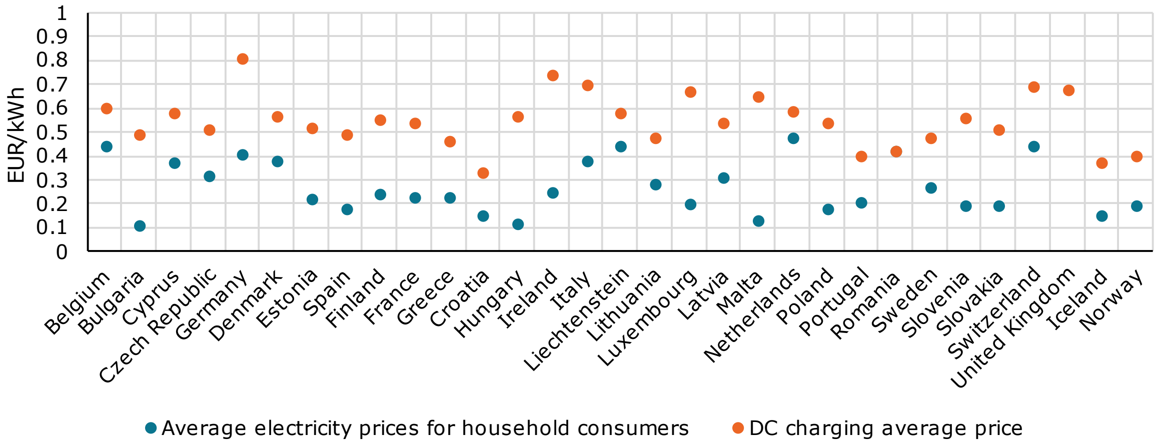


Figure 103: DC public charging price (energy component) (EUR2023/MWh)[210]

Source: Enerdata calculation from European Alternative Fuels Observatory (2023); Eurostat (2023)[209]

4.4.5. Electricity storage

Two key storage technologies must be considered at the EU and global levels to mitigate the negative impacts of growing penetration of variable renewable energy sources into the electricity grid: batteries and hydropower.

While most of the attention is usually on batteries, the most widely used storage technology in the EU remains pumped hydro energy storage (PHES).[211] In 2021, the global total installed production

[209] *Note: The energy price does not include the time fee and the session fee that are usually added to the final recharging bill.*
[210] Maximum price range capped at to make the graph easier to read
[211] *PHES involves pumping water into a reservoir and releasing it later to generate electricity.*

capacity of PHES was around 160 GW, representing over 90% of electricity storage at that time. In 2020 the global storage capacity was 8,500 GWh[212]. However, this technology is geographically limited to certain locations, constraining its deployment potential. Its use is also dependent on weather (albeit less so that variable renewable energy sources). In contrast, batteries have no such geographic limitations and can be installed almost anywhere. Although the current capacity of utility-scale batteries is still smaller than that of pumped-storage hydropower, they are projected to account for the majority of storage growth worldwide in the coming years[213].

Over the past decade, global battery storage capacity has expanded at an astonishing rate, escalating from about 1 GW in 2013 to over 85 GW in 2023[214]. Remarkably, 2023 alone saw an addition of over 40 GW, more than double the capacity added in 2022.[215] In 2023, around 65% of new installations were utility-scale systems and 35% were behind-the-meter battery storage[216]. Installed battery storage capacity in the European Union increased by 70% in 2023, with annual additions rising to nearly 6 GW[215].

This section focuses on the reducing production cost of batteries, the main driver behind its increasing penetration.

The significant increase in battery deployment is driven by rapidly falling costs and significant improvements in performance. Over a decade, the market price of an average lithium-ion battery pack has declined from around 800 USD/kWh in 2013 to less than 140 USD/kWh in 2023[216]. These improvements can be attributed to progress in R&D, economies of scale, decreasing raw material and component prices and production capacity outpacing demand at cell and stack level.

However, after a steady decrease up to 2021, the battery price increased for the first time in 2022. This spike is entirely due to the evolution of cell production costs. At pack level, the pack price (including the BMS, the casing, and the cooling system of the battery) continued decreasing (-5% CAGR between 2020 and 2023) driven by economies of scale and R&D developments.

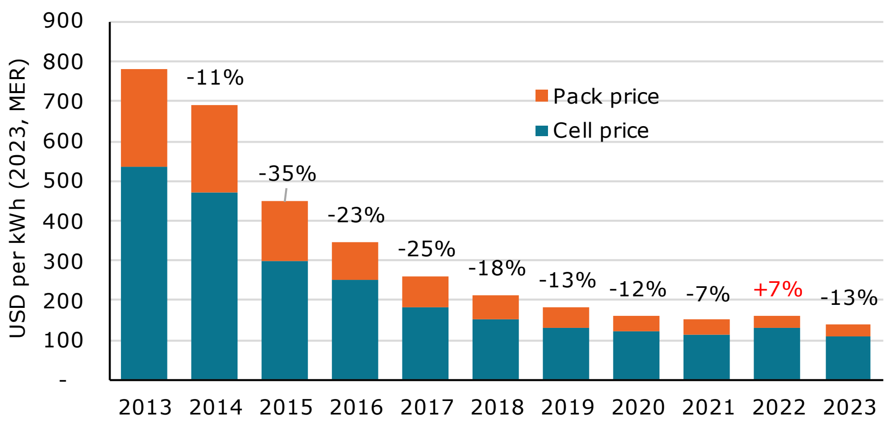


Figure 104: Lithium-ion battery pack and cell prices, 2013-2023

Source: IEA, 2024. Note: price is weighted average across regions and chemistries.

Two key factors have influenced the recent evolution of the battery prices highlighted in Figure 104. The first one is the price of raw materials. As highlighted in Figure 105 for the two most common type of cells (NMC and LFP), materials represent between 70 and 90% of the cell production cost.

[212] *IEA (2024). Grid-scale storage*
[213] *150 GW of PHES projects have been identified by Enerdata's Power Plant Tracker, while IEA's World Energy Outlook forecast the installation of over 400 GW of stationary batteries by 2028 globally.*
[214] *While the energy storage capacity (in GWh) in often not disclosed for battery projects, it usually ranges between 1 and 4 hours (e.g., a 1 MW battery will have a capacity between 1 and 4 MWh).*
[215] Utility-scale battery storage refers to systems directly connected to transmission or distribution networks, typically ranging from several hundred kWh to multiple GWh. Conversely, behind-the-meter battery storage systems are installed at residential, commercial, or industrial sites without a direct grid connection and are usually significantly smaller than utility-scale batteries.
[216] *IEA (2024). Batteries and Secure Energy Transitions*

Throughout 2023, labour and processing costs have barely evolved and do not depend on the battery chemistry. However, material costs have evolved in line with the market price of key materials highlighted in Figure 105.

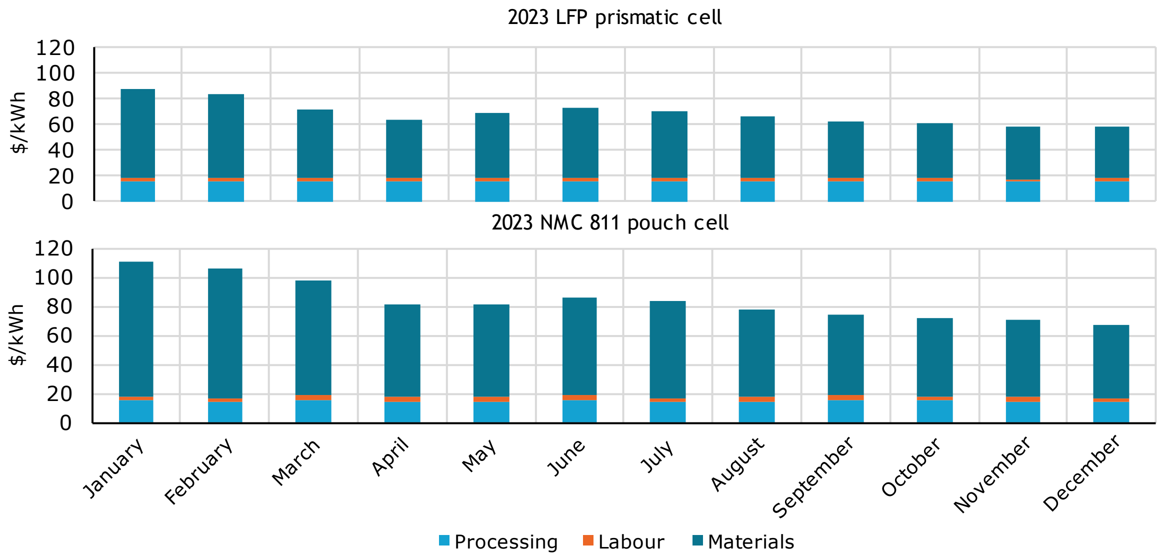


Figure 105: 2023 production costs of selected battery cells technologies

Source: Volta Foundation, 2024

Overall, in 2023, the production costs of both NMC and LFP batteries experienced an almost continuous decline. In January 2023, production costs for Chinese-made NMC (Nickel Manganese Cobalt) and LFP (Lithium Iron Phosphate) cells, were estimated at 108 USD/kWh and 85 USD/kWh, respectively. As lithium prices steadily decreased over the year, production costs dropped significantly, falling to 65 USD/kWh for NMC cells and 55 USD/kWh for LFP cells by December despite a rise in June 2023.[217,218]

Recent fluctuations in critical mineral prices have emerged as a significant concern within the battery mineral market. Notably, lithium prices skyrocketed, increasing nearly ninefold from January 2021 to December 2022. They have since decreased by nearly 80% from their 2022 peak. Similarly, other essential minerals such as Nickel, Cobalt, and Graphite experienced price surges in 2022 followed by declines. While the recent price downturn (even if Lithium and Phosphoric acid are not back to their 2021 levels yet) is a key driver to further reduce battery costs, it may dissuade investors towards future mining projects. This could exacerbate the risk of price volatility in the long term.

[217] *Volta Foundation (2024). Battery Report 2023*

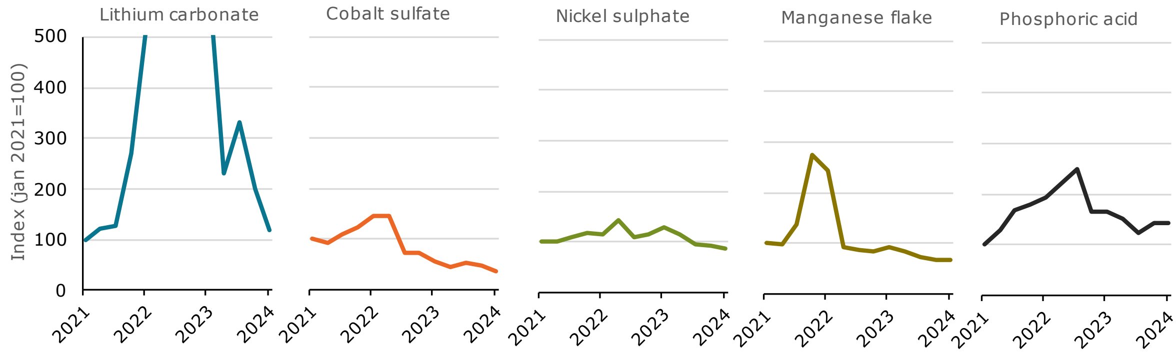


Figure 106: Price of selected battery materials and lithium-ion batteries, 2021-2024. Note: index for lithium carbonate reached 800 at its peak.

Source: IEA

The second factor influencing cell prices is the cathode's chemistry. Nickel Manganese Cobalt (NMC) and Lithium Iron Phosphate (LFP) batteries stand out as the two leading types of lithium-ion batteries, being used across diverse energy storage applications. LFP is today a lower cost battery chemistry compared to NMC. It does not contain nickel or cobalt, is less flammable, and has a longer cycle life. However, LFP batteries have a significantly lower energy density. Together, NMC and LFP batteries command the lion's share of global battery demand.

Both on the mobility and the stationary storage markets, the recent years have experienced a progressive growth in the use of LFP cells. These cells are less expensive to produce (see Table 6) and drive down the global average cell price.

Regarding EVs, which comprised over 90% of the battery demand from 2015 to 2023, NMC batteries still have the larger share of the market. However, the share of LFP batteries has been steadily increasing, reaching 40% of EV sales in 2023.[219] Although LFP batteries have a lower energy density compared to NMC batteries, which is a crucial factor for EV applications, they are becoming the preferred option among Chinese manufacturers. LFP batteries are now incorporated in most new Chinese EV models. It's quite likely that this trend will shortly expand to European manufacturers[220].

Regarding the stationary storage market, in 2023, LFP batteries accounted for about 80% of the total market up from about 65% in 2022[216]. The table below illustrates the transition of residential storage providers towards LFP products over the years.

[219] *IEA (2024) Batteries and Secure Energy Transitions*
[220] *An illustration of this is the recent announcement of LGES to build a LFP cells factory in Europe. Available at: https://battery-news.de/en/2024/07/25/lges-to-produce-low-cost-lfp-cells-for-europe/*

Table 6 – Battery chemistry of major products by selected residential storage providers

Company	2017	2021	2023
Pylontech	LFP	LFP	LFP
BYD	LFP	LFP	LFP
Panasonic	-	NMC	NMC/LFP
LG	NMC	NMC/LFP	NMC/LFP
Tesla	NMC	NMC/LFP	NMC/LFP
Enphase Energy	LFP	LFP	LFP
Sonnen	LFP	LFP	LFP
E3/DC	NMC	NMC/NCA/LFP	NMC/NCA/LFP
Senec	NMC	NMC	NMC
Powervault	NMC	NMC	LFP

Source: Bloomberg NEF[221]

These manufacturers are the key influencers of European stationary storage costs. Indeed, in the European Union, approximately 90% of the stationary battery storage capacity growth in 2023 was driven by behind-the-meter storage, compared to a 35% share globally.[222] This trend in the EU is primarily led by Germany and Italy, where high retail electricity prices and incentives such as tax breaks and low-interest loans promote the integration of rooftop solar PV with storage systems. Nearly 80% of the rooftop solar PV installations in Germany and Italy in 2023 included storage solutions.

In the coming years, the price of batteries could further decrease. In particular, CATL and BYD, two leading cell manufacturers have announced early 2024, an objective to cut their selling prices for LFP cells by 50% by the end of the year.[223] This will be a remarkable challenge in a context where raw material prices are becoming increasingly more volatile and where production yield-rate are estimated to approach practical limits[217].

4.4.6. Hydrogen

Introduction

Today's hydrogen production in the EU, EFTA, and UK is dominated by fossil fuels. Of the total available production capacity of 11.4 Mt per year in 2022 reforming, partial oxidation, and gasification of natural gas and coal accounted for 95.6%. Other clean pathways represent only a fraction of the overall production, where reforming coupled with carbon capture represents 3.7% and water electrolysis represents only 0.5% (30 kilo tonnes). In 2022, in the EU, EFTA, and the UK, the total demand for hydrogen was 8.2 Mt where the refining and ammonia sectors together accounted for 81% of the total consumption of hydrogen, methanol and chemicals 12%, industrial heat 3% and others less than 3%.[224]

[221] Note: NMC nickel manganese cobalt, LFP Lithium iron phosphate, NCA = nickel cobalt aluminum oxide.
Green entries refer to newly launched products or chemistry changes.
Grey entries refer to newly or upcoming products or chemistry changes.

[222] *It can be noted that this development is very different in the UK where the stationary storage market is mainly driven by front of the meter solutions.*

[223] *CATL announcement in January was followed by an internal note of BYD: https://cnevpost.com/2024/01/17/battery-price-war-catl-byd-costs-down/*

[224] *Hydrogen Europe (2023). Clean hydrogen monitor*

Production prices of hydrogen vary largely per country and technology. Clean hydrogen production pathways are still largely more expensive than conventional fossil fuel-based hydrogen. Fossil-based hydrogen average production cost in 2023 were estimated at about 0.06 EUR/kWh (2 EUR/kg), close to its historical average below 0.06 EUR/kWh (2 EUR/kg)[225]. 2022 prices were however far higher at 0.18 EUR/kWh (6 EUR/kg) due to very high wholesale natural gas prices.

Hydrogen produced by grid connected electrolysers stood at an average of 0.30 EUR/kWh (9.9 EUR/kg) in 2022, also highly impacted by increase of wholesale electricity prices linked to natural gas. Solar, onshore wind and offshore wind average production cost stood at 0.20 EUR/kWh (6.9 EUR/kg), 0.16 EUR/kWh (5.3 EUR/kg), and 0.19 EUR/kWh (6.3 EUR/kg) respectively (see Figure 107).

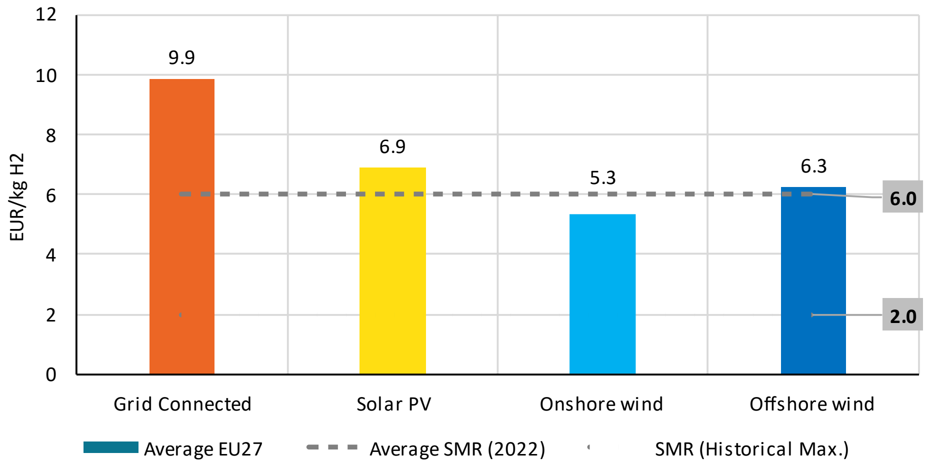


Figure 107: EU-27 Average production cost by various technologies- 2022. The bars show the EU-27 average prices.

Sources: European Hydrogen Observatory & Hydrogen Europe

Grey Hydrogen production cost by natural gas reforming

Conventional hydrogen production using fossil fuels currently accounts for more than 95% of the hydrogen production, mainly using Steam Methane Reforming (SMR) technology. According to the European Hydrogen Observatory, hydrogen production cost by SMR in 2022 maintained an average of 0.18 EUR/kWh (6 EUR/kg) for unabated H2 and 0.19 EUR/kWh (6.4 EUR/kg) for SMR coupled with carbon capture and storage CCUS (see Figure 108).

[225] *N.B: we converted kg of hydrogen using the Lower Calorific Value or Lower Heating Value (LHV) : 1 kg of H2 = 33,33 kWh*

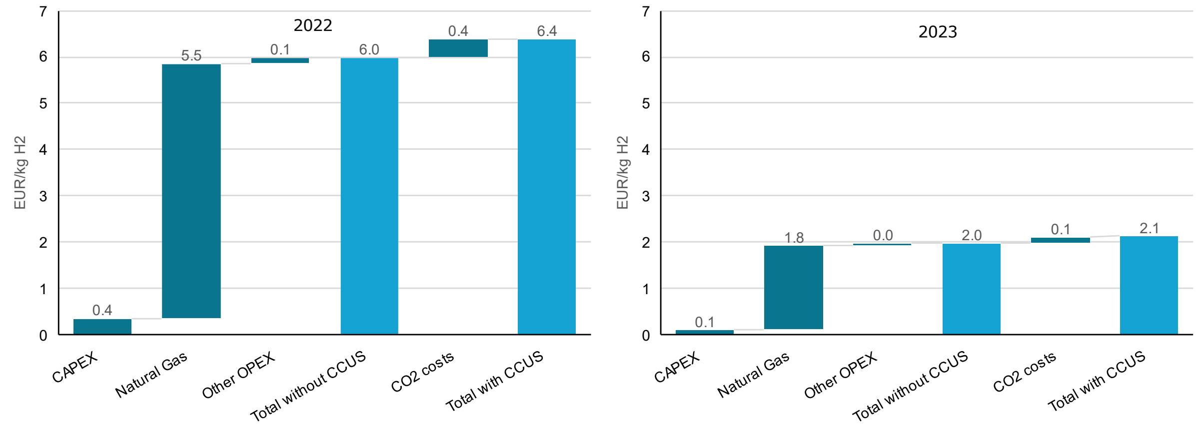


Figure 108: EU-27 Average H_2 Production Cost Breakdown by Natural Gas SMR - 2022 left graph & 2023 estimated right graph

Source: Enerdata with raw data retrieved from the European Hydrogen Observatory. Estimates of 2023 developed by Enerdata using the model of European Hydrogen Observatory of 2022.

In 2023, natural gas prices were largely volatile, however they sharply declined compared to 2022, the wholesale price hovered around 41 EUR/MWh (-67%).[226] As such, the 2023 natural gas price decrease should be reflected in an equivalent decrease of average production cost of H_2 by SMR. Enerdata estimates production cost for 2023 could range from 0.06 EUR/kWh (2 EUR/kg) for unabated H2 to 0.063 EUR/kWh (2.1 EUR/kg) for abated H2 [227]. The 2023 price is close to its historical average below 0.06 EUR/kWh for unabated hydrogen by SMR.[228] [229]

The 2022 average price was far higher (0.18 EUR/kWh), which was nonetheless lower than the peak of 0.21 EUR/kWh in December 2021 for the month-forward market price. The 2022 price increase is attributed to the increase of natural gas price that represents on average 92% of the total production cost in the EU-27 after the Russian invasion of Ukraine. Natural gas wholesale average annual prices increased on average in EU-27 from 47 EUR /MWh in 2021 to 123 EUR /MWh (+162%) in 2022.

On a country basis, the highest cost for unabated hydrogen is in Sweden at 0.29 EUR/kWh (9.6 EUR/kg) and the lowest is in Croatia and Slovenia at 0.12 EUR/kWh (4.1 EUR/kg). Key producing countries dispose prices as follow: Germany 0.18 EUR/kWh (5.9 EUR/kg), Netherlands 0.16 EUR/kWh (5.5 EUR/kg), Spain 0.15 EUR/kWh (5.1 EUR/kg), and France 0.13 EUR/kWh (4 EUR/kg), with other countries listed in Figure 109.

[226] *EU27 wholesale natural gas prices · (europa.eu)*
[227] *The cost calculation is based on the average wholesale natural gas prices across the EU27. In 2023 wholesale prices decreases, despite their retail household increase. Cost structure 92% NG, 6% CAPEX, 2% other OPEX & 7% CO2 abatement cost (Model of the European Hydrogen Observatory)*
[228] *Hydrogen Europe (2021). Clean Hydrogen Monitor 2021 – Hydrogen Europe*
[229] *Hydrogen Europe (2022). Clean Hydrogen Monitor 2022 – Hydrogen Europe*

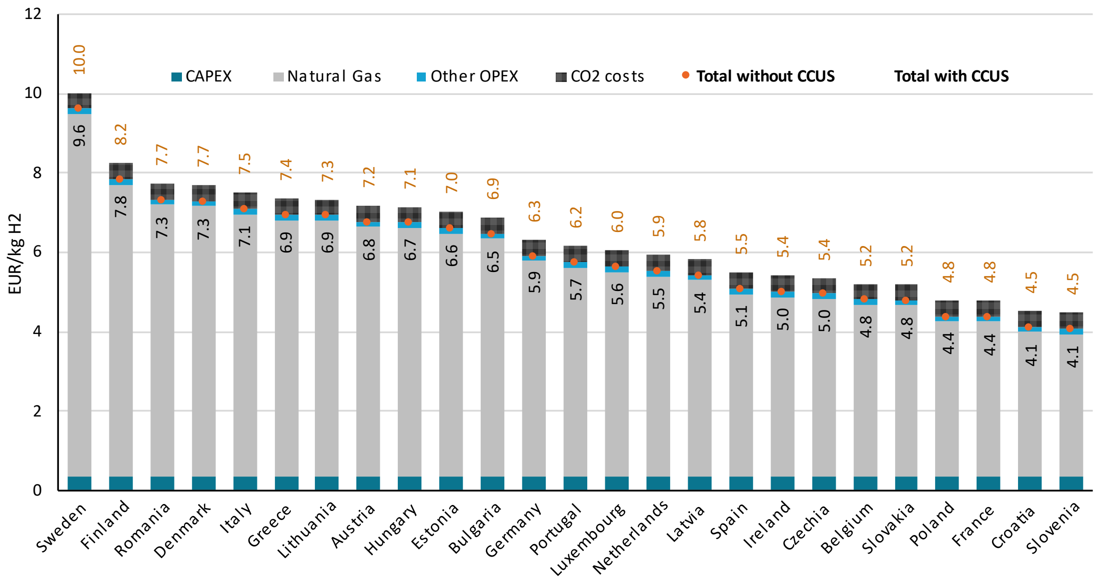


Figure 109: H_2 Production cost by SMR breakdown with and without CCUS by country - 2022

Source: Enerdata with raw data retrieved from the European Hydrogen Observatory

Historical prices

Since 2020 grey hydrogen by SMR production cost has been extremely volatile due to the volatility of the natural gas prices. From 2018 to 2020 production cost was quite stable at an average of 0.05 EUR/kWh (1.6 EUR//kg). However, a significant increase has been noted after the start of the Ukraine war, when prices declined in 2023. Production cost is estimated at 0.06 EUR/kWh (2 EUR//kg) in 2023 (Enerdata estimates) — that's (- 67%) decrease year-over year but still a (+30%) increase over its cost in 2020.

The European Hydrogen Observatory estimates average production cost in 2022 at 0.18 EUR/kWh (6 EUR/kg) which is slightly higher than that of Hydrogen Europe 0.17 EUR/kWh (5.7 EUR/kg).224 An important element of the cost structure is the low contribution of the CAPEX into the final cost as reforming infrastructure are operational and mostly have long amortised their cost. As such, marginal cost is better than levelised cost for benchmarking, as in Figure 110

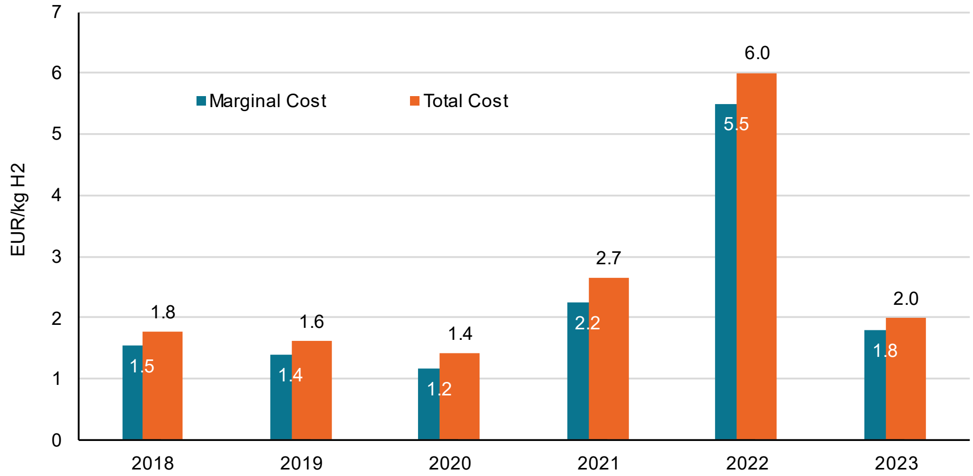


Figure 110, production cost of 2023 is estimated by Enerdata and shows a 67% decrease in costs.

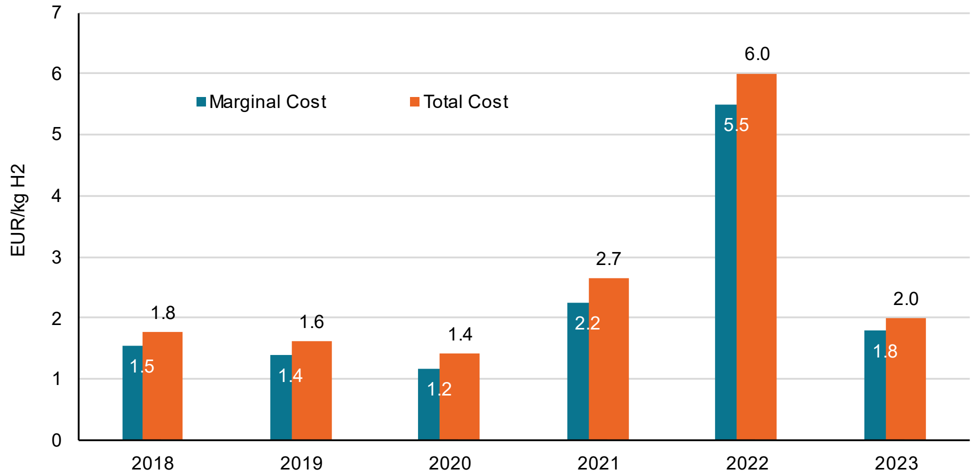


Figure 110: Grey Hydrogen by SMR Historical Production Cost[230]

Sources: Hydrogen Europe Clean Hydrogen Monitor, European Hydrogen Observatory & Enerdata

Hydrogen Production by electrolysers connected to the Grid[231]

Hydrogen production cost using grid-connected electrolysers in 2022 across Europe ranged from 0.10 EUR/kWh (3.4 EUR/kg) in Sweden to 0.49 EUR/kWh (16.4 EUR/kg) in Cyprus, as illustrated in Figure 111. The average of EU-27 countries plus Norway stood at 0.30 EUR/kWh (9.9 EUR/kg). The electricity price is the largest contributor to final cost standing on average at 72% of the total cost. While Cyprus, Poland, and Germany impose high electricity taxes of 0.12 EUR/kWh (3.9 EUR/kg), 0.08 EUR/kWh (2.7 EUR/kg) and 0.07 EUR/kWh (2.3 EUR//kg) respectively, Greece and Bulgaria offer tax incentives of –0.16 EUR/kWh (-5.2 EUR/kg) and –0.17 EUR/kWh (-5.6 EUR/kg) respectively. Other countries taxes range between 0.0009 EUR/kWh (0.03 EUR/kg) and 0.04 EUR/kWh (1.24 EUR/kg). On average, CAPEX represents 12%, grid fees represent 9% while taxes represent 2% of the production cost of H2.

[230] *Without carbon capture and storage CCUS.*

[231] *The European Hydrogen Observatory calculation model for grid-based hydrogen is based on the average wholesale price of electricity in each country. This doesn't reflect specific production case linked to peak or off-peak hours.*

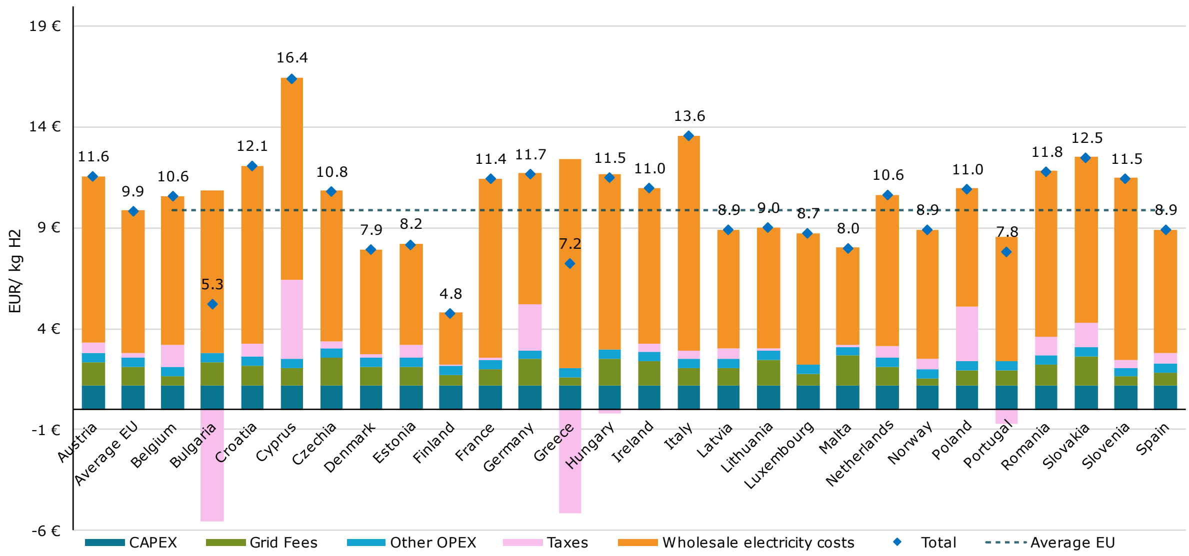


Figure 111: Hydrogen Production Cost by electrolysers connected to the Grid EU-27 - 2022

Source: Enerdata with raw data retrieved from the European Hydrogen Observatory.

In the 1st half of 2023 wholesale electricity prices increased in the EU-27 by 27% compared to the 1st half of 2022. Taking this increase into consideration, Enerdata estimates average hydrogen production cost by grid electricity to reach as high as 0.37 EUR/kWh (12.5 EUR/kg).

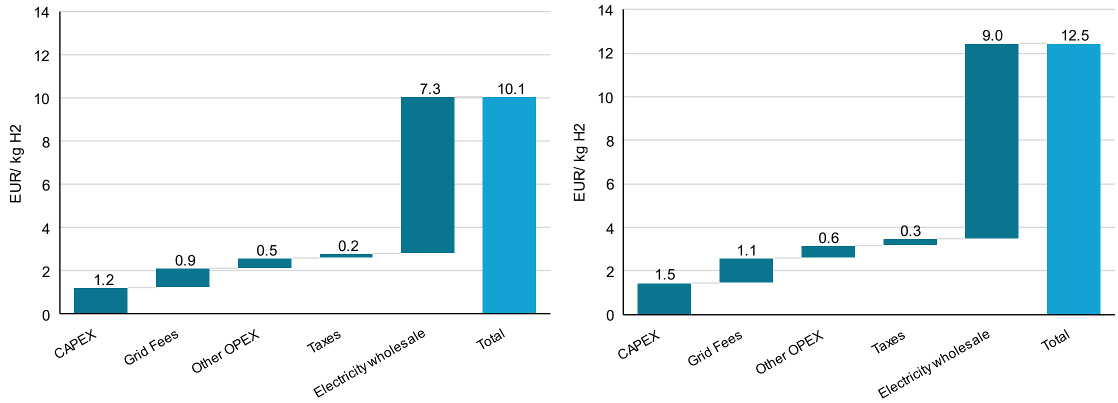


Figure 112: Average Cost Structure of H2 Production by Electrolysers connected to the Grid (EU-27 + Norway) 2022 left graph, 2023 estimates right graph.

Source: Enerdata with raw data retrieved from the European Hydrogen Observatory. Estimates of 2023 developed by Enerdata using the model of European Hydrogen Observatory of 2022.

Green Hydrogen Production by electrolysers Connected to Solar PV & Wind [232]

Electrolysers connected to renewable energy sources do not source electricity via wholesale markets, but produce it in a connected site or procure via PPAs. On the one hand, this leads to higher up-front investment costs and can be disadvantageous in cases where costs of capital are high. Their performance depends highly on the capacity factor of the electrolyser (does the electrolysers only run when the power plant is producing?). On the other hand, such projects avoid expensive grid fees, and taxes related to the grid supply of electricity and can have production cost much lower than retail prices (e.g., Solar in Spain, Wind power in Ireland). There is also some hedging on electricity procurement via ownership of generating assets. The overall cost is thus different for the two types of electricity.

[232] *The European Hydrogen Observatory calculation model is based on the average levelized cost of electricity (LCOE) of each technology in each country.*

Levelized cost of hydrogen (LCOH) produced with renewable electricity for 2022 shows large disparities across technologies and countries (Figure 113). For solar PV, the lowest LCOH is in Portugal at 0.11 EUR/kWh (3.8 EUR/kg) followed by Spain at 0.14 EUR/kWh (4.6 EUR/kg), while the highest is in Finland at 0.35 EUR/kWh (11.7 EUR/kg). On average the LCOH in the EU-27 is calculated at 0.20 EUR/kWh (6.8 EUR/kg). For onshore wind, the lowest LCOH is in Ireland at 0.08 EUR/kWh (2.8 EUR/kg) followed by Spain at 0.09 EUR/kWh 2.9 EUR/kg, while the highest is in Slovenia at 0.26 EUR/kWh (8.7 EUR/kg). The average for the EU-27 is calculated at 0.16 EUR/kWh (5.2 EUR/kg). For countries with offshore wind potential, the lowest LCOH is in Ireland at 0.13 EUR/kWh (4 EUR/kg) while the highest is in Cyprus at 0.31 EUR/kWh (10.4 EUR/kg). The average for the EU-27 is calculated at 0.19 EUR/kWh (6.2 EUR/kg).

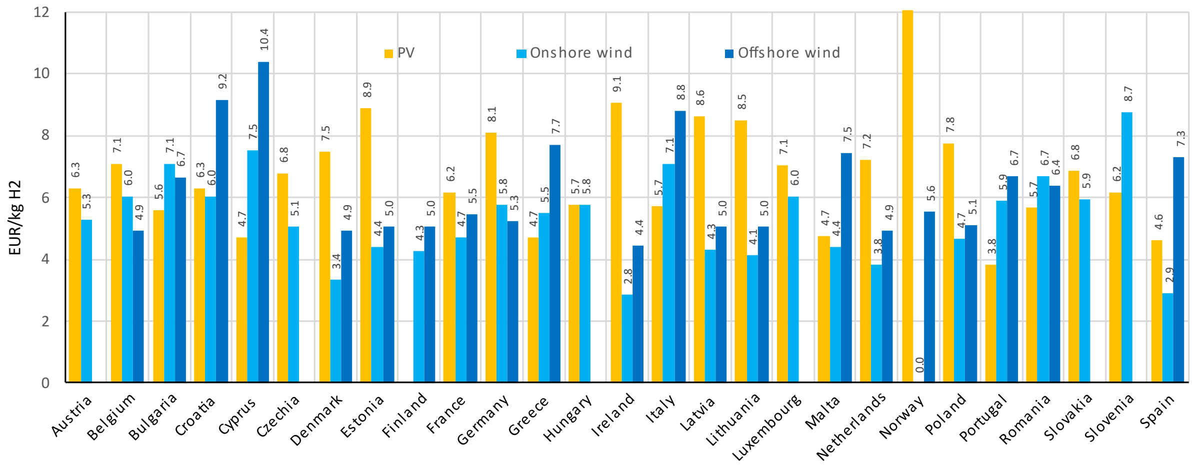


Figure 113: Average Renewable H2 Production Cost by Technology - 2022

Source: European Hydrogen Observatory

5. Energy costs for industry

5.1. Summary of main findings

This chapter covers the energy costs for EU industry and the impact of these energy costs on the competitiveness of EU industry. After energy prices have come down from the record-high levels experienced in the summer of 2022, the EU energy landscape is entering into a new era. The EU is transitioning away from Russian fossil fuels while accelerating the clean energy transition, diversifying supplies and saving energy[233]. The focus of this chapter is the competitiveness of EU industry compared to competitors elsewhere in the world in this new EU energy era. However, at the time of writing (July 2024), complete and reliable energy prices and costs data for EU industry from aggregated statistical information is only available up to 2021, while only partial data is available for 2022 and 2023. Findings have therefore been complemented with insights obtained from data up to 2023, directly collected from energy-intensive industries (EIIs) that participated in this study to try to draw general conclusions on the European industries.

The competitiveness of EU industries in the new EU energy era

- An analysis of data obtained from 81 plants across 10 industrial sectors showed that while in 2023 the average electricity and natural gas prices decreased from 2022 levels, EU averages paid in 2023 were still significantly higher than those from pre-COVID and pre-crisis levels (Cf Chapter 2–3).
- Electricity prices in 2023 are more than double compared to 2019 across the industrial sectors surveyed (*Mining*, *Secondary aluminium, Refineries*, *Flat glass* and *Ferro-alloys and Silicon)*. The electricity price increases for *Primary aluminium, Pulp and paper* and *Downstream aluminium* were less severe, but still between 78–83% higher than those paid in 2019.
- Natural gas price increase reached 2–4 times in every industrial sector surveyed in 2022 compared to 2019. In 2023, average natural gas prices for the surveyed sectors started a decreasing trend. However, for *Secondary aluminium*, *Ferro-alloys and Silicon, Flat glass*, and *Pulp and paper*, natural gas prices remained about double or more than that paid in 2019. The increase in natural gas prices paid in 2023 for *Refineries* and *Primary aluminium* and is less high, but 71% and 66% higher than those paid by these sectors in 2019, respectively.
- The increases in prices for electricity and natural gas led to an increase in the share of energy costs in the total production costs for almost all surveyed sectors. The highest energy cost share (electricity and natural gas costs combined) was found in the electro intensive sectors such as *Primary aluminium* (38%) and *Ferro-alloys and silicon* (29%). These are followed by the *Flat glass* sector (25%) and *Mining* sector that have both a relative high gas and electricity cost shares.
- Almost all surveyed sectors also experienced a decrease in production since their energy costs increased. Production output trends across the surveyed plants, show that average production output decreased by 43% and 18% for *Ferro-alloys and Silicon* and *Flat glass* sectors between 2019 and 2023. Public statistics also show a decline in *Ceramics* and *Iron and steel* output in 2023 compared to 2019.
- Besides energy costs and international trade exposure, factors such as raw material and personnel costs, market concentration, and product differentiation play crucial roles in deter a company's competitiveness. For sectors like *Primary Aluminium* and *Refineries*, where selling prices are set internationally, profitability is heavily influenced by internal cost structures. For *Downstream aluminium*, the prices of raw materials, in particular of unwrought aluminium, play a significant role on production costs.

[233] European Commission (2023). State of the Energy Union 2023: EU responds effectively to crisis, looks to the future, and accelerates the green transition

- Nevertheless, the soaring energy prices in 2022 and 2023 showed that energy costs have become a more decisive role in the competitiveness of the industrial sectors surveyed. While some sectors like *Downstream Aluminium* and *Flat Glass* have been able to pass on some of their costs to customers, their still have faced reduced competitiveness due to the increased energy costs. In sectors *Primary Aluminium*, *Flat Glass* and *Ferro-alloys and silicon*, surveyed plants have listed the increase in energy prices and costs as one of the main factors influencing curtailments and plant closures in the EU.
- Key non-EU competitors across most industrial sectors surveyed (*Aluminium, Ferro-alloys and Silicon, Flat glass, Refineries, Pulp and paper, Mining, Ceramics, Chemicals, Iron and steel* and *Zinc*) include China, United States, Brazil, India and Türkiye. For all those countries, surveyed plants estimated that the energy costs of their competitors in those countries are at least 20% lower and the total production costs at least 10% lower than in the EU. In the case of *Flat glass* and *Pulp and paper*, some plants estimate this difference to be larger than 30%. Other common key determinants in the competitiveness of the EU industry surveyed include cost of raw materials and labour.
- For the two sectors included in the scope of this study due to strategic interest (*Automotive* and *Batteries*), the direct impact of energy costs on their competitiveness is limited given the low share of energy costs in their total production costs. However, negative impacts on energy costs could manifest itself indirectly via material costs.
- Power Purchasing Agreements (PPAs) are one of the key hedging strategies available to the industry against energy price volatility, with the European PPA market having grown annually by 37% per year in the period 2018–2023. Key regions for renewable energy PPA's in the EU are Spain, with 22% of the total contracted capacity, Germany with 13%, and Sweden with 12%.
- PPAs become increasingly popular as they are quite flexible since they can be structured in several different ways depending on which party is willing to accept risk relating to volume or pricing requirements.

Long-term trends in energy costs in EU industries

- Energy cost as a share of production costs has declined in most EU Member States, although there was a noticeable increase in 2021, which coincides with the period of soaring energy prices. This is particularly noticeable in energy-intensive industries: *Pulp and paper*, *Basic chemicals*, *Man-made fibres*, *Glass*, *Clay Building Materials* and *Cement, lime and plaster*. Estimates of energy costs as a share of production costs for 2022 and 2023 show that the increasing trend of 2021 continues into the next two years. This is under the assumption that the increasing energy prices resulting from the energy crisis have propagated into the energy costs.
- Gross operating surplus (GOS) as a share of production costs remained fairly stable in most EU sectors from 2014 to 2021. GOS shares remain highest in the *Pharmaceutical products* and *Cement, lime and plaster* sectors. Conversely, GOS shares are lowest in the Basic metals industries – *Iron and steel* and *Non-ferrous metals*.
- Energy intensity (energy consumption as share of gross value added) varies significantly across different sectors. Energy intensity is particularly volatile in the most energy-intensive sectors: *Basic chemicals, Cement, lime and plaster*, *Iron and steel* and *Refineries*, where these sectors experienced significant fluctuations in energy intensity as their gross value added periodically rose and fell. Notably, *Air transport*—and to a lesser extent *Accommodation and restaurants*—reached a peak in energy intensity in 2020 due to a drop in value added, which corresponds to the period of COVID-19 restrictions.
- Energy cost shares from 2014 to 2021 tend to be similar or lower in the EU manufacturing sector compared to most other G20 countries. However, there are some exceptions in certain sectors; energy cost shares are relatively high in the EU in the sectors *Man-made fibres* and *Cement, lime and plaster*.

- The decomposition of drivers behind the change in energy costs showed that between 2014 and 2021, total EU industrial energy purchases increased by 19.3% from 2014 levels. Production output was the main driver, contributing 18.5 percentage points to the total change.
- Overall, the reduction in production in 2020 due to COVID-19 led to lower energy costs in the manufacturing sector, but rebound effects in production in 2021, and rising energy prices, pushed energy costs up by 24.7%, offsetting the reduction seen in 2020.
- Changes in energy cost over 2014–2021 only have a limited contribution to the changes of the total production costs, contributing 0.4% from of the 29.2% total increase of production costs in that period. Domestic demand was the strongest driver of changes in production costs.
- Energy intensities of EU manufacturing industries tend to be comparable or lower than in other countries with the exception of *Pulp and paper*, *Refineries, Fruits and vegetables* and *Stone*, where the EU is one of the most energy intensive geographies compared to main trading partners.
- Despite the similar or relative lower energy costs shared in the EU compared to most other G20 countries, the average profitability of the EU industry also tend to be lower than those of the EU's main trading partners. The GOS shares of the EU ranges between 10% and 15% in the time period 2014 to 2021, while that of most other G20 countries ranged between 15% and 25%. The top outlier was Saudi Arabia with an average GOS share between 50% and 80%. Towards the lower end, China had an average GOS share for its manufacturing sector between 5% and 10%. The relatively low GOS shares in majority of EU sectors means that the EU industry has limited room to absorb cost increases such as energy cost increases experienced in 2022 and 2023.

5.2. Introduction

Since 2020, the EU energy landscape has undergone a significant transformation, affecting the EU industry in different ways. The COVID-19 pandemic initially led to demand reductions and staff shortages as a result of widespread lockdowns. However, industrial production and trade initially rebounded in 2021 to levels higher than pre-COVID times. As a result, energy prices soared and escalated further into a full-blown global energy crisis following the Russian invasion in Ukraine.[234] This led to unprecedented high energy prices in the EU in the summer of 2022, resulting in wide-spread production curtailment and plant shutdowns in many EII sectors. These impacts were explored in the 2023 edition of the study[235]. The study showed that while the overall sentiment was that while COVID-19 was challenging, these were dwarfed by the challenges faced by industry in the recent energy crisis.

Since then, the EU energy landscape is entering a new era. This chapter focuses on the competitiveness of EU industry in this new EU energy era compared to competitors elsewhere in the world. Section 5.3. **Error! Reference source not found.**presents results from the analysis of data obtained from 81 plants across six energy-intensive sectors. These are *Aluminium, Ferro-alloys and Silicon*, *Flat glass, Pulp and paper, Refineries* and *Mining*. In addition, qualitative insights from information of 17 additional plants in the sectors *Basic chemicals, Fertilisers, Ceramics, Iron and Steel* and *Zinc* are also presented. This section is followed by results from analysis of the aggregated statistical information on energy costs in industry in a similar manner as the previous editions of this report. Section 5.4. provides an overview of the overall impact of energy costs on the economy of the EU and its Member States. Section 5.5. focuses on the energy costs of industry and profitability based the aggregated statistical information. These can serve as indicators for the energy cost impact on the competitiveness of EU industry sectors. Section 5.6. **Error! Reference source not found.**considers the energy intensity of the industry sectors studied in this report. Section 5.7. examines the drivers of energy costs in EU industry as well as the impact of energy costs in total production costs. Section

[234] IEA (2022). How the energy crisis started, how global energy markets are impacting our daily life, and what govenmnets are doing about it
[235] Trinomics (2022). Study on energy prices and costs: Evaluating impacts on households and industry: 2023 edition

5.8. **Error! Reference source not found.**compares the energy costs, profitability and energy intensity of EU industry with that of main trading partners. Finally, Section 5.9. discusses the benefits of price hedging and other arrangements in energy-intensive industries.

5.3. Overview of selected energy intensive industries (EII)

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 competitiveness of EU industry, compared to competitors elsewhere in the world. The bottom-up analysis covers the entire EU with a focus on the period 2017–2023 if data was available. Details of the methodologies used for this section are provided in Section 5.3.1. **Error! Reference source not found.**

While we sent the questionnaire to 20 energy-intensive sectors and their industry association, only 102 questionnaires across 10 EIIs which covers 12 industrial sectors[236] could be used for the analysis. However, only six sectors provided sufficient data to show findings in a confidential and anonymous manner: Aluminium, *Ferro-alloys and Silicon*, *Refineries*, *Pulp and paper*, *Mining*, and *Flat glass*. 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 four other sectors, namely *Ceramic*, *Chemicals*, *Iron and Steel* and *Zinc*, not enough responses from different companies were received to show findings in a confidential and anonymous matter, thus the answers received were assessed only in a qualitative manner. In total, the responses of 98 plants were analysed, with 81 questionnaires quantitatively and qualitatively, and 17 only qualitatively.

Finally, for 4 plants in the A*luminium and Ferro-alloys and Silicon* sectors, 4 plants in non-EU North Western European countries (UK, Norway, Iceland) also submitted data. These were from plants in the *Aluminium or Ferro-alloys and Silicon* sectors. These questionnaires have not been included in the analysis due to an insufficient sample size to maintain data confidentiality.

The analysis of the responses from 98 plants located within the EU cover various aspects of energy-intensive industries in the EU27:

- Natural gas-intensive sectors (e.g. Secondary aluminium), electricity-intensive sectors (e.g. Primary aluminium and *Ferro-alloys and Silicon*) and sectors where both natural gas and electricity are significant in the production costs (e.g *Flat glass*);
- Sectors concentrated in European regions (e.g. *Mining* is mainly located in Southern Europe) or geographically dispersed in Europe (e.g. *Ferro-alloys and Silicon*, *Refineries*, and Downstream aluminium);
- Net importer sectors (e.g. *Mining*, Aluminium, *Ferro-alloys and Silicon*) and net exporter sectors (e.g. *Pulp and paper*, *Refineries*, *Flat glass*) with different levels of exposure to international competition.

[236] *Of which three industrial sectors are aluminium subsectors: primary aluminium, secondary aluminium and downstream aluminium.*

Table 7 below shows the representativeness and geographical scope of the responses over three European regions.[237]

Table 7: Overview of EU27 plants participating in the study

Sector	Number of plants by geographical region(1)				Representativeness in 2023(2)
	Central Eastern Europe	North Western Europe	Southern Europe	**Total**	Share of output (O) or turnover (T)
Primary aluminium	1	1	2	**4**	55% (O)
Secondary aluminium	1	1	3	**5**	5% (O)
Downstream aluminium	3	11	7	**21**	18% (O)
Ferro-alloys and Silicon	1	4	3	**8**	59% (O)
Refineries	2	0	2	**4**	N/A
Pulp and paper	1	0	4	**5**	2%(O)
Mining	0	5	0	**5**	N/A
Flat glass	7	11	11	**29**	~60%(O)
Ceramics				***9(3)***	*N/A*
Chemicals				***3(3)***	*N/A*
Zinc				***3(3)***	*N/A*
Iron and steel				***2***	*N/A*

Only qualitative findings from sectors in italic have been in the report.
(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 2023. Estimates of the representativeness may vary from year to year although with a similar order of magnitude.
(3) In the case of Ceramics, Chemicals and Zinc, although a sufficient number of questionnaires were received for a quantitative analysis, there was only one company (with several plants) that sent questionnaires per sector. Thus, due to confidentiality precautions, it's not possible to disclose any quantitative information about these plants (including their geographical location).
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.

5.3.1. Methodology

The process of collecting data and information selected EIIs at a plant level was done in a two-staged approach, starting with a stakeholder workshop before widely distributing the dedicated questionnaire.

A **stakeholder workshop** was organised to present the key findings of the industry chapter of the 2023 study, which includes sectorial findings, to motivate participation in this 2024 study and to introduce the focus and timeline of the 2024 study, including updates to the questionnaire. The workshop was held in a hybrid format on 19 March 2024, with participants joining online and in person at the premises of the European Commission in Brussels.

Data collection from EIIs via a **dedicated Excel-based questionnaire** started on 20 March following the stakeholder workshop. The aim of the questionnaire was to collect data to inform both the energy

[237] *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.*

costs determinants of industrial competitiveness as well as the industrial product cost structures and the role of energy and other costs affecting production for the selected energy-intensive subsectors. To assess the impact of energy costs on the competitiveness of industry sectors in the bottom-up analysis, data was collected for the following key indicators, with a focus on electricity and natural gas:

- Energy prices;
- Energy costs per production quantity;
- Energy costs as a share of production costs;
- Energy intensity (energy consumed per production quantity).

Additionally, questions regarding competition with non-EU producers were asked. This includes:

- Identification of key competitors outside of the EU;
- Identification of the extent of impact that energy, labour, raw material costs, etc. affecting their competitiveness;
- Any estimation and/or indication of the estimated differences of overall production costs; and
- Any information regarding any subsidies or national support received by key competitors in non-EU countries.

The questionnaire was shared with **20 industry associations of EII sectors and 3 additional industry associations of sectors of strategic interest to be included in this study** (see Table 8). Industry stakeholders were given an initial deadline of 30 April to respond to the questionnaire. This deadline was subsequently extended several times up to late June 2024 due to several reasons:

- Lengthy administrative process to review the Non-Disclosure Agreements (both parties);
- The need from industry associations and companies for more time to gather the required data;
- The minimum response threshold not being met for presenting quantitative findings, i.e. having at least three responses from three distinct companies to maintain data confidentiality and to ensure some degree of sector representativeness;. Additional outreach was done to more companies in EII sectors where only 1 additional response was missing to be able to present quantitative findings;
- Incomplete and/or incorrect data that required followed up with the companies and/or the industry associations.

A total of **113 questionnaires** were received **across 10 EIIs** (see Table 8). However, 11 of these responses could not be incorporated due to insufficient and/or incorrect data received, and a lack of response from companies in attempts to follow-up to complemented the data. In addition, 4 questionnaires were from non-EU countries where the sample size was insufficient to maintain data confidentiality. As a result, ultimately, the responses from **98 questionnaires** were analysed. Additional inputs were also received from the industry associations to enrich the analysis, with sources being either from internal studies and reports prepared by the Industry Associations, or links to relevant public information that have not yet been considered.

Following the completion of the qualitative and/or quantitative analysis of each EII sector, a draft was shared with the respective industry associations for review. The purpose of this review was to ensure that the confidentiality of plant level data is respected, and to also ensure that the results are accurately represented.

Table 8: List of energy-intensive sectors and EU industry associations invited to participate in the bottom-up data collection

Energy intensive sectors	NACE 4-digit	Description	EU Industry association	Sufficient responses for analysis?
B – *Mining* and quarrying	B – Overarching		Euromines	Yes
C171 – Manufacture of pulp, paper and paperboard	C1711	Manufacture of pulp	CEPI – Confederation of European Paper Industries	Yes
	C1712	Manufacture of paper and paperboard		
C192 – Manufacture of refined petroleum products	C1920	Manufacture of refined petroleum products	FuelsEurope – European Petroleum Refiners Association Concawe – Environmental Science for European Refining	Yes
C201- Manufacture of basic chemicals, *Fertilisers* and nitrogen compounds, plastics and synthetic rubber in primary forms	C2011	Manufacture of industrial gases	EIGA – European Industrial Gases Association	Qualitative analysis only
	C2013	Manufacture of other inorganic basic chemicals	CEFIC – the European Chemical Industry Council	
	C2014	Manufacture of other organic basic chemicals		
	C2015	Manufacture of *Fertilisers* and nitrogen compounds	Fertilizers Europe – major fertilizer manufacturers in Europe	
C231- Manufacture of glass and glass products	C231 - Overarching		Glass Alliance Europe	No
	C2311	Manufacture of *Flat glass*	Glass for Europe – the trade association for Europe's *Flat glass* sector	Yes
	C2313	Manufacture of hollow glass	FEVE – European Federation of glass packaging makers	No
	C2314	Manufacture of glass fibres	Eurima – European insulation manufacturers association (including glass fibres)	No
C233 – Manufacture of clay building materials	C2331	Manufacture of ceramic tiles and flags	Cerame-Unie – the European Ceramic Industry Association	Yes
C235 – Manufacture of cement, lime and plaster	C2351	Manufacture of cement	Cembureau – European Cement Association	No
	C2352	Manufacture of lime and plaster	EuLA – European Lime Association	No
C241- Manufacture of basic iron and steel and of ferro-alloys	C2410	Manufacture of basic iron and steel and of ferro-alloys	Eurofer – European Steel Association	Qualitative only
			EUROALLIAGES – European ferro-alloy producers	Yes
C244- Manufacture of basic precious and other non-ferrous materials	C244 - Overarching		Eurometaux – European non-ferrous metals association	No
	C2442	Aluminium (primary, secondary and downstream)	European Aluminium	Yes
	C2443	Lead, zinc and tin production	International Zinc Association	Qualitative only
	C2444	Copper production	European Copper Institute	No
J631 Data processing, hosting and related activities	*J631 - Overarching*		*European Data Centre Association (EUDCA)*	*No*
Wind turbine manufacturers	*Spread over various NACE codes*		*WindEurope*	*No*

Energy intensive sectors	NACE 4-digit	Description	EU Industry association	Sufficient responses for analysis?
Solar PV manufacturers	*Subsector of 26.11 Manufacture of electronic components*		*Solar Power Europe*	*No*

Sectors in italic are additional sectors invited to participate in this study due to strategic interests

5.3.2. Cross-sectorial findings

Figure 114 provides the average and range in electricity price paid by the surveyed plants per selected sector, and their average and range in electricity intensity for 2023, on a logarithmic scale. These are represented by a box plot (or box and whiskers plot), providing a visual representation of the distribution of the surveyed sectors, including:

- Median (Q1): The line inside the box represents the median of the dataset, which is the midpoint value separating the higher half from the lower half.
- Quartiles (Q1 and Q3): The edges of the box indicate the first quartile (Q1) and the third quartile (Q3), which mark the 25th and 75th percentiles, respectively. The interquartile range (IQR) is the distance between Q1 and Q3, showing the spread of the middle 50% of the data.
- Whiskers: The lines extending from the box, called whiskers, typically represent the range of the data within 1.5 times the IQR from the quartiles. Data points outside this range are considered outliers.
- Simple averages of EU surveyed plants are also included per sector. In cases where there are only 3 or less data points, the box and whiskers are not presented, and instead only the simple average is provided.

In previous editions of this study, an inverse correlation between a high electricity intensity (i.e. generally high electricity consumption) and low average prices was identified. To a large extent, this correlation was also found in 2023. For example, *Primary aluminium* and *Ferro-alloys and Silicon*, the most electricity intensive sectors of the surveyed sectors, are also the sectors with the lowest electricity prices in the range of 89–101 EUR/MWh. Plants in less electricity-intensive sectors paid a higher average electricity price of 140–196 EUR/MWh[238]. Overall, this inverse relation can be attributed to several factors, namely:

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

ii) Larger consumers have more bargaining power to negotiate their prices and employ hedging strategies and consider options to better manage their energy costs;

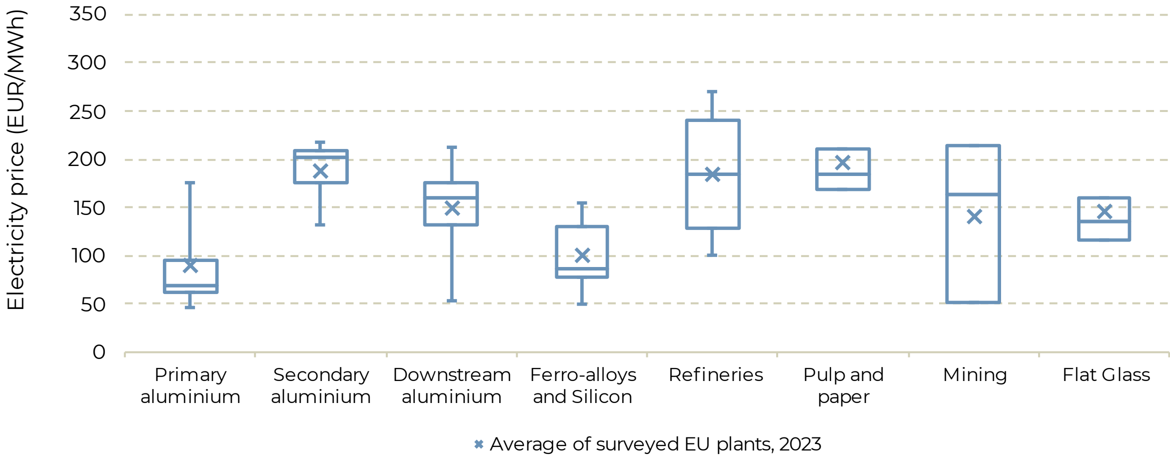
iii) Larger consumers of electricity are sometimes exempted from specific taxes and levies on electricity prices; and

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).

In the case of *Primary aluminium*, it should be noted that due to the presence of outliers, there were no sufficient reliable responses to provide an EU simple average for years 2022 and 2023[239]. However, the electricity intensity of 2021 (14.93 EUR/MWh) as well as previous editions of this study indicate this sector is indeed one of the most electricity intensive sectors. The average electricity price paid by the *Pulp and paper* sector is also relatively high.

[238] For the Pulp and paper sector it is important to note that the results are not representative of the entire sector due to the small sample size and the concentration of sampled plants being in Southern Europe, which according to Cepi, is the region that has been the hardest hit by high energy prices in recent years.

[239] Two of the plants were excluded from the EU average in 2022 and 2023, due to their curtailed status significantly affecting their electricity intensity, causing the EU average to not be representative of 'typical primary aluminium plants'.



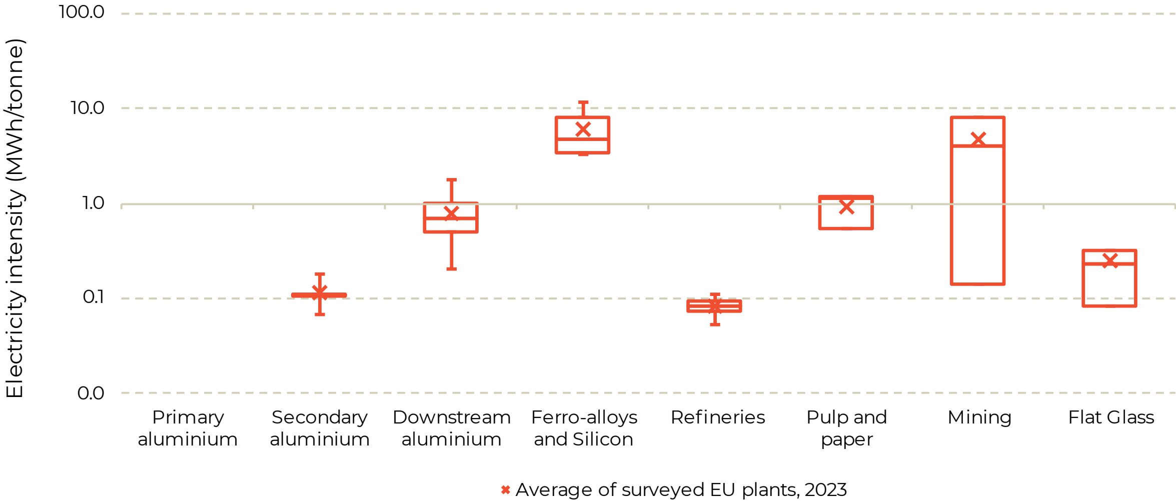


Figure 114: Electricity prices (above) and electricity intensity (below) per sector based on collected plant data for 2023

Source: Own elaboration based on data from industrial plant operators.[240]

Figure 115 and Table 9 below provide an overview of the evolution of EU average electricity price paid by the surveyed plants during the 2019-2024 period. For most of the sectors, the EU average electricity price follows a similar trend: in 2021 electricity prices started an increasing trend, peaking in 2022 with the highest electricity prices experienced by the sector. **Although in 2023 the average electricity prices decreased, from 2022 levels, EU averages paid in 2023 were still significantly higher than those from pre-COVID and pre-crisis levels:**

- *Mining* experienced the largest relative increase in electricity prices of the sectors sampled during the 2020–2023 period, followed by *Secondary aluminium, Refineries, Flat glass and Ferro-alloys and Silicon*, Their average electricity prices paid in 2023 were more than double than those paid in 2019.
- In the case of *Primary aluminium* and *Pulp and paper*, the relative increase was lower than the rest of the surveyed sectors, but average electricity prices paid in 2023 were still around 82% and 83% higher than those paid in 2019, respectively.

[240] *Note: Electricity intensity value for the Primary aluminium sector could not be shown due to insufficient responses after removing identified outliers.*

- *Downstream aluminium* experienced the lowest relative increase in electricity price paid by the surveyed plants, with average electricity prices in 2023 around 78% of those paid in 2019. Due to its sample size, a regional comparison is available for this sector:
    1. North Western Europe (NWE)[241] region: Electricity prices increased to 188.50 EUR/MWh in 2022 but fell to 143.44 EUR/MWh in 2023. No correlation was found for plants in this region with fixed contracts, as the only plant reporting having a fixed contract also had a variable contract in place , and experienced higher electricity prices than the regional average.
    2. Central Eastern Europe (CEE) region[242]: Prices surged from 63.73 EUR/MWh in 2019 to 224.3 EUR/MWh in 2022, then dropped to 159.05 EUR/MWh in 2023. Although the smaller sample size limited insights, plants with hedging mechanisms generally faced lower prices.
    3. Southern Europe (SE)[243] region: The highest prices in 2022 were 228.74 EUR/MWh, decreasing to 159.88 EUR/MWh in 2023. Plants with fixed or combined contracts had lower prices, though some contracts are nearing expiry.

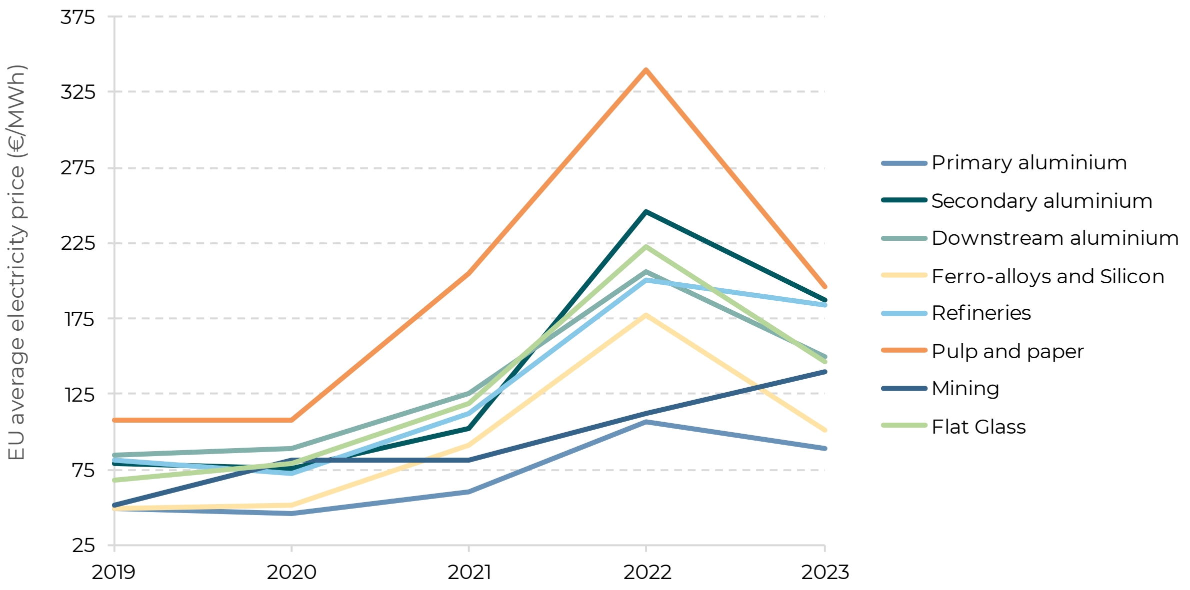


Figure 115: Electricity prices (EUR/MWh), EU averages 2019–2023

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

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

Table 9: Electricity prices (EUR/MWh), EU averages 2019–2024

Sector	2019	2020	2021	2022	2023
Primary aluminium	49.02	45.36	60.32	106.91	89.16
Secondary aluminium	79.11	75.52	102.00	245.27	186.99
Downstream aluminium	42.90	89.34	125.78	205.94	149.52
Ferro-alloys and Silicon	48.87	50.94	91.36	176.87	101.00
Refineries	85.8	67.2	89.3	185.8	172.9
Pulp and paper	107.21	107.52	205.05	340.22	195.81
Mining	51.43	81.13	81.09	112.54	139.64
Flat glass	67.65	78.60	119.19	222.10	146.30

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

Information for natural gas prices and natural gas intensity was limited, with fewer plants providing information on this energy carrier. **For the surveyed sectors, there is no clear correlation between the sector's natural gas intensities and their natural gas prices.** Moreover, some sectors that paid lower electricity prices in 2023 on average also paid lower natural gas prices. Nevertheless, when compared to electricity prices, average natural gas prices paid seem to vary less widely across the sectors surveyed. This could be explained by natural gas prices being largely set by international markets, and thus industry might have less room for negotiation in comparison to electricity prices. Some sector-specific observations include the following:

- Similar to electricity prices, *Primary aluminium* had one of the lowest average natural gas prices amongst the surveyed sectors. Historically, this was not a particularly natural gas intensive sector. However, plants in the sample have reported curtailment of their electricity furnaces in order to cope with soaring electricity prices since 2022. To compensate, the plant shifted towards using cold metal (ingots acquired at market prices from various suppliers) and liquid recycled metal (secondary aluminium). In this scenario, more natural gas is consumed to compensate for the lack of heat of the liquid aluminium coming from the electrolysers.
- When compared to *Primary aluminium*, *Secondary aluminium* experienced prices significantly higher than those of *Primary aluminium*. This is a significant deviation from findings of the previous study. A possible explanation could be on the different strategies regarding the type of natural gas contracts used by the two sectors. As of March 2024, some of the *Primary aluminium* plants surveyed reported using a contracts with fixed and variable price for natural gas. In contrast, none of the *Secondary aluminium* plants sampled reported having in place contracts with fixed price for natural gas. Instead, the majority reported having variable contracts in place, or a combination of variable and fixed rates.
- For *Downstream aluminium* plants, natural gas prices were relatively stable from 2017 to 2019, averaging 25.14 EUR/MWh. Prices began rising in 2020, reaching 27.28 EUR/MWh, and peaked at 91.24 EUR/MWh in 2022. In 2023, prices decreased to 61.66 EUR/MWh, but remained well above pre-2021 levels. Moreover, there was considerable variation in prices across regions:
    i. Surveyed plants from the NWE region experienced the highest natural gas prices of the sector, especially post-2020, where prices rose from 29.31 EUR/MWh in 2020 to 99.12 EUR/MWh in 2022, before falling to 70.02 EUR/MWh in 2023.
    ii. Surveyed plants from the SE and CE regions saw sharp increases in prices until 2022, with CE rising to 94.66 EUR/MWh and SE to 73.44 EUR/MWh. In 2023, prices in these regions decreased to around 51 EUR/MWh, though they remained much higher than in 2019. Contract strategies varied, but in many cases, the type of contract did not consistently correlate with lower prices, especially in the SE and CE regions, where findings were inconclusive.

- The average natural gas price paid by the surveyed plants in the *Ferro-alloy and Silicon* sector were the highest in 2023 with 96 EUR/MWh. Surveyed plants in the sector were amongst the plants with the lowest natural gas intensities.
- *Refineries* had the lowest average natural gas price of the surveyed sectors in 2023, while it also has the lowest average natural gas intensity. This tendency for lower natural gas price for *Refineries* may be due to several factors: i) long-term, fixed contracts (though this was not reported by all *Refineries* sampled), ii) ability to adjust feedstock (*Refineries* may choose to process heavier crude oils if natural gas is too expensive), iii) integrated operations (some *Refineries* may be a part of a larger, vertically integrated oil and gas companies which produce their own natural gas (though none of the sampled *Refineries* reported own production of natural gas)), iv) proximity to natural gas production sites/pipelines (reducing distribution costs) and v) *Refineries* may receive tax exemptions for the use of natural gas to produce fuels.
- *Pulp and paper* and *Flat glass* have the highest average natural gas intensity among the sampled sectors. In the *Flat glass* sector, The sampled plants are float glass plants, which require a process that operates continuously for uninterrupted periods of 16 to 20 years[244]. Although these are natural gas intensive sectors, their natural gas prices were not the lowest of the sampled sectors. An analysis of their contracting strategies suggest that for *Pulp and paper*, contracts are generally short-term, and plants do not engage in other hedging mechanisms (e.g. PPAs, etc.). For *Flat glass*, most plants have natural gas contracts, and have reported similar natural gas prices.

[244] *Glass for Europe. (2020). 2050 | Flat glass in Climate Neutral Europe. Page 19. Available at; https://glassforeurope.com/wp-content/uploads/2020/01/flat-glass-climate-neutral-europe.pdf*

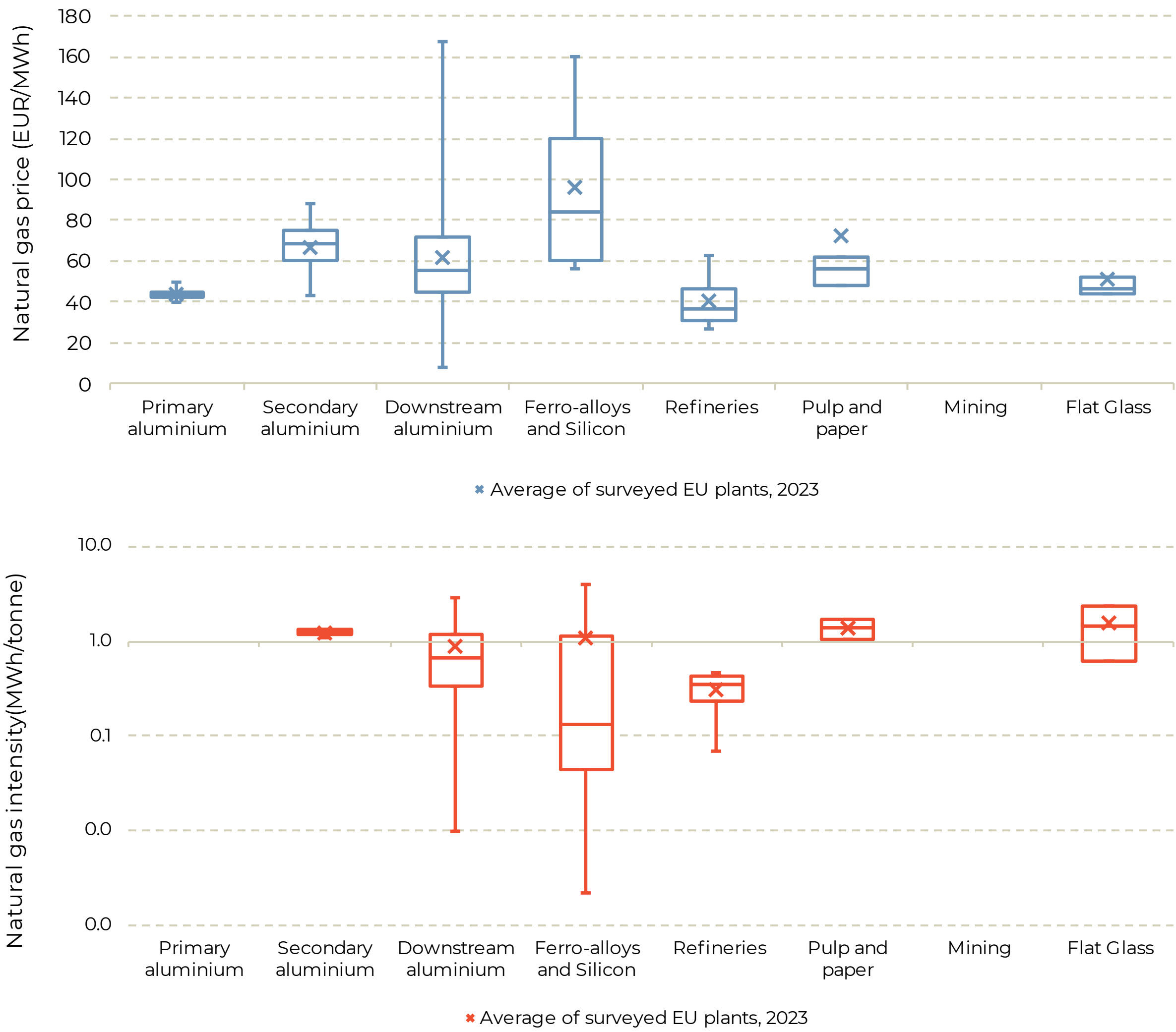


Figure 116: Natural gas prices (above) and natural gas intensity (below) per sector based on collected plant data for 2023

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

Values for the Mining sector could not be shown due to insufficient responses to ensure data confidentiality. Natural gas intensity values for the Primary aluminium sector could not be shown due to insufficient responses after removing identified outliers.

Figure 117 and Table 10 show that for average natural gas prices, the difference between the surveyed sectors over the years between 2019–2022 is relatively small. Sectors experiencing similar fluctuations in their paid natural gas prices in the observed period: average **natural gas price increase reached 2-4 times in every sector in 2022 compared to 2019. In 2023, average natural gas prices for the surveyed sectors started a decreasing trend. However, similarly to electricity prices, these are still significantly higher than those paid in 2020 and 2021.**

- *Secondary aluminium* and *Ferro-alloys and Silicon Pulp and paper* experienced the largest increase in natural gas prices. Secondary aluminium and Ferro-alloys and Silicon had the highest of the surveyed sectors in 2023, with prices in 2023 almost three times higher than those paid in 2019 (186% and 182% respectively). Similarly, for *Flat glass*, *Downstream aluminium* and *Pulp and paper* natural gas prices in 2023 remained between 156% and 128% higher than those paid during 2019.
- Although *Refineries and Primary aluminium* had the lowest natural gas prices of the surveyed sectors in 2023, prices in 2023 still remain 71% and 66% higher than those paid by these sectors in 2019, respectively.

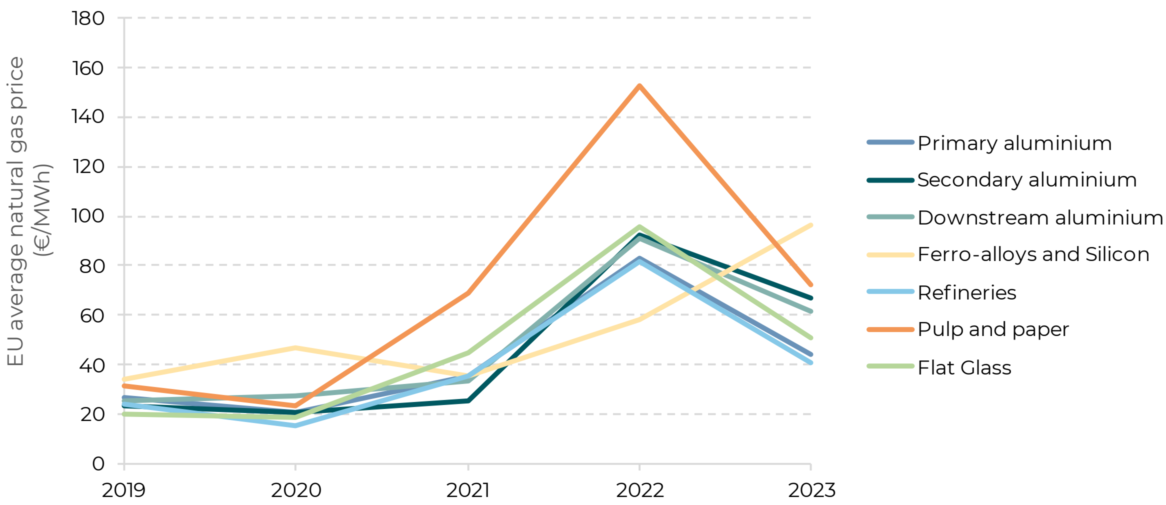


Figure 117: Natural gas prices (EUR/MWh), EU averages 2019–2023

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

Value for the Mining sector could not be shown due to insufficient responses to ensure data confidentiality.

Table 10: Natural gas prices (EUR/MWh), EU averages 2019–2023

Sector	2019	2020	2021	2022	2023
Primary aluminium	26.59	20.96	35.08	82.96	44.06
Secondary aluminium	23.46	20.65	25.01	92.25	67.11
Downstream aluminium	43.77	27.28	33.29	91.24	61.66
Ferro-alloys and Silicon	34.18	46.72	35.15	58.17	96.26
Refineries	23.85	15.35	35.49	81.64	40.69
Pulp and paper	31.61	23.29	69.18	152.70	72.21
Flat glass	19.91	18.48	44.65	95.48	51.06
Mining	*Not available due to insufficient responses*				

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

Relation between energy prices, energy costs and energy intensity of selected EIIs

Table 11 provides an overview of the average electricity prices and costs of the surveyed EU plants in 2023. The table also shows the share of electricity costs in production costs and the electricity intensity in 2023. The table shows that the plants operating in sectors with a high electricity intensity (*Primary aluminium, Ferro-alloys and Silicon*) also have a relative high share of electricity costs in their production costs despite their lower electricity prices paid. Only among the surveyed plants in *Mining* relative high electricity prices are observed while the electricity costs as share of production costs is also relatively high. However, the sample size for this sector is small and results are skewed by the different types of mining sites. Electricity prices vary across the metal and non-metal *Mining* sites sampled depending on the electricity contracts, whereas the metal *Mining* sites that are particularly electricity intensive increase the average electricity cost shares.

Table 11: Electricity prices & costs in selected EII sectors – simple EU averages, 2023.

Sector	Electricity prices (EUR/MWh)	Electricity costs per production quantity (EUR/tonne)	Electricity costs as a share of production costs	Electricity intensity (MWh/tonne)
Primary aluminium	89.16	826.19	36.2%	N/A
Secondary aluminium	186.99	20.79	0.8%	0.12
Downstream aluminium	149.52	106.78	2.5%	0.80
Ferro-alloys and Silicon	101.00	630.42	29.4%	6.14
Refineries	172.95	15.08	2.0%	0.08
Pulp and paper	195.81	52.85	n.d.	0.93
Flat glass	146.30	44.06	6.8%	0.25
Mining	139.63	355.48	11.7%	4.71

Source: Own elaboration based on data from industrial plant operators.[245]

[245] 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. However, 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 are not the same. As a consequence, the electricity price times the electricity intensity does not necessarily match the electricity costs per production quantity.

Table 12**Error! Reference source not found.** shows the same information as Table 11, but for natural gas. As noted in the section above, no correlation between natural gas intensity and the natural gas price can be observed from the surveyed results. A light correlation between the natural gas costs as share of production costs and the average natural gas prices paid by the surveyed plants can be observed. The average natural gas prices paid by the surveyed *Flat glass* plants of 51 EUR/MWh are on the lower side compared to sectors with lower natural gas costs shares such as *Secondary* and *downstream aluminium* of 62–67 EUR/MWh in 2023. The average natural gas price paid by the surveyed plants in the *Ferro-alloy and Silicon* sector, where natural gas costs only account for a negligible share of 0.1% of total production costs, are even higher with 96 EUR/MWh. However, this observation does not hold for *Primary aluminium* and *Refineries*, for which the average prices paid for natural gas in 2023 are at the low end with 41–44 EUR/MWh despite the relative low share in production costs. The natural gas prices paid in the *Pulp and paper* sector is also comparatively high, while their natural gas intensity is comparable to that of the surveyed plants in *Flat glass*. However, as explained above, the results for *Pulp and paper* may be skewed due to the small sample size and the concentration of sampled plants in Southern Europe.

Table 12: Natural gas or fuel prices & costs in selected EII sectors – simple EU averages, 2023.

Sector	Natural gas prices (EUR/MWh)	Natural gas costs per production quantity (EUR/tonne)	Natural gas costs as a share of production costs	Natural gas intensity (MWh/tonne)
Primary aluminium	44.06	47.15	2.2%	N/A
Secondary aluminium	67.11	77.18	3.5%	1.25
Downstream aluminium	61.66	54.64	1.2%	0.90
Ferro-alloys and Silicon	96.26	68.26	0.1%	1.07
Refineries	40.69	13.38	1.6%	0.31
Pulp and paper	72.21	104.68	n.d.	1.42
Flat glass	51.06	105.49	18.9%	1.55
Mining	*Not available due to insufficient responses*			

Source: Own elaboration based on data from industrial *plant operators.*[246]

Notably, the results above do not include the costs of oil, which is particularly relevant for the *Refineries* sector, where other fuels (e.g. self-produced fuel gas and fuel oil as well as fluid catalytic cracking (FCCU coke) make up almost 4% of production costs.

Overall, the share of total energy costs in production costs vary widely across sectors. The energy cost shares in 2023 of the surveyed plants were as follows:

- The highest energy cost share was found in surveyed plants in the electro-intensive sectors *Primary aluminium* (38%) and *Ferro-alloys and silicon* (29%), driven by electricity costs;
- High energy cost shares were also found in *Flat glass* plants (25%) and surveyed *Mining* respondents (21%), where both electricity and natural gas costs play a prominent role in the total production costs.
- Although *Refineries* are energy intensive, energy costs account for a relatively low share of production costs (8%). The majority of production costs for *Refineries* are primarily driven by the purchase of crude oil, of which about only 7% is used for energy consumption, and the rest is used as feedstock[247]. According to Concawe, if crude oil costs were excluded from production costs, energy costs would reach around 50% of production costs[248].

The increases in prices for electricity and natural gas led to an increase in the share of energy costs in the total production costs for almost all surveyed sectors. With electricity and natural gas prices increasing faster than other production costs in 2022, this also resulted in record high energy cost shares in the surveyed sectors. In 2023, the share of energy costs in total production costs has dropped. However, this drop can only partly be attributed to a decrease in energy prices. In most sectors the other production costs, primarily driven by material costs, increased in 2023 compared to prior years. Nonetheless, the share of energy costs in total production costs remain higher than pre-crisis levels for all sectors.

[246] Value for some sectors could not be shown 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. However, 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.

[247] Not published, based on Concawe's LP modelling of the entire refining industry in the EU28.

[248] Solomon Associates (2019) via Concawe. Shares are the result of dividing energy costs (USD/bbl) by Cash OpEx (USD/bbl) for the EU28 for years 2016 and 2018. Cash OpEx is the sum of personnel costs, energy costs and other costs.

The findings above show that overall since the start of the energy crisis in 2021, **energy costs have played a decisive role in the competitiveness for most of the sampled sectors, negatively affecting their production output:**

- In the case of the Primary aluminium sector, the increase of other production costs (including raw materials) can still be linked to a rise of electricity prices. Curtailed plants in the sector reported reducing their aluminium electrolytic production in response to the rise of electricity prices, causing either ultimate plant closure, or a shift towards using cold metal (ingots acquired at market prices from various suppliers) to complement its reduced production of liquid metal from the electrolysis increasing 'Other production costs' as well as the market risk to their operations.
- Some sectors are able to pass through the increased production costs by rising their products selling prices, however, sharp increases in electricity and natural gas costs since 2020 have reduced the profitability of the *Downstream Aluminium* and *Flat glass* sectors. In the *Flat glass* sector, while some of the increased energy costs have been passed on to customers, the closure of many plants since the energy crisis suggests a significant reduction in profitability and a loss of competitiveness.
- High energy prices were cited by the European *Ferro-alloys and Silicon* sector as one of the main drivers behind the significant plants closures in the sector.
- Across the surveyed plants, average production output decreased by 43% and 18% for *Ferro-alloys and Silicon* and *Flat glass* sectors between 2019 and 2023. Production output did, however, increase in the same period for the few surveyed plants in *Pulp and paper* by 70%.
- In 2023, the European crude steel production fell to historic low levels, at 126 million tonnes, a 7% decrease from 2022 levels and 17.5% decrease compared to 2021. In 2023, the sector also witnessed a spike in global excess capacity due to weak demand, peaking at 550 million tonnes. [249] Likewise, data collected and shared by Cerame-Unie indicated that there has been a consistent decline in the production output of ceramics from 67 089 067 million tons in 2019 to 58 960 599 million tons in 2023.[250]

Exposure to international trade

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 13 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 2023 to balances out the impacts of COVID-19 and the energy crisis[251].

Table 13 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. Even for the sectors marked as medium exposure to international trade, due to their energy-intensive nature, changes in energy costs can also significantly affect their international competitiveness.

[249] *EUROFER, Annual Report 2024.* https://www.eurofer.eu/publications/reports-or-studies/annual-report-2024
[250] Cerame-Unie estimates based on data collected.
[251] *Overall, international trade experienced a downturn in 2020 but rebounded in 2021 to levels higher than 2019. In 2022, international trade, primarily import from outside of the EU, grew even further as the reliant on imported goods because higher due to EU industrial production scaling or shutting due to the soaring energy prices. In 2023, imports decreased again as energy prices decreased and production in the EU partially recovered. See Commission (2024).* International trade in goods.

Table 13: Exposure of EU selected energy intensive industries to international trade average of 2019–2023[252]

Sector	Gross imports (MEUR)	Gross exports (MEUR)	Production value (MEUR)	Internal consumption (MEUR)	Import exposure[253] (%)	Export exposure[254] (%)	Exposure to international trade[255]
Mining (B)	36 259	13 674	70 242	91 608	38%	19%	High
Pulp and paper (C17.11-17.12)	9 436	23 352	69 785	57 116	15%	30%	High
Refineries (C19.20)	77 269	90 231	332 023	324 017	19%	21%	High
Flat glass (C23.11)	274	753	6 242	5 802	4%	11%	Medium
Ferro-alloys (C24.10.12)	9 922	1 547	2 515	10 493	91%	64%	Very high
Silicon[256] (C20.13.21.50)	1 423	78	857	2 202	65%	9%	Very high
Unwrought aluminium (primary and secondary aluminium) (C24.42.11)	27 922	2 198	7 774	31 943	81%	27%	Very high
Downstream aluminium (C24.42.12-24.42.26)	16 049	16 026	23 205	18 587	68%	69%	Very high

Source: Own elaboration based on Eurostat data (Comext and Europroms)

Other key determinants of competitiveness

Besides energy costs and international trade, other aspects that are **key factors determining the competitiveness of a company** include raw material and personnel costs, market concentration and conditions, and price and product differentiation. Particularly, the following aspects were highlighted by the surveyed plants:

- **Other operating costs besides energy costs** can strongly influence a sector's profitability and competitiveness. For example, in *Downstream aluminium*, operating costs are dominated by unwrought aluminium purchases (i.e. the output of primary aluminium plants).
- **Market conditions also strongly affect the competitiveness of a sector.** In the case of *Ferro-alloys and Silicon*, of the plants surveyed, average gross operating surplus (GOS) and turnover has increased between 2019 and 2020, increasing every year except between 2022 and 2023. This may be explained by the shortage of supplies of ferro-alloy and silicon products from the EU due to plant closures (49% of furnaces of the Euroalliages' members have closed as of December 2023), trade sanctions imposed on Russian imports, and the temporary trade disruptions experienced at the Suez Canal. The constricted supply has led selling prices to increase, resulting in higher GOS.
- **For some sectors (e.g. Primary *aluminium* and *Refineries*), trading prices are set internationally**. The profitability and competitiveness of plants in these sectors is therefore determined by the internal cost structure of these plants.
  - For *Primary aluminium,* price is mainly based on the London Metal Exchange (LME), i.e. all unwrought aluminium is sold roughly at the same price internationally.
  - Similarly for *Refineries*, price differentiation is difficult given the homogeneous nature of the product's quality across regions. However, for the sampled plants in sector, GOS increased in 2022 and 2023. This could be explained by the sanctions

[252] *Average of 2019–2023 is calculated where available. In some cases, data from 2022 and/or 2023 is not available. Percentages are only calculated for years where all data is available.*
[253] *Share of internal consumption served by extra-EU imports*
[254] *Share of production dedicated to extra-EU exports*
[255] *The exposure to international trade is assessed based on trade intensity [(imports + exports)/(imports + production value)]: medium = <30%; high = >30%; very high = >60%. The 30% threshold is based on the trade intensity criteria used by the 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 form industry associations.*
[256] *Latest available values were from 2018, as production values were not available for 2019-2023.*

imposed on Russian imports, a main source of imports of refinery products in the EU27 competing with EU producers.

The next subsection discusses the impact of energy costs and other key determinants on the competitiveness of selected sectors in more detail. In addition, Annex A provides a detailed analysis of energy costs and the sectors' market developments for sectors where detailed data could be collected (*Aluminium, Ferro-alloys and Silicon, Flat glass, Pulp and paper, Refineries* and *Mining*).

5.3.3. Impact of energy costs on the competitiveness of selected EU EIIs

After the collapse of production due to the pandemic restrictions on the economy in 2020, the overall EU industrial output rebounded and exceeded the 2019 (pre-pandemic) levels by 2022– despite the unfolding energy crisis[257]. However, the energy-intensive industries' (EII) output specifically – for which sectors the energy costs represent a high share of production costs – declined within the same period[258]. The 2023 edition of this report found the impact of the energy crisis on these industries to be much more severe than the impact of the pandemic restrictions – with the soaring energy prices leading to cutbacks and closures in several sectors. The energy cost share increased between 20 and 55 per cent in the production of A*luminium*, *Ferro-alloys and silicon*, Z*inc, Fertilisers*, I*ron and steel*, and the *Chemicals* (chlorine production) sectors[259, 260].

Since then, the energy prices seem to have stabilised, albeit at a higher than pre-pandemic levels in Europe[261,262]. It is important to reflect on the significance of energy prices and costs regarding the competitiveness of EU industry against its peers. At the same time, it is not only important to look at the impact of energy costs on the competitiveness of current EIIs sectors, but also at manufacturing sectors of future strategic interest to the EU.

This section provides a snapshot of the impact of energy costs on the competitiveness of EU EIIs in the aftermath of the energy crisis. In addition, the *Automotive industry* and *Batteries* sectors have been selected for an analysis of their energy cost impacts. The findings in this section are primarily based on publicly available information, complemented with feedback from the sector associations and insights from the surveyed plants for selected sectors. 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* and *Flat glass;*
- Selected energy-intensive sectors with information from a non-representative sample of surveyed plants: *Refineries*, *Pulp and paper* and *Mining;*
- Selected energy -intensive sectors with participation from less than 3 surveyed companies and for which only qualitative findings can be presented: *Ceramics*, *Chemicals*, *Iron and steel* and *Zinc*;
- Other included sectors for which findings could only be based on publicly available information: *Automotive industry* and *Batteries*

[257] Eurostat (2024). *Industrial production down by 3.2% in the euro area and by 2.1% in the EU*
[258] Bruegel (2023). *Adjusting to the energy shock: the right policies for European industry*
[259] Trinomics (2022). *Study on energy prices and costs: Evaluating impacts on households and industry: 2023 edition*
[260] European Commission (2024). *Report on energy prices and costs in Europe*
[261] Hertie School Jacques Delors Centre (2023). *Rustbelt relics or future keystone? EU policy for energy-intensive industries*
[262] Bruegel (2023). *Adjusting to the energy shock: the right policies for European industry*

Aluminium

Key takeaways:

- Overall, energy prices and energy costs of the aluminium plants participating in the survey significantly rose during the analysed period, both for electricity and natural gas.
- Some *Primary aluminium* plants reported a significant reduction of their aluminium electrolytic production and the use of scraps as inputs (acting de facto as a secondary aluminium plant), a measure taken in response to rising electricity prices. Primary aluminium prices are set globally, thus, plants in this sector are unable to pass through increases in their production costs.
- In particular, *Secondary aluminium* experienced the largest increase in electricity prices of the sectors sampled in 2022 and 2023. The sector's average electricity price was 187 EUR/MWh in 2023.
- For Downstream aluminium producers, electricity and natural gas prices vary significantly across EU regions, with downstream aluminium plants in the NWE region experiencing some of the highest increases. The SE and CE regions also saw substantial price rises but have seen varying levels of reduction in 2023.
- Overall, EU aluminium producers estimate production costs to be 10% to over 30% higher compared to non-EU competitors. For energy costs specifically, differences are between 11–30% for primary aluminium and over 30% for secondary aluminium.

The findings in this section are based on a sample consisting of 33 installations spread across 13 Member States.

For the *Primary aluminium* plants surveyed energy costs represent a substantial fraction of production costs and of turnover: on average, energy costs account for 38.4% of production costs, and between 43.5% of turnover in 2023. Electricity is the main input for primary aluminium production, with electricity cost accounting for 36.2% of production costs in 2023.

- From 2017 to 2020, the *Primary aluminium* sector experienced relatively stable electricity prices, ranging from 42.44 EUR/MWh in 2017 to 45.36 EUR/MWh in 2020. However, this stability was followed by a sharp increase, with prices rising from 60.32 EUR/MWh in 2021 to a peak of 106.91 EUR/MWh in 2022. Although prices decreased slightly in 2023 to 89.16 EUR/MWh, they remained much higher than pre-2021 levels. In terms of electricity contracts, only one plant in the sector had a fixed-rate contract, while others used a combination of fixed and variable rates or alternative hedging mechanisms.
- In response to the increasing electricity prices of the 2021–2023 period, two of the four participating EU primary aluminium plants reported reducing their aluminium electrolytic production, increasing 'Other production costs' as well as the market risk to their operations. In this scenario, more natural gas is consumed to compensate for the lack of heat of the liquid aluminium coming from the electrolysers. For one of the plants, their gradual reduction of electrolysis furnaces and, consequently, a reduction in production quantities, since 2019 led to its ultimate closure in 2024. Due to the small sample for this sector, the reduction of production output of these curtailed plants contributed to an increase in the calculated costs estimations (energy costs, personnel costs and other production costs) of these years. It should also be noted that electricity consumption is closely linked to the level of usage of capacity, therefore curtailed plants face higher inefficiencies in their process.
- In 2021 and 2022, energy costs rose to 45.9% of production costs due to increases in both electricity and natural gas costs. Electricity alone accounted for 41.3% of production costs in 2022, the highest share in the period analysed, while natural gas costs reached 4.6%. Despite rising energy costs, profitability improved in 2021 and 2022, with GOS increasing from 239.76 EUR/tonne in 2021 to 1 317.93 EUR/tonne in 2022, partly due to a surge in global aluminium prices, as determined by the London Metal Exchange (LME). However, both energy and other production costs also peaked, likely influenced by the curtailed plants in the sample.

- In 2023, average energy costs decreased to 873.35 EUR/tonne, still higher than pre-2021 levels, while personnel and other production costs dropped below 2020 levels, possible due to the exclusion of one plant that closed, and the remaining curtailed plant: the plant had a continuous reduction of production output, while their reported Other costs and personnel costs remained at consistent levels. As a result, the average EU energy costs as a share of production costs fell to 38.4%, still higher than pre-2021 levels, and accounted for 43.5% of turnover, slightly lower than in 2019.
- Overall, the data suggests a strong correlation between turnover and other production costs, particularly input materials. While energy costs were relatively stable between 2019-2020, high non-energy production costs led to negative GOS during this period, indicating that the sampled plants are unable to pass on these costs into their product price.

In the case of the *Secondary aluminium* sector, the energy costs per tonne of output remained relatively stable between 2017 and 2020, fluctuating between 32 and 36 EUR/tonne. However, starting in 2021, energy costs began to rise, reaching 42.1 EUR /tonne in 2021 and peaking at 136.58 EUR/tonne in 2022. In 2023, these costs slightly decreased to 97.98 EUR/tonne, still significantly higher than pre-2021 levels.

- The Secondary aluminium sector experienced higher electricity prices than those of the primary aluminium sector during the analysed period. For primary aluminium plants it is crucial to secure electricity supply at a reasonable cost. This is evidenced by the use of electricity contracts[263] in the sector. In the previous editions of this study, different strategies regarding the type of electricity contracts used by the two sectors was found to be a possible explanation for this. In the 2022 analysis, the majority of *Primary aluminium* plants reporting having contracts with a set rate per unit of energy for electricity, while most of *Secondary aluminium* plants pointed to having short-term contracts of variable rates, exposing them more to market price fluctuations. In the current sample, information about contracts was found to be more limited, but the conclusions are in line to those of the previous edition of this study: none of the *Secondary aluminium* plants had fixed-rate contracts; instead, they relied on variable or mixed contracts, which exposed them more to market price fluctuations.
- The sector saw natural gas prices fluctuate between 20.26 EUR/MWh in 2017 and 23.46 EUR/MWh in 2019, with a drop to EUR 20.65/MWh in 2020. Natural gas prices then climbed to 25.01 EUR/MWh in 2021 and soared to 92.25 EUR/MWh in 2022, before decreasing to 67.11 EUR/MWh in 2023. Notably, natural gas prices for *Secondary aluminium* were generally lower than those for *Primary aluminium* from 2017 to 2021 but exceeded them in 2022 and 2023. This shift may be due to differences in natural gas contract strategies, as *Secondary aluminium* plants reported variable and combined contracts, in contrast to the more stable contracts in primary aluminium.
- Natural gas costs make up the majority of energy expenses for *Secondary aluminium* plants. In 2022, natural gas costs surged to 102.9 EUR/tonne, though this increase was less pronounced than in *Primary aluminium* plants, reflecting differences in natural gas intensity. *Secondary aluminium* plants saw a slight increase in natural gas consumption, from 1.11 MWh/tonne in 2019 to 1.25 MWh/tonne in 2023, while the higher consumption in primary plants was driven by the use of scraps, as discussed earlier.
- Despite the rise in energy costs in 2022 and 2023, their share of total production costs for secondary aluminium remains relatively low compared to personnel and other production costs. Energy costs rose from 2.5% of production costs during 2017–2020 to 5.1% in 2022, and slightly decreased to 4.3% in 2023.

[263] *For this study, electricity and natural gas contracts were classified as follows: Fixed contract: when a set rate per energy unit (e.g. Euro/kWh) is charged for the fixed term of the contract. Energy bill is charged based on energy usage. Variable contract: when the rate per unit is linked to market activity, and could therefore be subjected to changes throughout the contract period. A combination of fixed and variable contract combines fixed rates (usually to hedge against typically volatile periods), and variable rates (which can be structured around peak, non-peak or around the clock prices).*

For *Downstream aluminium* plants:

- Electricity prices were relatively stable between 2017 and 2018, averaging around 76 EUR/MWh. However, prices began to rise in 2019, increasing from 83.94 EUR/MWh in 2019 to 205.94 EUR/MWh in 2022. By 2023, prices had decreased to 149.52 EUR/MWh, though they remained significantly higher than those prior to 2021.
    - Regionally, the NWE region experienced the lowest price increase in 2022, with electricity prices averaging 188.50 EUR/MWh, before decreasing to 143.44 EUR/MWh in 2023. No correlation was found for plants in this region with fixed contracts, as the only plant reporting having a fixed contract also had a variable contract in place, and experienced higher electricity prices. The majority of the NWE plants reported having both a variable and a combined electricity contract (of fixed and variable prices) in place, while also experiencing higher prices than the NWE average indicating they were still exposed to market price changes.
    - In the CE region, electricity prices rose from 63.73 EUR/MWh in 2019 to 224.3 EUR/MWh in 2022, and then decreased to 159.05 EUR/MWh in 2023. Although the smaller sample size limited insights, plants with hedging mechanisms in the form of variable contracts, generally faced lower prices.
    - In the SE region, electricity prices were the highest in 2022, reaching 228.74 EUR/MWh, but decreased to 159.88 EUR/MWh in 2023. Plants in this region with fixed or variable contracts had lower prices, although some of these contracts are set to expire soon.
- For *Downstream aluminium* plants, natural gas prices were relatively stable from 2017 to 2019, averaging 25.14 EUR/MWh. Prices began rising in 2020, reaching 27.28 EUR/MWh, and peaked at 91.24 EUR/MWh in 2022. In 2023, prices decreased to 61.66 EUR/MWh, but remained well above pre-2021 levels.
    - There was considerable variation in prices across regions, with the NWE region experiencing the highest prices, especially post-2020, where prices rose from 29.31 EUR/MWh in 2020 to 99.12 EUR/MWh in 2022, before falling to 70.02 EUR/MWh in 2023.
    - Regionally, the SE and CE regions saw sharp increases in prices until 2022, with CE rising to 94.66 EUR/MWh and SE to 73.44 EUR/MWh. In 2023, prices in these regions decreased to around 51 EUR/MWh, though they remained much higher than in 2019. Contract strategies varied, but in many cases, the type of contract did not consistently correlate with lower prices, especially in the SE and CE regions, where findings were inconclusive.
- The GOS of the surveyed downstream aluminium plants increased from 2017 to 2023, driven primarily by a rise in the selling price per tonne. This selling price trend mirrors the fluctuations in Other production costs, particularly the costs of aluminium ingots, suggesting that downstream aluminium producers can pass through their costs, unlike primary aluminium producers. As turnover increased in primary aluminium production, downstream aluminium producers experienced higher costs.
- While energy costs have risen in recent years, their share of total production costs remains relatively low compared to GOS, personnel, and other production costs per tonne. Thus, the impact of rising energy prices on the competitiveness of downstream plants is primarily reflected through increased aluminium input material costs.
- From 2017 to 2020, energy costs accounted for a small fraction of production costs and turnover, averaging 2.4% and 2%, respectively. However, since 2021, rising electricity and natural gas prices have increased energy costs for downstream aluminium plants. By 2022, energy costs represented an average of 4.3% of production costs and 3.8% of turnover. In 2023, energy costs decreased but remained above pre-2021 levels, averaging 3.6% of production costs and 3.1% of turnover.

Finally, surveyed plants were also asked to provide a comparison of their energy and production costs vs those of their Non-EU competitors. According to the surveyed organisations across the three aluminium sectors, the impact of energy costs represents a high impact on the production costs for most of the respondents:

- In the *Primary* and *Secondary aluminium* sectors, respondents reported that energy costs have a significant impact on production costs, with only a minority noting that labour and raw material costs also play a significant role. They estimated that production costs in their organizations are 10% to over 30% higher compared to non-EU competitors. Specifically, energy costs were estimated to be 11–20% higher for *Primary aluminium* producers and over 30% higher for *Secondary aluminium* producers.
- For the *Downstream aluminium* sector, most respondents highlighted the high impact of both energy and labour costs, with raw material costs ranging from medium to high impact. They estimated the production cost gap with non-EU competitors to be between 21% and over 30%, while a minority suggested a smaller gap of 5%-20%. Half of the respondents believed energy costs were more than 30% higher than those of non-EU competitors, with the other half estimating a 5–30% difference.
- Respondents identified China, Russia, Saudi Arabia, Türkiye, and India as the main non-EU competitors, with additional mentions of Canada (*Primary aluminium*) and the United States, South Africa, and Egypt (*Downstream aluminium*). Some respondents also pointed out that non-EU competitors benefit from energy subsidies, particularly in China, where state subsidies have played a significant role in the country's expansion in the global aluminium market.

Ferro-alloys and Silicon

Key takeaways:

- Overall, energy costs per tonne of output have increased significantly in between 2020 and 2022, which is the result from an increase in energy prices and costs over the same period.
- Over the same period where energy costs increased, production output has declined. In 2023, production output decreased by 42.9% as compared to 2019.
- As price takers, the high electricity cost decrease the profitability of *Ferro-alloys and Silicon* plants. High electricity prices has been cited as a key contributing factor to the closure of 49% of furnaces of members of Euroalliages located in the EU, as of December 2023.
- Surveyed plants indicated that their key competitors are in South Africa, China, India, South Korea, Kazakhstan, Brazil, United States and Indonesia. Some of these plants estimated that the total production cost of those non-EU competitors is 21% to 30% lower. The energy cost differential was identified as a key factor, but also material and personnel costs in the EU had an important negative impact.

The findings in this section based on the responses provided by eight plants spread across six different Member States, which represents 58.7% of the total production output of Ferro-alloys and Silicon in EU27 in 2023.

The *Ferro-alloys and Silicon* sector is an electricity intensive industry, which accounts for about 30% of the total production costs.

Based on the data from the surveyed plants, average electricity costs per tonne of output remained relatively stable between 2017 and 2020, but increased from 284.78 EUR/tonne of output in 2020 to 608.95 EUR/tonne of output in 2021, i.e. by 2.14 times. This figure further increased to 1 129.57 EUR/tonne of output in 2022, increasing by 1.85 times compared to 2021. In 2023, the electricity costs per tonne of output decreased by 44.2% to 630.42 EUR/tonne of output, although it is still 2.35 times higher than in 2019 (pre-COVID 19).

Personnel costs per tonne of output has also increased by 3.1 times in 2023 compared to 2019. At the same time, average production output of the sampled plants also fell by 42.9% in the same period. This could be due to the need to maintain a minimum baseline of personnel to run the plants even though production output has decreased.

The surveyed plants identified the following countries where key competitors are located: South Africa, China, India, South Korea, Kazakhstan, Brazil, United States and Indonesia. Lower energy and labour costs in these non-EU countries are seen as having a high negative impact on the competitiveness of EU plants. Differences in raw material costs between EU manufacturers and non-EU competitors were considered as having a medium negative impact. In addition, the surveyed plants also mentioned several other factors affecting their competitiveness including lower shipping and transportation costs of non-EU competitors and non-cost barriers such as raw material availability and 'EU regulations', although no further information was provided. Some of the surveyed plants estimated the product cost difference with their non-EU competitors to be between 21% to 30%.

Flat glass

Key takeaways:

- Average energy costs per tonne of output increased significantly between 2019 and 2023. The average cost of electricity per tonne of output increased by 4.77 times, while the average cost of natural gas per tonne increased by 5.25 times in this period.
- Over the same period, i.e. 2019 and 2023, the EU average production output of the sampled plants declined by 17.7% and the number of float glass manufacturing sites of the sampled plants also reduced by 11.6%.
- Key competitors identified by the sampled plants are China, Türkiye and Russia.
- 14 out of 22 responses (64%) estimated that the difference in production costs compared to non-EU competitors is more than 30%. Lower energy costs of their competitors are seen as having a high negative impact on competitiveness. Lower labour and raw material costs were also seen as having a significant negative impact on competitiveness.

The findings in this section based on the responses provided by 29 flat glass plants spread across 11 different Member States, representing slightly more than 60% of the total production output of Flat glass in EU 27 in 2023.

Based on the data from the surveyed plants, the following evolution of prices and costs for electricity could be observed between 2019 and 2023:

- The EU average price of electricity increased significantly between 2020 and 2023. Compared to 2019, average EU electricity price increased by 2.16 times, from 67.65 EUR/MWh in 2019 to 146.30 EUR/MWh in 2023. The highest year-on-year increase occurred between 2021 and 2022, during which the EU average price of electricity increased by 1.86 times, reaching 222.10 EUR/MWh. Average EU average price of electricity in 2023 decreased by 34.1% compared to 2022 to 146.40 EUR/MWh, although this is still 2.16 times higher than in 2019. As of 2023, the average price of electricity in Central Europe is the highest compared to North Western and Southern Europe, at 1.17 times more than the EU average.
- The EU average price of natural gas remained relatively stable between 2017 and 2019. Between 2019 and 2023, average EU cost of natural gas increased by 2.56 times, from 19.91 EUR/MWh to 51.06 EUR/MWh. The highest year-on-year increase occurred between 2020 and 2021, during which the EU average price of natural gas increased by 2.42 times, from 18.48 EUR/MWh to 44.65 EUR/MWh. The EU average price of natural gas increased further in 2022 by 2.14 times compared to 2021, reaching 95.48 EUR/MWh. Prices fell in 2023 by 46.5% to 41.06 EUR/MWh, although this is still significantly higher than in 2019.

- The average electricity cost per tonne of output increased significantly, by 4.77 times, from 11.29 EUR/tonne of output to 53.78 EUR/tonne of output. This figure has decreased to 44.06 EUR/tonne of output in 2023, although it is still 3.9 times higher than in 2019.
- In 2022, the average natural gas cost per tonne of output also increased substantially, by 5.25 times compared to 2019, from 35.34 EUR/tonne of output to 185.45 EUR/tonne of output. This figure has decreased to 105.49 EUR/tonne of output, although it is still 2.99 times higher than in 2019.

The surveyed plants identified China, Türkiye and Russia as key competing countries. 91% of the responses (20 out of 22) consider lower energy costs in non-EU countries to have a high negative impact on the competitiveness of EU plants. Additionally, other factors such as lower labour and raw material costs in these non-EU countries are seen as having a significant detrimental impact on the competitiveness of EU plants. The estimated difference in production cost with their non-EU competitors is estimated to be more than 30% by 64% of the responses (14 out of 22)

Refineries

Key takeaways:

- Overall, energy costs have increased in 2022 and 2023 for the surveyed plants. This correlates with trends in energy prices for *Refineries*, which have increased significantly from 2020 to 2022. This is particularly the case for refinery fuel gas, natural gas and electricity. Prices generally have dropped in 2023, but still higher than pre-2020 levels.
- Recent trends of higher energy prices, historical high trade exposure and the sector's product prices dependent on crude oil prices would signal a negative impact on the sector's profitability. However, recent increases in GOS indicate that the recent sanctions on Russia, the top importer to the EU for refinery products, have created a shift in the market, allowing for the refinery sector to increase their profitability.

The findings in this section are based on insights from four plants spread across four Member States that responded to the questionnaire, with these Refineries producing more than 2.5 million tonnes of refinery products per year. Production output remained fairly stable, on average, for the sampled Refineries.

Based on the surveyed plants, the evolution of prices for electricity, natural gas, and other fuels, namely self-produced refinery fuels, could be observed with the following insights:

- Electricity prices paid by the surveyed plants were relatively stable from 2017 to 2020 (70–80 EUR/MWh), where prices sharply increased in 2022 up to EUR 200/MWh. Prices slightly decreased, but remained high in 2023, at about 185 EUR/MWh. Further, there is an increased variability of prices for the surveyed *Refineries* due to differences in types and durations of electricity contracts. Some *Refineries*' energy prices are fixed in contracts which pre-date 2021.
- Natural gas prices paid by the surveyed plants increased in recent years, ranging from 15–26 EUR/MWh during 2017–2020, increasing to 35 EUR/MWh in 2021 and peaking in 2022 at 82 EUR/MWh. In 2023, prices dropped to 41 EUR/MWh, however still higher than pre-2020 levels. Notably, *Refineries* had the lowest average natural gas price of the surveyed sectors in 2023, while it also has the lowest average natural gas intensity. This tendency for lower natural gas price for *Refineries* may be due to several factors:
    i. Long-term, fixed contracts
    ii. Ability to adjust feedstock to other, less-expensive crude oils
    iii. Own production of natural gas
    iv. Proximity to natural gas production sites/pipelines (reducing distribution costs)
    v. *Refineries* may receive tax exemptions for the use of natural gas to produce fuels

- Other fuels, namely refinery fuel gas, refinery fuel oil and FCCU coke, follow similar trends as electricity and natural gas, where prices were fairly stable before 2020, where prices increased in 2021 and 2022. There is a drop in prices in 2023, though still higher than pre-2020 levels.

Historically, the EU refinery sector is greatly exposed to international trade, where the EU is a net exporter of refinery products. The COVID-19 crisis led to a drop in trade of refinery products, which recovered and increased in 2021 and 2022.

One respondent listed Türkiye, Saudi Arabia and Russia as the major competitors. According to think tank and government website reports, some of these countries face favourable energy subsidies. For instance, according to a 2020 IISD report, Saudi Aramco, the state-owned petroleum and natural gas company, provides USD 33 billion of support each year to oil and gas exploration, production and refining[264]. Similarly, the Turkish government indicated that they subsidised USD 4.5 billion for natural gas in the first six months of 2022[265]. However, precise details on how these subsidies are favourable for the *Refineries* sector is not available.

The increase of energy costs per tonne in recent years (without an equivalent increase in turnover per tonne), historically limited ability for *Refineries* to adjust product prices[266] and high trade exposure would typically signal a negative effect on profitability from 2021 to 2023. However, the surveyed plants showed a GOAS increase in 2022 and 2023. This may be due to the sanctions on Russia related to the war in Ukraine, where Russia has historically been the top importer to the EU for refinery products and these sanctions have created a shift in the market.

Pulp and paper

Key takeaways:

- Average energy prices have increased between 2017 and 2022, with significant increases between 2021 and 2023. Prices have decreased in 2023, although it is still significantly higher than the levels before 2021.
- Despite energy prices in 2023 being significantly higher than pre-2021 levels, average production output of the sampled plants has increased by 70% between 2019 and 2023.
- Lower energy and labour costs of non-EU competitors were seen to be the key factors that negatively affects the competitiveness of EU companies, which could be driven by the presence of national subsidies for production costs in non-EU countries.
- The share of energy and labour costs in EU are higher compared to seven non-EU countries that have been identified as key competitors, according to Q4 2023 data collected by the industry association CEPI in 2024.

The findings in this section are based on insights from five plants mainly located in Southern Europe, with limited data received on the key performance indicators to analyse the competitiveness of the sector. The sampled plants represent less than 2% of the total production output of pulp, paper and paperboard production in the EU27 in 2023.

Based on the surveyed plants, the evolution of energy prices and costs could be observed with the following insights:

- Electricity prices remained relatively stable between 2017 and 2020. Prices increased by 1.91 times from 107.52 EUR/MWh in 2020 to 205.05 EUR/MWh in 2021, and by a further 65.9% to 340.22 EUR/MWh in 2022 as compared to 2021. In 2023, the average electricity price paid by

[264] G20 scorecard of fossil fuel funding: Saudi Arabia, International Institute for Sustainable Development, 2020. G20 Scorecard of Fossil Fuel Funding: Saudi Arabia Saudi Arabia on JSTOR

[265] Türkiye subsidised 150 billion liras for natural gas in 1h22: Energy Min. Republic of Turkiye Ministry of Energy and Natural Resources, 2022. Republic of Türkiye Ministry of Energy and Natural Resources - News (enerji.gov.tr)

[266] Refinery products' value are highly dependent on crude oil prices and have limited ability to differentiate products from international competition

the surveyed plants dropped to 195.81 EUR/MWh. While this is 42.4% less than electricity price paid in 2022, it is still 1.83 times higher than the pre-COVID-19 prices in 2019.
- Natural gas prices were quite volatile between 2017 to 2023, increasing significantly after 2020. Average natural gas prices increased by 2.97 times to 69.18 EUR/MWh in 2021 compared to 23.29 EUR/MWh in 2020. It increased a further 2.21 times to 152.70 EUR/MWh in 2022 compared to 2021. In 2023, the price decreased by 52.7% to 72.21 EUR/MWh compared to 2022, although it is still 2.28 times higher than the pre-COVID-19 prices in 2019.
- Average electricity cost per tonne of output remained relatively stable between 2017 and 2019. Between 2019 and 2023, the highest year-on-year increases occurred between 2020 and 2021 (by 1.63 times) reaching 44.98 EUR/tonne of output, and between 2021 and 2022 (by 1.74 times) reaching 78.07 EUR/tonne of output. In 2023, there was a decrease of 32.3% to 52.85 EUR/tonne of output, although it is still 1.44 times higher than in 2019 (pre-COVID 19).
- Average natural gas cost per tonne of output saw a brief decrease of 23.4% between 2019 and 2020, but increased significantly between 2021 and 2023. The highest year-on-year increase occurred between 2020 and 2021, during which natural gas cost per tonne of output increased by 2.99 times, reaching 99.31 EUR/tonne of output. It increased even further, by 2.0% between 2021 and 2022, reaching an all-time high of 199.79 EUR/tonne of output. The cost of natural gas per tonne of output decreased in 2023 to 104.68 EUR/tonne, although this is still 2.41 times higher than in 2019.

In addition, the Confederation of European Paper Industries (CEPI) also shared data that was used for an internal analysis on comparing competitiveness with non-EU countries for Q4 2023. Compared to the overall cost structure of seven key competitors in non-EU countries:[267]
- The share of fuels and electricity costs in the overall cost structure for EU plants is the second highest at 20.8% after Japan (24.4%), with significant differences when comparing across the countries, ranging from 1 to 12 percentage points;
- The share of labour costs in the EU is also higher than most countries, at 8.9%, except in the United States and Canada where they accounted for 15.8% and 15.5% respectively; and
- The material cost share, at 52.1%, is lower in the EU than in five countries (Russia, China, Japan, Indonesia and Brazil) and higher than in the United States and Canada, where it accounted for 50.9% and 46.5% respectively.

Mining

Key takeaways:
- Overall, energy costs have increased significantly in 2022 and 2023. This correlates with trends in electricity prices for *Mining*, which have also increase in 2022 and 2023 for the surveyed sites.
- Considering the increase of energy costs per tonne in recent years (without an equivalent increase in turnover per tonne) and high exposure to international trade in the EU market, this points to a negative impact of the rising energy costs to the competitiveness of the surveyed *Mining* sites in the recent years

The findings in this section is based on insights from five Mining sites in Europe, spread across five Member States, where the Mining companies are involved in extracting metals and Mining of minerals. Notably, production output for the sampled Mining sites has gradually declined from 2017 to 2023, on average.

Based on the surveyed plants, the following insights can be obtained from the evolution of prices/intensity for electricity and fuel oil:

[267] *Namely Russia, China, Japan, Indonesia, Brazil, United States and Canada. Q4 2023 data received from internal analysis carried out by the Confederation of European Paper Industries (CEPI) in 2024*

- There has been an increasing trend of electricity prices from 50 EUR/MWh in 2017 to 140 EUR/MWh in 2023. During the same period, variation in electricity prices has increased, where some *Mining* sites have experienced fairly stable prices and other have increased significantly due to variation in types of electricity contracts. Electricity intensity of *Mining* varies considerably per surveyed site, as for some *Mining* companies, energy prices are fixed in contracts which pre-date 2021.
- From three sites that provided their refinery fuel use in 2020–2023, their fuel oil intensity in has gradually increased from 2020 to 2023 on average, where the intensity has ranged from 0.12 MWh/tonne in 2020 to 0.17 MWh/tonne in 2023. Fuel oil prices cannot be presented due to confidentiality reasons.

Due to confidentiality reasons, results on the natural gas prices from the surveyed *Mining* sites cannot be presented. However, one *Mining* site did commented that there was a high impact of gas prices on its competitiveness as it is a main source of energy.

In terms of the main non-EU competitors, respondents of the questionnaire listed China, Brazil, Mexico and United States. According to the respondents, the difference in energy costs between their operations and the competitors' operations is more than 30%. Some of the respondents indicated that non-EU competitors like the United States benefitted from energy subsidies under the Inflation Reduction Act. In Brazil, a new investment fund was launched to boost the production from the *Mining* sector. In the same period of increases in energy prices and costs, the turnover of the surveyed plants did not increase at the same pace. Historically, the EU *Mining* sector faced high international competition on the EU market, where there is a high dependency on imported *Mining* products in the European market. Thus, combined with the high exposure to international trade in the EU market, the increase in energy costs without an equivalent increase in turnover points to a negative impact of the rising energy costs to the competitiveness of the surveyed *Mining* sites in the recent years.

Ceramics

Key takeaways:

- The increase in energy prices had a large impact on the Ceramics sector, which has experienced a significant increase in the share of energy costs as a share of production costs at the height of the energy crisis from 30% to 60%.
- Key competition from non-EU countries include China, Brazil, the United States, India and Türkiye, where energy costs are perceived to be lower and production in some of these countries being subsidised.
- Increasing costs in the EU and financial support received by non-EU competitors lead to the expectation of the sector that many ceramic producers in EU may shut down; most are SMEs, many of whom are more vulnerable to increases in energy costs and other costs.

The findings in this section are based on the survey received from one organisation with several plants active in the EU ceramic sector, complemented with insights from the industry association Cerame-Unie and public sources. This section is therefore limited to qualitative findings to ensure the data confidentiality of the participating company.

According to the surveyed company, the impact of energy costs represents a moderate to high impact on the production costs of the ceramics sector. This corresponds to the insights provided by Cerame-Unie, which indicated that the share of energy costs in productions costs has grown from 30% to over 60% during the height of the energy crisis. Furthermore, data collected and shared by Cerame-Unie indicated that there has been a consistent decline in the production output of ceramics from 67 089 067 million tons in 2019 to 58 960 599 million tons in 2023, as seen in Figure 118. Similarly, the Eurostat manufacturing index also indicates a significant decline in percentage across all the ceramic products covered in Table 14. Cerame-Unie indicated that the energy crisis fuelled by growing energy costs and increasing inflation and interest rates as major reasons for this decline[268].

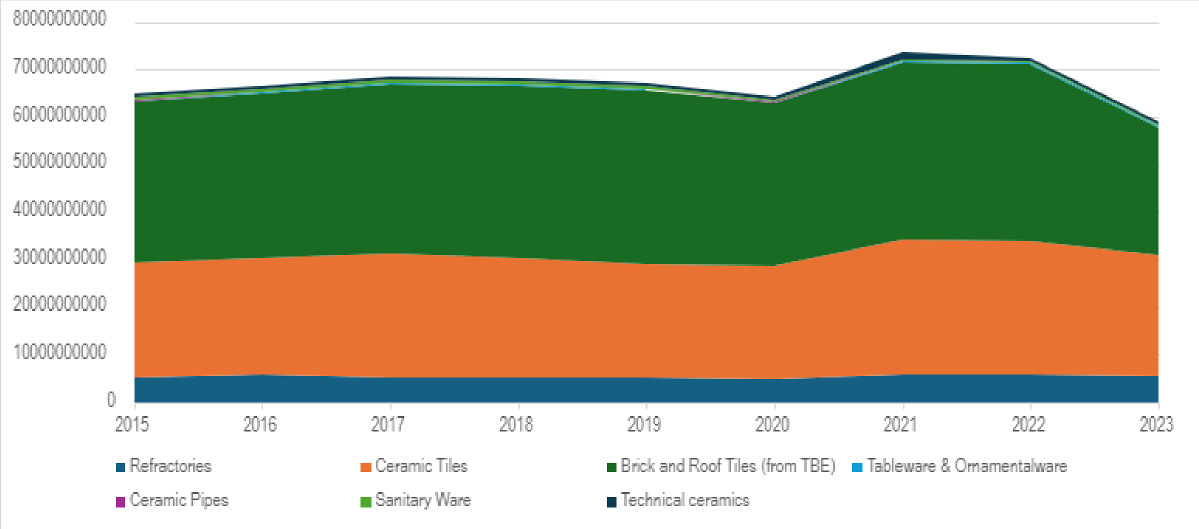


Figure 118: Production quantities across all ceramics from 2015 to 2023 (million tons)

Table 14: Eurostat manufacturing index for most ceramic products from 2021 Q3 2021 to Q1 2024

Ceramic products	2021		2022				2023				2024
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Refractory ceramics	29.0	16.6	4.4	2.4	-3.9	-8.6	-5.2	-9.0	-12.5	-5.2	-5.3
Clay building materials	9.6	4.1	-0.5	0.9	-5.3	-1.1	7.0	-11.6	-23.4	-24.1	-12.6
Ceramic Tiles	11.7	5.2	-3.9	0.4	-7.6	-0.6	18.7	-8.1	-18.1	-19.6	-6.5
Bricks and roof tiles	3.2	-0.7	4.6	3.4	0.9	-1.2	-15.3	-21.8	-37.2	-37.5	N/A
Tableware and ornamental ware	15.7	19.4	35.2	38.6	8.0	-5.1	-3.9	-11.5	-9.1	-6.6	N/A
Ceramic sanitaryware	17.2	1.0	11.2	8.3	17.6	-8.0	-21.7	-20.8	-34.1	-19.9	-8.2
Ceramic insulators and insulating fittings	24.6	18.7	14.4	6.3	3.8	14.6	-0.3	0.9	-11.5	-22.1	N/A
Other technical ceramic products	20.4	4.1	4.4	3.4	2.9	-1.5	-6.9	-6.1	-1.1	5.7	13.1
Manufacture of other ceramic products	9.3	3.3	-20.5	-26.4	-28.7	-39.1	-21.6	-14.8	-5.1	0.3	N/A

Similarly, according to findings in several media reports from 2021 to 2023, the impact of energy prices on the ceramics sector has been high[269]. The surge in gas prices, as a result of Russia's invasion of Ukraine, has left several organisations in the sector choosing between passing higher costs to customers and scaling back or halting production. News articles highlighted multiple cases of companies having to pass higher costs to customers or scale back production. One such example is the Iris Ceramica Group that is based in Italy. The organisation had to introduce an energy surcharge of 3% on invoices to help reduce the impact of the rise in gas prices[270]. Similarly, CINCA, a Portuguese ceramic wall and floor tile producer mentioned that their gas and electricity bill used to represent 30% of production costs, however, in 2022 it has risen to over 55%. Early in 2022, the company had to

[268] *Cerame-Unie data collected and the Eurostat manufacturing index data, 2024.*
[269] *Early starts, new ovens as ceramics industry feels energy pinch, Reuters, 2022.* https://www.reuters.com/markets/europe/early-starts-new-ovens-ceramics-industry-feels-energy-pinch-2022-09-02/
[270] *Focus: Gas price surge pushes Europe's ceramic s industry to breaking point, Reuters, 2021.* https://www.reuters.com/world/europe/gas-price-surge-pushes-europes-ceramics-industry-breaking-point-2021-10-27/#:~:text=Europe's%20ceramics%20industry%20guzzles%20gas,up%20to%2020%25%20of%20overheads.

temporarily shut down[271]. According to Cerame-Unie, most ceramic producers in the sector are SMEs, many of whom face a major impact from energy costs.

In terms of non-EU competitors, China was listed as the highest competitor for the surveyed company, followed by Brazil and the United States. According to Cerame-Unie, other strong competitors in the ceramic sectors include India and Türkiye. They also mentioned that for specific ceramic sectors, such as ceramic tiles, India has become the world's largest exporter and is massively investing to expand its production capacity. The surveyed company further mentioned the Inflation Reduction Act as a major support measure that helped industry in the United States, across sectors, including the ceramics industry. Similarly in China, the surveyed company indicated that the ceramic sector receives financial support from the various state levels, which may take the form of financial transfers (available under individual policy measures), preferential loans, export incentives, tax relieves and land-use cost relief, which contributes significantly to the ease of doing business[272].

As a result of increasing costs in the EU and financial support that non-EU competitors receive, some firms could decide to relocate to regions with lower energy costs. However, according to Cerame-Unie, since 80% of the European ceramic industry consists of SMEs, the relocation of factories will not be an option for most organisations. They expect that EU production will have to shut down and products will be imported in this case. They further indicated that in certain sectors, like ceramic tiles, the competitiveness of EU ceramics manufacturers continues to be negatively affected with a growing market share of products are already being imported from third countries at very low prices, as a consequence of high production costs in the EU.

Chemicals

Key takeaways:

- The EU chemical industry has historically established a competitive advantage over other non-EU competitors despite higher costs. However, they have slowly fallen behind China, and is experiencing a decrease in EU's share of global chemical sales and in 2022, the EU began importing more chemicals than it exports.
- Key competitors of the chemical industry in the EU include China, United States and Canada, where energy prices, labour costs, raw material costs and regulatory expenses are perceived to be lower than in the EU.
- The higher costs in the EU and financial support provided to non-EU competitors as led to several companies closing their plants in the EU, with the surveyed companies estimating production costs between the company's plant and competitors outside of the EU to be more than 30%.

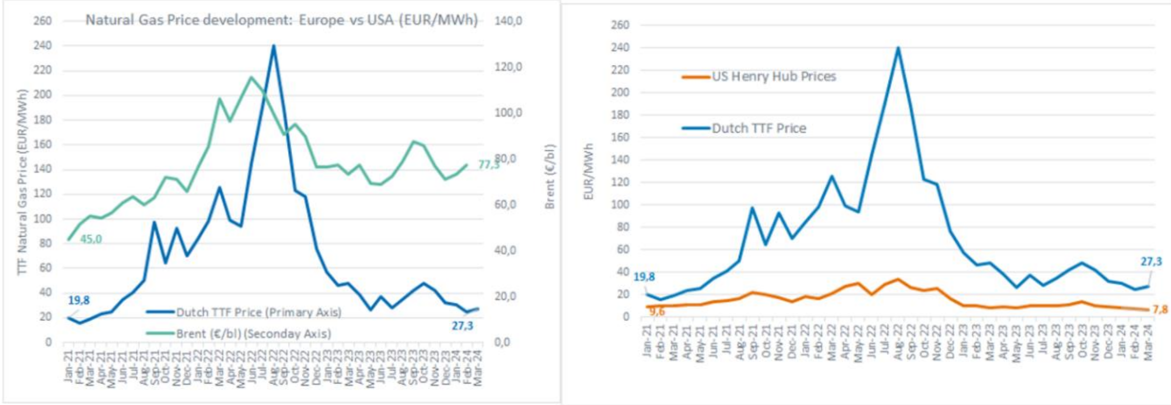
The findings in this section are based on the survey received from less than three companies active in the EU chemicals sector, complemented with insights from the European Chemical Industry Council (CEFIC) and public sources. This section is therefore limited to qualitative findings to ensure the data confidentiality of the participating company.

A study of the EU's chemical industry showed that despite its disadvantage on feedstock, labour and capital costs, the sector has performed well until 2020[273]. The study indicates that from 2000 to 2020, the EU chemical industry has delivered the same total return to shareholders as its North American counterparts, and a higher total return to shareholders than Asia. They largely attributed this to the EU's strengths in innovation, due to investing similar amounts in Research and Development and registering an equal number of patents. The European business environment also fosters an active

[271] *Portuguese ceramic industry takes a dent as energy crisis looms, EuroNews, 2022. https://www.euronews.com/2022/09/13/portuguese-ceramic-industry-takes-a-dent-as-energy-crisis-looms*
[272] *On significant distortions in the economy of the People's Republic of China for the purposes of trade defence investigations (Staff Working Document), European Commission, 2024.*
[273] *Securing the competitiveness of the European chemical industry, McKinsey (2023). Securing the competitiveness of the European chemical industry | McKinsey*

space for chemical startups. European companies also typically have developed a better understanding of local end consumers' needs and have learned to tailor products to them, generating competitive advantage.

According to the CEFIC chemical monthly report, gas prices in the first quarter of 2024 are at least 50% above pre-crisis levels (2014–2019). The report further indicates the level of gas prices through a comparison with the United States, where the gas price in Europe remains 3.9 times higher. As indicated in Figure 119 below, the gas prices were particularly high in 2022. The EU chemical industry reported a severe output decline of more than 6% in 2022 and 2023, and 2024 is still showing a weak start, with no strong signs of recovery.[274]



Source: : ICE Dutch TTF Natural Gas Futures Historical Prices - Investing.com and INSEE Oil Prices

Figure 119: Natural gas price development: Europe versus United States

Furthermore, according to CEFIC, the EU has slowly fallen behind China in recent years and has become the second biggest producer of chemicals; the European chemical industry generated annual sales of about EUR 760 billion in 2022, compared to China's EUR 2.3 trillion[275]. In addition, the EU's share of global chemical sales has dropped from 17% to 14% between 2012 and 2022, with growing concerns among market analysts about further reductions in the coming years[276]. In the first half of 2022, industry reports also indicated that for the first time, the EU began importing more chemicals than it exports, both in terms of value and volume, resulting in a trade deficit of EUR 5.6 billion[277]. This resulted mainly from the energy crisis where energy prices in the EU soared and plants curtailed their production[278]. Findings from media reports also indicate that the level of gas prices is putting the competitiveness of the European chemical industry at risk. One such example is the chemical company, BASF, which announced in 2023 that by the end of 2024 it would close plants making ammonia, caprolactam, toluene diisocyanate and other key products at its Ludwigshafen complex, in Germany. Similarly, several other companies have also announced plans to close chemical capacity in Europe during 2024, citing high energy costs, weak demand and falling prices and in some cases, competition from cheaper imports.

Market analysts state that the EU's chemical industry struggled with weak demand in 2023, which resulted in chemical prices dropping further when costs were historically high. These historically high costs primarily related to energy and feedstocks, further exacerbated by heavy labour, high raw material and regulatory expenses. According to market analysts, these factors have led to the

[274] *Cefic Chemical Monthly Report. Restocking brings some relief but no serious growth in demand, 2024. Chemical-trends-monthly-report-April-2024.pdf (cefic.org)*
[275] *World chemical sales 2022, Profile, CEFIC. https://cefic.org/a-pillar-of-the-european-economy/facts-and-figures-of-the-european-chemical-industry/profile/#h-world-chemical-sales-2022-5-434-billion*
[276] *No recovery in sight in 2024 for Europe's crisis-ridden chemical industry, S&P Global, 2023. No recovery in sight in 2024 for Europe's crisis-ridden chemical industry | S&P Global Commodity Insights (spglobal.com)*
[277] *Impact of the energy crisis on the EU chemical industry, 2023, IndustriAll, European Trade Union. https://industriall-europe.eu/Article/868*
[278] *Trinomics et al. (2023). Study on energy prices and costs - Evaluating impacts on households and industry: 2023 edition.*

exposure of Europe's lack of competitiveness, most notably in the petrochemicals sector, which has resulted in several companies closing plants in the region. These findings correspond to the input from the surveyed plant, which also highlighted that the factors with the highest impact on their competitiveness were costs of energy products (including feedstock), followed by labour costs and raw materials.

The surveyed plants listed China as the biggest competitor, followed by United States and Canada. Media reports and studies indicate that non-EU competitors benefit from favourable energy subsidies. In the United States, the Inflation Reduction Act includes USD 369 billion of incentives and tax breaks applicable across sectors, including the chemicals sector[279]. Similarly in China, the domestic companies have a significant price advantage, in part because many Chinese-owned chemical companies receive hefty direct and indirect government subsidies. Examples include the Wanhua Chemical Group that received government subsidies totalling USD 91.5 million and Rongsheng Petrochemical Co. that received subsidies of USD 330 million in 2022. In addition to this, some companies are state-owned and do not have to earn as high a profit as the foreign companies[280].

Considering the cost factors and subsidies mentioned above, the surveyed plant estimated difference between its own production costs and that of competitors outside of the EU to be more than 30%.

Iron and steel

Key takeaways:

- Competitiveness of the iron and steel industry in the EU is heavily impacted by ongoing global trade tensions resulting from the war in Ukraine and tensions in the Middle East, supply chain disruptions, volatile energy markets (and energy costs) and the influence of major global steel markets such as China and India.
- Key competitors of the iron and steel industry in the EU are in China, Taiwan, Indonesia, India and Türkiye, which are estimated to have lower energy, labour and raw material costs.
- The surveyed companies in the EU estimated that their energy costs are at least 20% higher than their non-EU competitors and their total production costs between the 11 to 30%.

The findings in this section are based on the survey received from two organisation, each with one plant active in the EU iron and steel sector, complemented with insights from the European Steel Association EUROFER and public sources. This section is therefore limited to qualitative findings to ensure the data confidentiality of the participating company.

According to EUROFER, there are several key factors that determine the competitiveness of the EU iron and steel sector[281]. This includes ongoing global trade tensions resulting from the war in Ukraine and tensions in the Middle East, supply chain disruptions and volatile energy markets. Other key factors driving the competitiveness include the increasing influence of China, now considered the largest steel market in the world, ahead of the EU, along with the influence of other steel markets such as India. These international market powers contribute to price volatility for raw materials and currency dynamics in the EU. In 2023, the European crude steel production fell to historic low levels, at 126 million tonnes. This is a 7% decrease from 2022 levels and 17.5% decrease compared to 2021. Due to weak demand, 2023 had also witnessed a spike in global excess capacity, peaking at 550 million tonnes. Subsequently, the import share of crude steel market in the EU has reached historic high levels at 27%. In addition to this, EUROFER stated current trade defence instruments are insufficient to halt the flow of cheap and carbon intensive steel imports from abroad. A study on the

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[279] *European response to US cleantech incentives leaves industry and environmentalists fuming, C&EN, 2023.* https://cen.acs.org/business/European-response-US-cleantech-incentives/101/i10
[280] *How innovative is China in the Chemicals Industry? Robert D. Atkinson, Information Technology and Innovation Foundation, 2024.* https://cen.acs.org/business/European-response-US-cleantech-incentives/101/i10
[281] *EUROFER, Annual Report 2024.* https://www.eurofer.eu/publications/reports-or-studies/annual-report-2024

future outlook of the EU steel industry indicates that it remains sluggish and is subject to very high uncertainty due to high energy prices, supply chain disruptions and trade tensions in the steel sector[282].

The volatile energy prices and uncertain market conditions have contributed to some EU steelmakers having to substantially reduce production. In 2024, the steelmaker, Thyssenkrupp announced a reduction in steel output at its site in West Germany[283]. This is a step that would likely lead to roughly 13 000 layoffs. The company claimed that high energy prices and tight emission reduction regulations contributed to its decision to reduce steel output by about 2 million tonnes per year. Other reasons the company cited included increasing pressure from imports that were coming in from Asia. The surveyed plants in this study echoed the same concerns, mentioning that the energy price volatility, coupled with the increasing demand for cutting CO_2 emissions (including the taxes and levies attached to it) were constantly pushing the production cost of steel higher. Other costs that the surveyed companies mentioned as important determinants of their competitiveness are labour costs and raw material costs.

In terms of the main countries in the list of non-EU competitors, China, Taiwan, Indonesia, India and Türkiye were all listed as competitors by the surveyed companies from the steel sector. For both the respondents, China was listed as the top competitor. The surveyed companies estimated that their energy costs were at least 20% higher than these competitors outside of the EU, and their total production costs between 11% to 30% higher.

Zinc

Key takeaways:

- High energy costs have negatively impacted the competitiveness of the zinc sector in recent years, with the share of energy costs as a share of total costs estimated to be around 50% for manufacturers of zinc products.
- As a result of the soaring energy prices in the recent years, several zinc operations having to temporarily shut down and are only started to reopen again after energy prices have come down, and in some cases with government support.
- Key non-EU competitors identified by the surveyed company include Norway, Peru and Mexico.

The findings in this section are based on the survey received from one organisation with several plants active in the EU zinc sector, complemented with insights from the International Zinc Association Europe (IZA Europe) and public sources. This section is therefore limited to qualitative findings to ensure the data confidentiality of the participating company.

According to the International Zinc Association Europe (IZA Europe), high energy costs and a reduction in zinc demand in the construction and car manufacturing sectors has impacted the competitiveness of the zinc sector in recent years. This is further mentioned in a consulting report by Wood Mackenzie, which indicates that zinc demand in Europe dropped by 2% in 2022 and more than 15% in 2023, with this drop largely attributed to the reduction in demand in the construction sector. However, in terms of growth, estimates indicate that there is an expectation to see a modest growth rate of 2–3% in 2024. In addition to these findings, regarding zinc concentrates, a drop of 300 t/y of the import volume (30%) was seen over the period 2020–2023[284].

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[282] *The future of the European steel industry, Mckinsey, 2021. https://www.mckinsey.com/~/media/mckinsey/industries/metals%20and%20mining/our%20insights/the%20future%20of%20the%20european%20steel%20industry/the-future-of-the-european-steel-industry_vf.pdf*

[283] *Energy costs, regulation see drastic steel output reduction at German factory – Thyssenkrupp. https://www.cleanenergywire.org/news/energy-costs-regulation-see-drastic-steel-output-reduction-german-factory-thyssenkrupp*

[284] *Global Zinc Strategic Planning Outlook Q1 2024, Wood Mackenzie. https://www.woodmac.com/reports/metals-global-zinc-strategic-planning-outlook-q1-2024-150238256/*

The impact of energy costs represents a very significant share of the total costs of the zinc sector, with research reports in 2023 indicating that the share of energy costs, as a share of total costs is around 50% for manufacturers of zinc products, making it one of the most energy intensive industries in the EU[285]. According to media reports, there are several examples of zinc *Mining* and power plant operations having to temporarily shut down in recent years. One such example is Tara Mines, one of the biggest operational zinc mines in the world (located in Ireland), that temporarily shut down in 2023, due to elevated energy costs and a fall in global zinc prices[286]. However, the mines are now reopening with significant organisational changes, including reduced employment. The ramp up of production is expected to start during the third quarter of 2024 and full production expected from January 2025[287]. Another such example is Glencore's zinc smelter in Nordenham, Germany which shut down temporarily between November 2022 to March 2024 due to high energy costs. Media reports indicate that the plant restarted recently but likely at a reduced capacity[288]. Similarly, Nyrstar's plant operations in Budel, Netherlands were put under 'care and maintenance' temporarily stopping production for a period of four months in 2024. The halt in operations was largely in response to ongoing and projected high energy costs, challenging market conditions and the Dutch government's cessation of support measures for energy intensive industries. Nyrstar has now decided to restart operations in Budel at a reduced capacity from May onwards, because of improved market conditions and a temporary cost relief from the Dutch government[289]. According to media reports, industry experts indicate that for highly energy intensive operations, such as electrified zinc smelters, access to low-cost renewable sources of energy and LNG is extremely important. However, certain industry analysts also say that the availability of renewable energy for zinc smelting and production at present is limited and is not an option in the EU[290]. A respondent of the questionnaire representing the EU zinc sector, suggested that the standardisation of available instruments across the EU for sourcing renewable energy would help to keep energy costs low enough to be able to compete with similar industries outside of Europe. According to them, keeping these costs low would help to keep operations economically viable and enable ongoing investments in further increasing its sustainability of operations.

In terms of the main countries in the list of non-EU competitors, Norway was listed as the highest competitor for the surveyed company, followed by Peru and Mexico. No information on estimates of differences in energy or production costs between the surveyed company and its non-EU competitor was mentioned.

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[285] *Rust belt relics or future keystone? EU policy for energy intensive industries, Philipp Jäger, Jacques Delors Centre, 2023.* https://www.delorscentre.eu/en/publications/energy-intensive-industries
[286] *Tara Mines 'will have to close' permanently if it can't reopen profitably, warns owner's CEO, Irish Independent, February 2024.* https://www.independent.ie/business/irish/tara-mines-will-have-to-close-permanently-if-it-cant-reopen-profitably-warns-owners-ceo/a27057704.html
[287] *Boliden inks deal to reopen Tara in major boost for Irish mining, International Mining, May 2024.* https://im-mining.com/2024/05/09/boliden-inks-deal-to-reopen-tara-in-major-boost-for-irish-mining/#:~:text=Employees%20will%20commence%20their%20return,is%20expected%20from%20January%202025.
[288] *Glencore's Nordenham zinc smelter starts ramping up production, Mining.com, March 2024.* https://www.mining.com/web/glencores-nordenham-zinc-smelter-starts-ramping-up-output/#:~:text=Nordenham%20in%20Germany%20halted%20production,prices%20after%20Russia%20invaded%20Ukraine
[289] *Nyrstar plans to restart zinc production at Dutch smelter in May, Chemanalyst.com, May 2024.* https://www.chemanalyst.com/NewsAndDeals/NewsDetails/nyrstar-plans-to-restart-zinc-production-at-dutch-smelter-in-may-27629
[290] *High energy costs are pushing zinc smelters to the brink, Business Insider, 2022.* https://markets.businessinsider.com/news/stocks/high-energy-costs-are-pushing-zinc-smelters-to-the-brink-1031210750

Automotive industry

Key takeaways:

- Energy costs shares in the EU's automotive industry are relatively low, with average share of energy costs in the total production costs of 0.3–0.4% between 2014–2021.
- The direct impact of energy costs on the competitiveness of the EU car manufacturing industry is limited, but energy costs could still have a significant indirect impact of their competitiveness with 70% of all energy consumption attributed to the preceding *Mining* and material production step.

The findings in this section are based on aggregated statistical information that was only available up to 2021, complemented with insights from literature.

Energy costs only constitute a small share of the total production costs of the European automotive industry. Between 2014 and 2021, the overall EU average share of energy costs in the total production costs was 0.3–0.4%. This indicates that energy costs were not a driving factor of the EU's automotive industry in those years. Figure 120 shows the energy costs shares for the sector Manufacture of motor vehicles in different Member States over time (in the Member States for which sufficient data was available). The average values over the selected period between 2014 and 2021 show significant variation between 0.1% (in Italy) and 6% (in Latvia). The overall EU average is comparable to peer competitors like the US (0.3%) and the UK (0.4%).

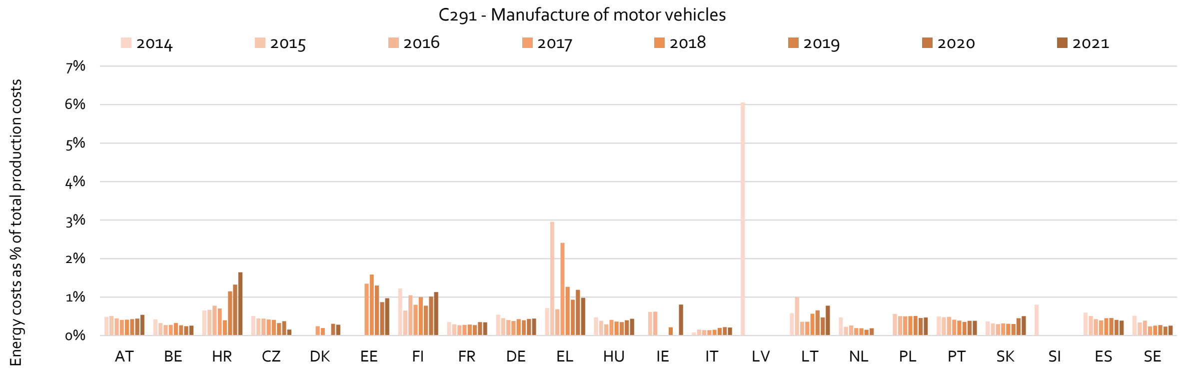

Figure 120: Energy costs as share of total production costs in the automotive industry by EU Member State

Source: Own calculations based on data from Eurostat SBS

Figure 120 shows that the energy costs share in the different MS fluctuate over the years, but overall remain relatively stable. Energy intensity improvements in the EU automotive industry have been limited over the years, with a less than 6% reduction in energy consumption per car produced between 2005 and 2022[291]. The manufacturing of increasingly sophisticated systems (due to improved safety, comfort, etc.) means that by 2022 the production of one vehicle still requires 2.71 MWh of energy – down from 2.88 MWh in 2005, over the European manufacturing chain – accounting for the assembly of vehicles itself only. The UK shows similar trend with very little efficiency improvement (from 2.3 MWh in 2005 to 2.1 MWh energy used per vehicle produced in 2017)[292].

The overall energy consumption of the sector in Europe declined much more significantly. Energy consumption in the sector has decreased by more than 30% in the past (almost) two decades – from 33 million MWh/year in 2005 to 23 million MWh/year in 2022[293]. This corresponds to an overall decline

[291] ACEA (2023). Energy consumption during car production in the EU
[292] Giampierie et al., (2020). A review of the current automotive manufacturing practice from an energy perspective
[293] ACEA (2023). Energy consumption during car production in the EU

in European production[294]. Notably, the EU share in global car production has been decreasing for more than decade and in the recent years has dropped behind China as the largest car producing region[295].

While the energy consumption in vehicle production is limited, most energy use precedes the assembly and is attributed to the *Mining* and material production[296]. Steel makes up about half of the material composition of a vehicle, followed by aluminium and plastics with each about 13%. The production of these materials are all energy-intensive processes as can be observed in Section 5.6. This is also reflected in the total energy consumption throughout the value chain of car manufacturing: 70% of all energy consumption takes place in *Mining* and material production step, increasing the energy cost of producing one vehicle to about 15 MWh per vehicle altogether. Parts production accounts for another 20%, and the vehicle assembly itself represents only about 10-15% of the total energy consumed in the production of vehicles. While the direct impact of energy costs on the competitiveness of the EU car manufacturing industry is limited as shown in the low energy costs shares, energy costs could still have a significant indirect impact of their competitiveness via costs of energy-intensive materials.

Batteries

Key takeaways:

- Energy costs shares in the EU's batteries manufacturing sector are relatively low, with average share of energy costs in the total production costs of 1.2–1.5% between 2014–2021.
- The direct impact of energy costs on the competitiveness of the EU battery manufacturing industry is limited with energy costs being less than 5% of the total production costs over the lifecycle of a battery. Negative impacts on energy costs would therefore only manifest itself indirectly via material costs.

The findings in this section are based on aggregated statistical information that was only available up to 2021, complemented with insights from literature.

The energy costs constitute about 1–8% share of the overall production costs of batteries in the EU. Figure 121 shows the relationship between energy costs over the years in different EU Member States as a share of total production costs in sector Manufacture of batteries and accumulators. The average values show great variation between Member States, with the average energy cost share between 2014 and 2021 going as low as 0.05% (Denmark) and getting as high as 7.7% (Croatia). The EU average energy cost shares showed a decreasing trend over the past years, changing from 1.5% to 1.2% between 2014 and 2021.

[294] ACEA (2023). Energy consumption during car production in the EU
[295] ACEA (2023). The automobile industry
[296] Sato and Nakata (2020). Composition of a standard internal combustion engine passenger vehicle.

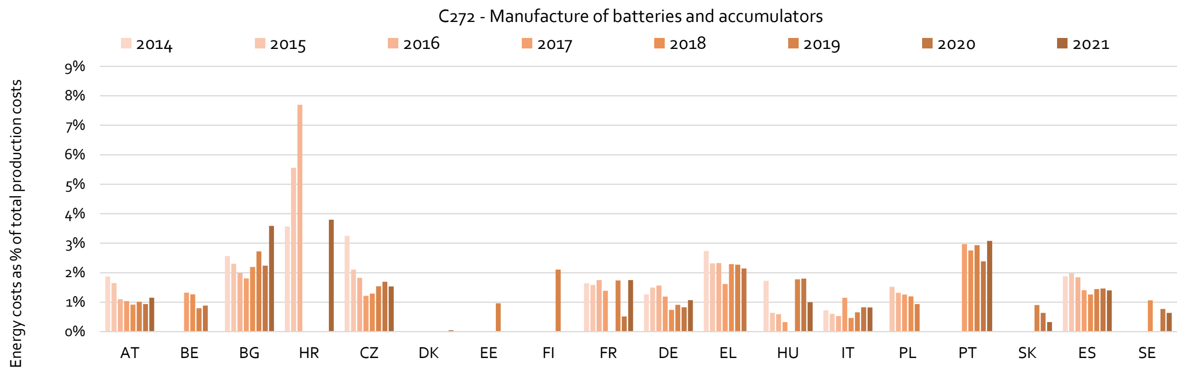

Figure 121: Energy costs as share of total production costs in the battery and accumulator industry by Member State

Source: Own calculations based on data from Eurostat SBS

Overall, the energy costs of battery manufacturing show a significant increase in the 2014-2021 period in Europe, from EUR 113 million to EUR 174 million, with Germany being the largest consumer, responsible for more than 33% of this. However, the increase in energy costs have been outpaced by the production value rising from EUR 5 to 12 billion in the same period[297]. This indicates that the growing EU production is the key driver of the growth in energy costs in the sector.

The estimates of energy use in the battery cell manufacturing shows significant variations. Depending on the technology, utilisation, etc. the amount of energy required to produce 1 kWh of cell storage capacity ranges from 10.6 kWh to 37.5 kWh overall[298]. Other estimations from literature show that the manufacturing alone (excluding the *Mining* and processing of materials) can cost 40-65 kWh of energy per 1 kWh of storage capacity[299,300]. The largest amount of energy is consumed for the coating (about 25%), drying (another 25%) and formation processes– these three steps accounting to about 75% of energy used altogether[301]. However, energy costs only constitute a small proportion of the total production costs. One study estimates that over the whole lifecycle of a battery, energy costs are estimated to be less than 5% of the total costs[302]. The majority of the costs (about 70%) relate to material costs. The direct impact of energy costs on the competitiveness of batteries therefore appears limited and may mainly manifest itself indirectly via material costs.

5.4. Energy costs and their impact at macroeconomic level

This section provides a summary of the overall impact of energy costs on the EU economy and its Member States, in terms of the share of energy costs in the total production costs in each Member State for the sectors for which data is available. Hence, the impact of energy costs on the competitiveness of EU industries is estimated through this parameter. Measuring this share can shed light on the impact changes to energy prices would have to the production costs of industries, and more broadly, to the EU economy.

[297] *Based on Eurostat Structural Business Statistics for C272 – Manufacture of batteries and accumulators.*
[298] *Degen et al., (2023). Energy consumption of current and future production of lithium-ion and post lithium-ion battery cells*
[299] *Kurland (2019). Energy use for GWh-scale lithium-ion battery production*
[300] *Degen and Schutte (2022). Life cycle assessment of the energy consumption and GHG emissions of state-of-the-art automotive battery cell production*
[301] *Degen and Schutte (2022). Life cycle assessment of the energy consumption and GHG emissions of state-of-the-art automotive battery cell production*
[302] *Gutsch and Leker (2024). Costs, carbon footprint, and environmental impacts of lithium-ion batteries – From cathode active material synthesis to cell manufacturing and recycling*

5.4.1. Methodology

The calculations of energy cost shares depend on three variables based on available parameters in Eurostat: *Purchases of energy products*[303] as a proxy for *total energy costs*, and the sum of *personnel costs*[304] and *purchases of goods and services*[305] serves as proxy for *production costs*. Expressed in formula form:

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

For the majority of data to analyse the energy costs, including data from Eurostat, the latest available year is 2021. The results for the indicators with figures are therefore shown from 2015 until 2021. Thus, the results capture the impacts of COVID-19, but not the energy crisis. To at least show these recent impacts for the most energy-intensive sectors, these have been explored in the findings of the bottom-up approach in Section 5.3.

Available data in 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*) of NACE Rev. 2, based on the Statistical classification of economic activities. NACE sector F encompasses *Construction*.

The energy cost shares could not be calculated for the services sectors (NACE sectors G to N) because Eurostat does not contain 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 with Eurostat. For this reason, some qualitative insights of energy costs related to the service sectors is provided at the end of this subsection. Moreover, the limitations inherent to the chosen approach and data sources are listed as specific annotations attached to the data presented in the figures.

5.4.2. Results

Key takeaways:

- Energy cost shares in production costs for industry and construction have declined in most Member States for which data is available, although there is a noticeable increase in 2021, coinciding with soaring energy prices.
- This decreasing trend over time is particularly noticeable in Estonia, Romania, Sweden and Finland. Whereas, in Czechia, there has been a sharp increase in energy cost shares during the same period.
- When looking at manufacturing sectors exclusively, the energy cost shares are highest in Luxembourg and Latvia, while in Ireland, Italy and Denmark, energy cost shares remained relatively low.

[303] *Based on the definition of the Commission Implementing Regulation (EU) 2020/1197), the Structural Business Statistics (SBS) 240105 includes only energy products which are purchased to be used as a fuel. Energy products purchased as a raw material (feedstock) or for resale without transformation (such as crude oil) are excluded. Self-consumption of energy is also not captured.*

[304] *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.*

[305] *Based on Eurostat's definition, this includes 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).*

Figure 122 shows the evolution of the energy-related cost share of production costs for industry and construction. To allow for an equal comparison between countries and years, values are only shown if sufficient data was available for the entire industry and construction 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. While the available values in the figure vary significantly across Member States, overall, most Member States show a decreasing trend over time, though there is a noticeable increase in 2021 for several Member States. This increase coincides with the soaring energy prices that started in 2021.

The decreasing trend in energy cost shares is observed in Estonia (from 4.6% to 3.5% for 2014–2021). For other countries, such as Romania, Sweden and Finland, this trend is also seen, but less profound. On the other hand, most notably is Czechia, where energy cost shares increased sharply from 2018 up until now. Czechia also shows relative higher energy costs shares than 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.

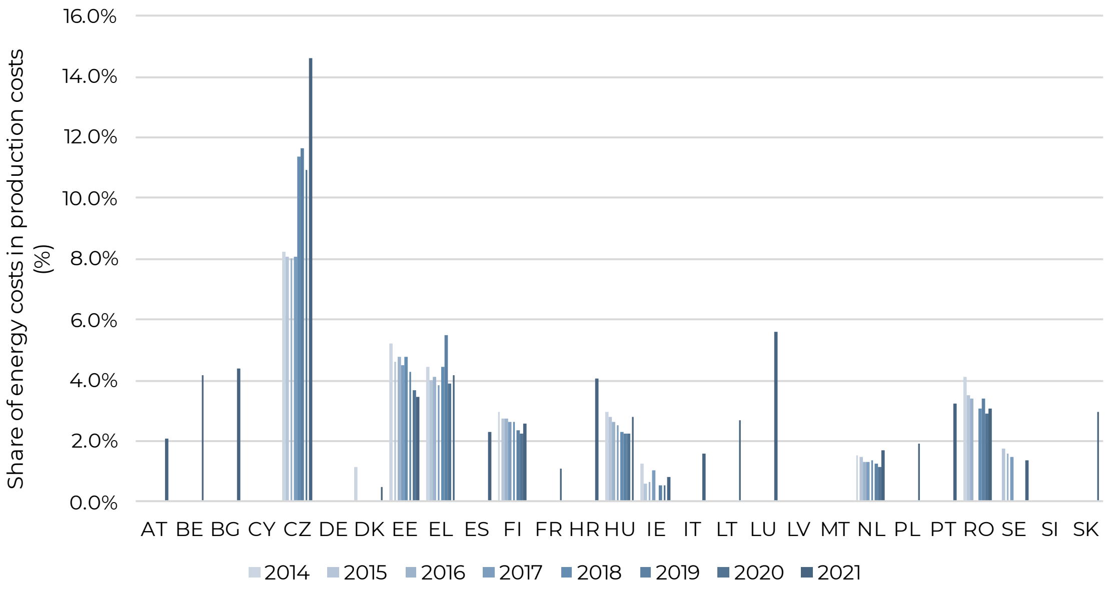

Figure 122: Evolution of energy cost shares in production costs, industry and construction, per EU Member State[306]

The chart in Figure 123 displays the cost shares of production costs in the manufacturing sector across the EU. There is a downward trend from 2014 to 2020 in most EU countries, with a notable increase in 2021. This change reflects the impact of the energy crisis, which resulted in escalated prices and subsequently influenced the production cost dynamics within the sector. When analysing the data for 2021, Luxembourg has the highest energy cost shares in production costs, surpassing 10%, followed by Latvia. The lowest energy cost shares are observed in Ireland, followed by Italy and Denmark, staying below 1%.

306 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 (CY, DE, LV, MT, SI). Because of the substantial lack of data, an EU average of the energy cost shares has also not been calculated.

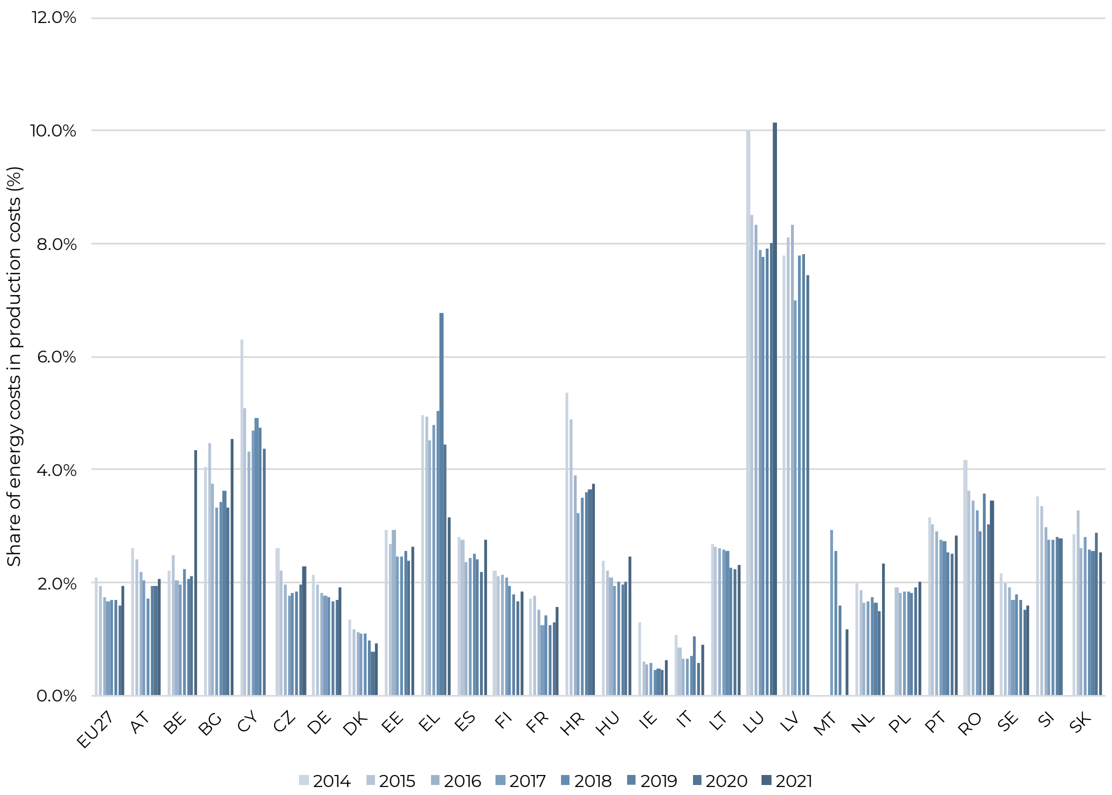

Figure 123: Evolution of energy costs shares in production costs for the manufacturing sector (NACE Sector C) per EU Member State.[307]

Energy cost shares could not be calculated for the service sectors due to the absence of any data on Eurostat concerning purchase of energy products in these sectors. Nonetheless, services play an important and growing role in the EU economy, and therefore also constitute a significant sector of energy demand. This is particularly the case in the EU which, like most developed economies, have in the past decades shifted from an industry-based economy to one increasingly based on services. This resulted in an increase in energy consumption in the EU service sectors. Eurostat reported that, out of all energy demand of the EU in 2021, 9.1% went to service sectors, therefore representing a significant share of all EU energy demand[308]. At the same time, there has been a strong drive for energy efficiency and reduction of energy consumption in the EU, including in service sectors.

5.5. 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.

5.5.1. Methodology

This analysis examines the extent to which energy costs contribute to the total production expenses for industries in the EU. To provide a comprehensive overview, two different methods are being employed. The first method involves collecting plant-specific data through questionnaires to take a bottom-up approach, with the results presented in Section 5.3. The second approach involves using aggregated statistical data to take a top-down perspective presented in this section.

[307] Note: The energy costs shares for Malta could not be calculated for several years primarily due to the lack of data on the purchases of goods and services and personnel costs in Eurostat.
[308] Based on Eurostat (2022). Energy statistics – an overview. Available at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview#Final_energy_consumption.

Data collected from individual plants provides a closer view of what makes each segment of the industry unique. However, obtaining this data poses challenges, particularly having a sufficient number of plants providing data that accurately represent each segment of the industry. The analysis of the aggregated statistical data is therefore used to complement the findings from the plant-specific data for other industry sectors. The aggregated statistical data is also used to put the findings in a broader perspective of long-term trends.

Sectoral coverage

The analysis of energy costs focuses on manufacturing sectors while also including relevant sectors like agriculture, extractive industries and services. Table 15 provides an overview of the manufacturing (NACE code C) and non-manufacturing sectors covered. **In total, 45 sectors were analysed using combined statistical data.** This report mainly concentrated on EU energy intensive industry sectors with the highest energy cost shares and facing significant levels of international competition. Additionally, Table 15 also indicates the subsectors that were analysed using plant-level data in Section 5.3. :

- The sectors *Aluminium, Ferro-alloys (& Silicon)* and *Flat glass* provided data for a representative plant level analysis;
- The sectors *Mining, Pulp & Paper* and *Refineries* provided data for a limited analysis, but insufficient to be representative of their sectors;
- The sectors *Basic organic chemicals and plastics in primary form, Ceramics, Fertilisers, Iron and steel* and *Zinc* provided data and/or information, but insufficient to show quantitative results and only qualitative findings can be presented;
- The sectors *Cement*, *Copper*, *Data centres, Hollow/container glass, Hydrogen*, *Lime*, *Mineral wool, Solar photovoltaics, Wind turbines* were also contacted but were unable to provide any data or qualitative information.

Table 15: Coverage of sectors in the manufacturing and non-manufacturing sector

Sectors analysed with aggregated statistical data		**Sectors analysed using plant level data**	
NACE	**Sector description**	**NACE**	**Sector description**
Manufacturing sectors			
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	***C171***	***Manufacture of pulp, paper and paperboard***
C172	Manufacture of articles of paper and paperboard		
C192	Manufacture of refined petroleum products	***C192***	***Manufacture of refined petroleum products***
C201	Manufacture of basic chemicals, *Fertilisers* and nitrogen compounds, plastics and synthetic rubber in primary forms	*C2014, C2016*	*Manufacture of other basic organic chemicals and plastics in primary form*
		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		
C231	Manufacture of glass and glass products	**C2311**	**Manufacture of *Flat 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		

Sectors analysed with aggregated statistical data		Sectors analysed using plant level data	
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		
C272	Manufacture of batteries		
C28	Manufacture of machinery and equipment n.e.c.		
C29	Manufacture of motor vehicles, trailers and semi-trailers		
C291	Manufacture of motor vehicles		
C30	Manufacture of other transport equipment		
C32	Other manufacturing		
C33	Repair and installation of machinery and equipment		
Non-manufacturing sectors			
A	Agriculture, forestry and fishing		
B	*Mining* and quarrying	***B***	***Mining and quarrying***
B06	Extraction of crude petroleum and natural gas		
B07	*Mining* of metal ores		
B08	Other *Mining* and quarrying		
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		

Note: For the sectors listed in bold only, sufficient plants provided data to provide results representative of the sector. For the sectors in italic and bold, insufficient plants responded to the questionnaire to be representative of the sector and only limited quantitative findings can be presented. For the sectors listed in italics only, insufficient plants provided data to show quantitative results and only qualitative findings could be presented. Shaded sectors are the most energy-intensive manufacturing sectors.
**The sectors analysed are a subsector of the NACE code mentioned. This is Fertilisers for C2015, ferroalloys for C2410, and Zinc for C2443.*

Data sources used

Eurostat was used as the main source of aggregated statistical data for analysing energy costs. The analysis was further supplemented with data obtained from national statistics, industry associations, paid sources, and other international institutions. The data extracted from Eurostat and other institutions for the analysis included[309] [310]:

- **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, Türkiye;
- **Eurostat Energy Balances** provides data on Energy Consumption per fuel type in the sector of Agriculture, forestry and fishing, Construction, *Mining* and quarrying, Land transport and

[309] *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.*
[310] *Data from public sources was extracted from March to May 2024.*

transport via pipelines and two manufacturing sectors (Manufacture of basic precious and other non-ferrous metals, Manufacture of machinery and equipment n.e.c.)[311] for EU countries, Norway and Türkiye;
- **IEA World Energy Balances** provides data on Energy Consumption per fuel type across several non-EU G20 countries;
- **Odyssee (by Enerdata)** provides data on Energy Consumption per fuel type 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 has been complemented with data from the following national databases[312]:

- The **US Bureau of Economic Analysis (BEA)** provides data on Turnover, Value added and Personnel Costs for the United States of America;
- 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 Energy Security & Net Zero, 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 type.

Data from publicly available sources has been further complemented with the following sources:

- Data received from the **Confederation of European Paper Industries (CEPI)** on Energy Consumption per fuel type in the *Pulp and paper* sector (NACE 3 level) of several EU Member States received for previous editions of this report;
- **S&Ps 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.

Data gap management

Despite the efforts made, there were still some gaps in the available data. To address these gaps, a variety of strategies were employed in order to minimise their impact on the analysis. The following approaches were taken to bridge these gaps:

- Where **energy costs** (purchases of energy) data is unavailable, but energy consumption and price data is available, energy costs (purchases of energy) are calculated as energy consumption multiplied by prices.
- **Energy consumption** is calculated by dividing the energy costs by energy prices per fuel type. Where the energy cost per energy carrier type is not available, the historical average

[311] *Not elsewhere classified*
[312] *Where necessary, monetary values have been converted to Euros with the exchange rates of the European Central Bank*

energy mix is used to determine the weighted average energy price to estimate the total energy consumption.

- 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 for a typical consumer was 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. The consumption bands are based on data from 2017–2022[313].

The allocation of the consumption bands to each sector are provided in **Error! Reference source not found.**Table 16 for electricity and gas. The corresponding consumption bands are given listed in Box E.

Box E: Annual consumption bands for electricity and gas as defined by Eurostat

For electricity prices of non-households:
Band IA: annual consumption below 20 MWh
Band IB: annual consumption between 20 and 499 MWh
Band IC: annual consumption between 500 and 1 999 MWh
Band ID: annual consumption between 2 000 and 19 999 MWh
Band IE: annual consumption between 20 000 and 69 999 MWh
Band IF: annual consumption between 70 000 and 149 999 MWh
Band IG: annual consumption above 150 000 MWh

For gas prices of non-households:
Band I1: annual consumption below 1 000 GJ
Band I2: annual consumption between 1 000 and 9 999 GJ
Band I3: annual consumption between 10 000 and 99 999 GJ
Band I4: annual consumption between 100 000 and 999 999 GJ
Band I5: annual consumption between 1 000 000 and 3 999 999 GJ
Band I6: annual consumption above 4 000 000 GJ

Table 16: Allocation of Eurostat electricity and gas consumption band to sectors

Sector	Eurostat electricity consumption band	Eurostat gas consumption band
Manufacturing sectors		
C10 – Manufacture of food products	ID	I3
C103 - Processing and preserving of fruit and vegetables	ID	I3
C106 - Manufacture of grain mill products, starches and starch products	IE	I3
C11 - Manufacture of beverages	ID	I3
C12 - Manufacture of tobacco products	ID	I3
C13 - Manufacture of textiles	ID	I3
C132 - Weaving of textiles	ID	I3
C14 - Manufacture of wearing apparel	IB	I2
C15 - Manufacture of leather and related products	IC	I2
C16 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	IE	I4
C161 - Sawmilling and planing of wood	ID	I3

[313] *By using the average of 2017-2022, the impact of COVID-19 on the allocation of consumption bands is mitigated while based on the most recently available data.*

Sector	Eurostat electricity consumption band	Eurostat gas consumption band
C17 - Manufacture of paper and paper products	IE	I3
C171 - Manufacture of pulp, paper and paperboard	IG	I4
C172 - Manufacture of articles of paper and paperboard	ID	I3
C18 - Printing and reproduction of recorded media	ID	I2
C19 - Manufacture of coke and refined petroleum products	IF	I4
C192 - Manufacture of refined petroleum products	IG	I4
C20 - Manufacture of chemicals and chemical products	IE	I3
C201 - Manufacture of basic chemicals, *Fertilisers* and nitrogen compounds, plastics and synthetic rubber in primary forms	ID	I3
C206 - Manufacture of man-made fibres	ID	I2
C21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations	ID	I3
C22 - Manufacture of rubber and plastic products	ID	I3
C222 - Manufacture of plastics products	ID	I3
C23 - Manufacture of other non-metallic mineral products	ID	I3
C231 - Manufacture of glass and glass products	ID	I3
C232 - Manufacture of refractory products	ID	I3
C233 - Manufacture of clay building materials	ID	I3
C234 - Manufacture of other porcelain and ceramic products	ID	I3
C235 - Manufacture of cement, lime and plaster	IF	I4
C236 - Manufacture of articles of concrete, cement and plaster	ID	I3
C237 - Cutting, shaping and finishing of stone	ID	I3
C239 - Manufacture of abrasive products and non-metallic mineral products n.e.c.	IE	I4
C241 - Manufacture of basic iron and steel and of ferro-alloys	IG	I5
C244 - Manufacture of basic precious and other non-ferrous metals	IF	I4
C245 - Casting of metals	ID	I3
C25 - Manufacture of fabricated metal products, except machinery and equipment	IC	I2
C26 - Manufacture of computer, electronic and optical products	ID	I2
C27 - Manufacture of electrical equipment	ID	I3
C272 – Manufacture of batteries and accumulators (*same as C27*)	ID	I3
C28 - Manufacture of machinery and equipment n.e.c.	ID	I3
C29 - Manufacture of motor vehicles, trailers and semi-trailers	ID	I3
C291 - Manufacture of motor vehicles	ID	I3
C30 - Manufacture of other transport equipment	ID	I2
C31 - Manufacture of furniture	IC	I2
C32 - Other manufacturing	ID	I2
C33 - Repair and installation of machinery and equipment	IC	I2
Non-manufacturing sectors		
A - Agriculture, forestry and fishing	IB	N/A
B - *Mining* and quarrying	ID	I3
B06 - Extraction of crude petroleum and natural gas	IF	I4
B07 - *Mining* of metal ores	IG	I4
B08 - Other *Mining* and quarrying	ID	I3
D35 - Electricity, gas, steam and air conditioning supply	IE	I4
E38 - Waste collection, treatment and disposal activities; materials recovery	ID	I3
F - Construction	IC	I2
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	IC	I2
H - Transportation and storage	IC	I2

Sector	Eurostat electricity consumption band	Eurostat gas consumption band
H49 - Land transport and transport via pipelines	IC	I2
H51 - Air transport	ID	I2
I - Accommodation and food service activities	IC	I2
J - Information and communication	IC	I2
J63 - Information service activities (*same as J*)	IC	I2

Note: Air transport excluded as non-relevant for electricity and gas consumption

5.5.2. Energy cost shares

Key takeaways:

- Between 2014 and 2021, energy expenses for most manufacturing sectors ranged from 1% to 10% of total production costs. However, two sectors had costs that exceeded 10% throughout the period: The *Cement, lime and plaster* sector has had fairly consistently high costs shares above 10%, while the *Clay Building* sector only exceeded the 10% threshold in 2014 and 2015.
- Between 2014 and 2019, the percentage of manufacturing costs related to energy decreased in almost all sectors, including energy-intensive industries like *Cement, lime and plaster*, *Clay building materials*, and *Iron and steel*. In 2021, an upward trend in energy cost shares can be observed in these same sectors.
- In the non-manufacturing sectors, it was found that the share of energy costs is particularly high in five sectors. In fact, the energy cost shares in these sectors are comparable to, or even exceed, those of energy-intensive manufacturing sectors. The five sectors are *Air transport*, *Electricity, gas & steam*, *Land transport*, *Mining of metal ores* and *Other Mining*.
- Energy cost shares show a decreasing trend for most non-manufacturing sectors over 2014–2021 except for *Accommodation and restaurants, Air transport, Construction*, *Land transport* and *Mining of metal ores*. In these sectors, an increase in energy cost shares can be seen in certain years, especially in the year 2021.

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 5.4. , energy cost shares are calculated by dividing the purchases of energy by total production costs[314].

It is crucial to bear in mind that the results presented here may underestimate the true impact of energy costs, particularly within industrial segments where significant amounts of consumption of self-produced energy and use of waste products for energy are utilised. This is especially relevant to energy intensive industries such as Chemicals, Iron and steel, Non-ferrous metals, *Pulp and paper*, and *Refineries*. Moreover, the aggregated data provides only sectoral averages, with highly energy-intensive primary producers grouped together with low-intensive secondary products. Therefore, the analysis of plant-level data in Section 5.3. and in previous editions of this study should be viewed 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.

[314] *The consumption of self-produced energy and use of waste products for energy are not included in the energy costs shares shown in the results. Results may be an underestimation of the impact of energy costs. 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.*

Table 17 provides a summary of energy cost shares over time for all sectors included in the study. It outlines the changes observed during the period 2014-2021. Additionally, the table includes the average rate, maximum, and minimum level attained, demonstrating the variability of cost shares over the years.

The findings from Table 17 are visualised in Figure 124, focusing on manufacturing sectors within the EU. This graph illustrates the proportion of energy costs relative to total production costs for subsectors categorise under NACE code C *Manufacturing* from 2014 to 2021. Highlights from the figure are:

- Energy costs typically comprised **1-10% of total operational production costs**, with sectors experiencing costs exceeding 10%; these are *Cement, lime and plaster* along with *Clay building materials* in certain years.
- Energy costs for **several energy-intensive sectors surpassed 5% of their total production costs** in at least one year. This trend is notable in sectors such as *Pulp and paper*, *Basic chemicals*, *Man-made fibres*, *Glass*, *Clay building materials*, *Cement, lime and plaster* and *Iron and steel*. This indicates that these sectors are relatively sensitive to energy prices and cost differentials.
- Energy costs typically represent **less than 3% of production costs among sectors with lower energy intensity**, making them a relatively minor cost component for most businesses in these industries. Sectors such as *Fruit and vegetables*, *Beverages*, *Refineries*, *Pharmaceutical products* and *Fabricated metal products* generally have energy cost shares ranging between 1 and 3%. In several manufacturing sectors, such as *Computer and electronics*, *Motor vehicles*, *Other transport equipment*, and *Other manufacturing* do not exceed 1% of production costs.
- During this period, **initially a downward trend can be observed. However, in 2021, there is again an upward trend, indicating greater exposure to energy price increases in this year**[315]. The sectors where this downward trend followed by an increase in 2021 can be observed clearly are: *Fruit and vegetables*, *Grain products*, *Pulp and paper*, *Articles of paper*, *Basic chemicals*, *Man-made fibres*, *Glass*, *Refractory products*, *Clay building materials*, *Cement, lime and plaster* and *Abrasive products*.

The findings from the analysis for non-manufacturing sectors are illustrated in Figure 125. Energy cost shares stand out notably high in five non-manufacturing sectors, reaching levels comparable to or even exceeding those of energy-intensive manufacturing sectors. These sectors comprise *Land transport*, *Air transport*, *Electricity, gas and steam*, *Mining of metal ores* and *Other Mining*. Fuel costs evidently play a significant role in production costs within the transport and energy generation sectors, while *Mining* inherently entails high energy consumption. In 2021, energy costs shares particularly increased in the following sectors: *Accommodation and restaurants, Air transport, Construction*, *Land transport* and *Mining of metal ores*.

[315] *Note that in theory the energy cost share can also increase due to a decrease in production costs. However, this does not seem likely the cause of this observation, as material and labour costs have increased in the past few years (Eurostat, SBS_NA_IND_R2).*

Table 17: Energy costs as shares of total production costs for all sectors studied averaged across the EU

Manufacturing sectors (NACE C)	2014	2015	2016	2017	2018	2019	2020	2021	Average	Max. level	Absolute change 2014-2021	Relative change 2014-2021
C103 - Fruit and vegetables	2.7%	2.4%	2.3%	2.1%	2.2%	2.1%	2.1%	2.3%	2.3%	2.7%	-0.5%	-16.8%
C106 - Grain products	3.7%	3.3%	2.9%	2.4%	2.6%	2.5%	2.2%	2.6%	2.8%	3.7%	-1.2%	-31.4%
C11 - Beverages	1.6%	1.6%	1.5%	1.2%	1.4%	1.4%	1.3%	1.3%	1.4%	1.6%	-0.3%	-20.5%
C132 - Weaving of Textiles	2.0%	1.9%	1.9%	2.0%	1.7%	1.7%	2.0%	2.1%	1.9%	2.1%	+0.0%	+2.4%
C161 - Sawmills	3.0%	2.7%	2.8%	2.7%	2.5%	2.6%	2.6%	2.1%	2.6%	3.0%	-0.9%	-29.8%
C171 - *Pulp and paper*	8.8%	7.6%	6.3%	5.9%	5.9%	5.9%	5.2%	6.7%	6.5%	8.8%	-2.1%	-24.3%
C172 - Articles of paper	2.3%	2.2%	2.0%	2.0%	2.5%	2.3%	2.0%	2.7%	2.3%	2.7%	+0.4%	+18.7%
C192 - *Refineries*	1.0%	1.0%	1.1%	1.6%	1.1%	1.8%	1.7%	1.5%	1.3%	1.8%	+0.5%	+52.4%
C201 - Basic chemicals	5.3%	5.1%	4.7%	4.2%	4.5%	4.1%	4.3%	7.0%	4.9%	7.0%	+1.7%	+31.5%
C206 - Man-made fibres	5.3%	5.3%	6.2%	4.6%	5.2%	4.8%	5.5%	6.1%	5.4%	6.2%	+0.8%	+14.7%
C21 - Pharmaceutical products	0.9%	0.8%	0.8%	0.7%	0.6%	0.7%	0.6%	0.6%	0.7%	0.9%	-0.3%	-30.8%
C222 - Plastics products	2.4%	2.3%	2.1%	2.0%	2.0%	2.1%	2.1%	2.0%	2.1%	2.4%	-0.4%	-16.8%
C231 - Glass	8.1%	7.3%	6.1%	5.6%	5.8%	5.2%	5.0%	6.6%	6.2%	8.1%	-1.5%	-18.5%
C232 - Refractory products	5.1%	5.1%	5.2%	4.4%	2.8%	4.0%	4.2%	5.3%	4.5%	5.3%	+0.2%	+3.5%
C233 - Clay building materials	10.3%	10.0%	8.4%	7.7%	7.5%	7.7%	6.9%	8.1%	8.3%	10.3%	-2.2%	-21.2%
C234 - Porcelain and ceramics	4.3%	4.2%	4.1%	3.8%	4.1%	4.1%	4.3%	3.9%	4.1%	4.3%	-0.4%	-9.1%
C235 - Cement. lime and plaster	15.8%	13.4%	11.5%	10.8%	11.4%	10.6%	9.0%	10.2%	11.6%	15.8%	-5.5%	-35.0%
C237 - Stone	2.8%	3.2%	2.5%	3.0%	3.0%	3.1%	2.6%	2.4%	2.8%	3.2%	-0.3%	-11.8%
C239 - Abrasive products	4.9%	4.4%	4.4%	4.1%	3.8%	3.9%	4.0%	4.7%	4.3%	4.9%	-0.2%	-4.1%
C241 - Iron and steel	6.8%	6.9%	6.6%	6.0%	5.8%	6.2%	6.2%	5.4%	6.2%	6.9%	-1.5%	-21.8%
C244 - Non-ferrous metals	3.9%	3.8%	3.2%	3.2%	3.2%	3.2%	3.0%	2.8%	3.3%	3.9%	-1.1%	-28.6%
C245 - Casting of metal	5.1%	4.8%	4.6%	4.2%	4.0%	4.1%	4.5%	4.2%	4.4%	5.1%	-0.9%	-17.6%
C25 - Fabricated metal products	1.7%	1.6%	1.5%	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%	1.7%	-0.3%	-18.9%
C26 - Computer and electronics	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%	0.6%	0.5%	0.5%	0.6%	-0.0%	-7.5%
C27 - Electrical equipment	1.0%	0.8%	0.8%	0.7%	0.7%	0.7%	0.8%	0.7%	0.8%	1.0%	-0.3%	-29.7%
C272 - Batteries	1.5%	1.5%	1.4%	1.3%	1.0%	1.1%	1.1%	1.2%	1.3%	1.5%	-0.3%	-22.9%
C28 - Machinery and equipment	0.8%	0.8%	0.7%	0.7%	0.7%	0.6%	0.7%	0.7%	0.7%	0.8%	-0.2%	-19.8%
C29 - Motor vehicles and trailers	0.7%	0.7%	0.5%	0.5%	0.6%	0.5%	0.6%	0.6%	0.6%	0.7%	-0.1%	-16.8%
C291 - Motor vehicles	0.5%	0.4%	0.4%	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%	0.5%	-0.1%	-18.1%
C30 - Other transport equipment	0.6%	0.6%	0.4%	0.4%	0.4%	0.4%	0.4%	0.5%	0.5%	0.6%	-0.2%	-26.3%
C32 - Other manufacturing	0.8%	0.8%	0.8%	0.7%	0.6%	0.6%	0.7%	0.7%	0.7%	0.8%	-0.1%	-16.7%
C33 - Repair of machinery	0.8%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%	0.7%	0.8%	-0.2%	-22.9%
A - Agriculture	5.5%	4.9%	4.5%	4.6%	4.8%	5.1%	4.6%	5.0%	4.9%	5.5%	-0.5%	-8.6%
B - *Mining* and quarrying	3.4%	3.4%	3.5%	5.2%	4.4%	4.8%	5.4%	4.9%	4.5%	5.4%	+1.5%	+45.9%
B06 - Oil and gas	0.7%	0.5%	0.7%	1.7%	1.3%	0.8%	0.8%	0.6%	0.9%	1.7%	-0.1%	-17.4%
B07 - *Mining* of metal ores	10.1%	10.3%	11.2%	9.9%	8.2%	12.1%	11.4%	16.6%	11.4%	16.6%	+6.4%	+63.4%
B08 - Other *Mining*	9.2%	8.6%	7.7%	8.4%	7.6%	7.3%	8.1%	7.8%	7.9%	8.6%	-1.3%	-14.3%
D35 - Electricity. gas and steam	8.9%	9.0%	8.8%	7.9%	8.3%	8.9%	9.1%	6.7%	8.4%	9.1%	-2.2%	-25.0%
E38 - Waste management	2.0%	1.6%	1.5%	1.5%	1.4%	1.5%	1.6%	1.3%	1.5%	1.6%	-0.7%	-33.5%
F - Construction	1.3%	1.1%	1.1%	1.0%	1.0%	1.0%	0.9%	1.1%	1.0%	1.1%	-0.2%	-16.8%
G - Wholesale and retail trade	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	-0.0%	-8.9%
H49 - Land transport	44.2%	34.2%	28.3%	31.4%	34.8%	33.3%	24.8%	32.8%	31.4%	34.8%	-2.3%	-18.9%
H51 - Air transport	25.9%	20.4%	17.1%	20.3%	24.7%	22.9%	13.4%	20.6%	19.9%	24.7%	-5.4%	-20.7%
I - Accommodation and restaurants	3.1%	3.0%	2.7%	2.6%	2.5%	2.5%	2.9%	2.9%	2.7%	3.0%	-0.2%	-5.3%
J - Information and communication	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	-0.0%	-4.1%

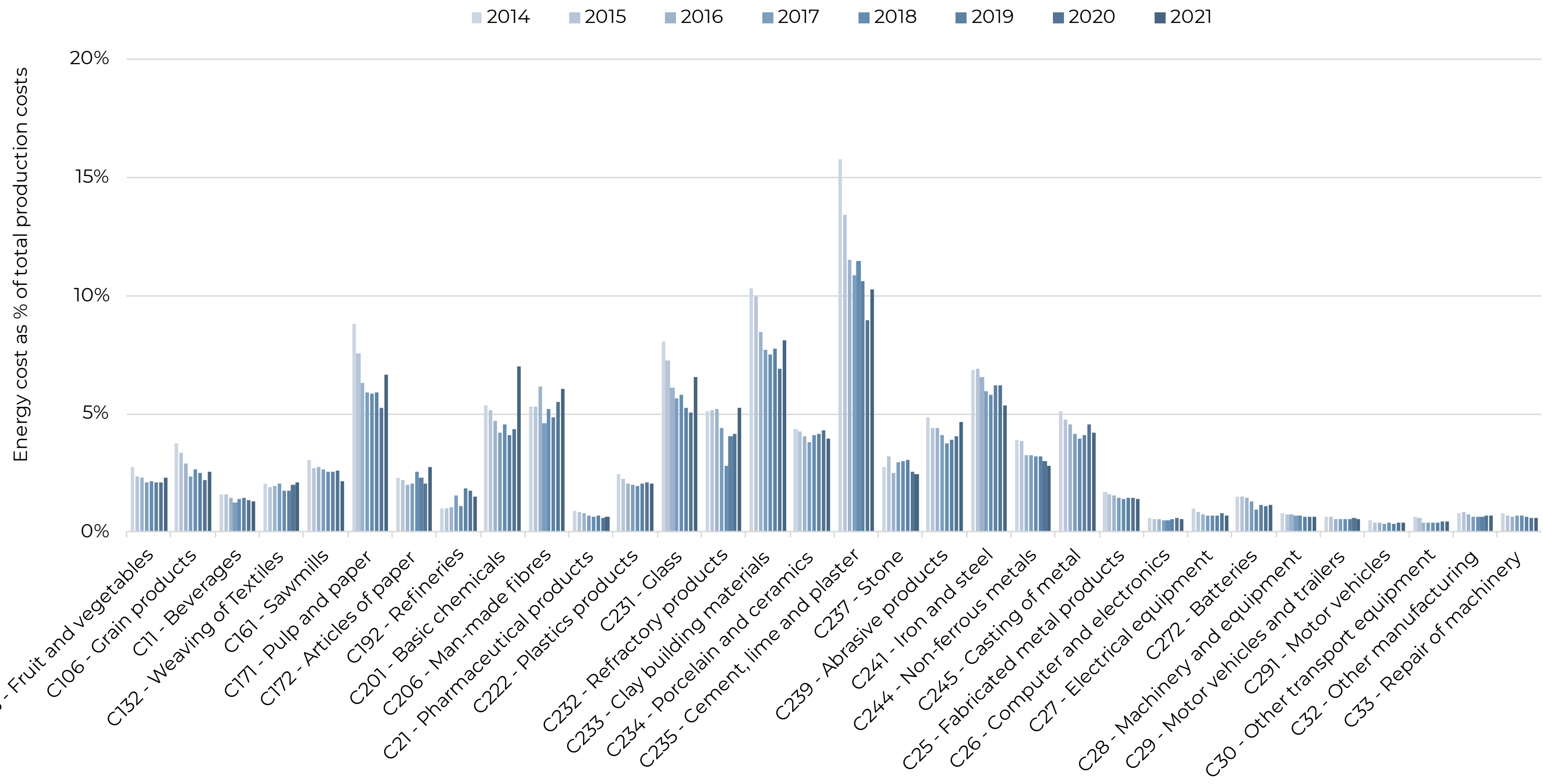

Figure 124: Average energy costs (as shares of production costs) for manufacturing sectors, averaged across the EU

Source: Own calculations based on data from Eurostat SBS

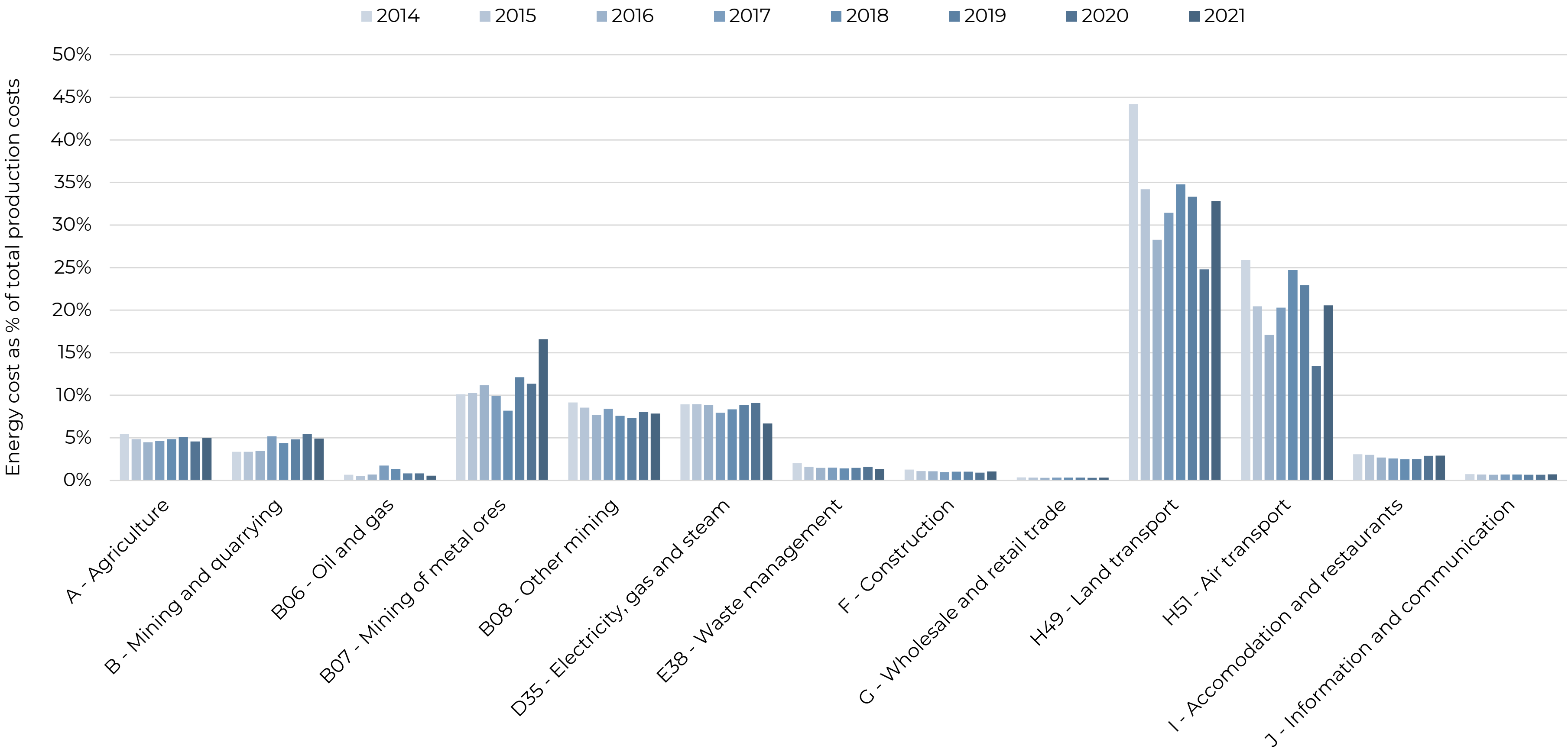

Figure 125: Average energy costs (as shares of production costs) for non-manufacturing sectors, averaged across the EU

Source: Own calculations based on data from Eurostat SBS

Energy costs and energy consumption mix in manufacturing sectors

Energy costs are affected by two factors: energy prices and the amount of energy used in the production of goods. In the short term, changes in energy prices have a significant impact on energy costs in a particular sector. In contrast, energy consumption tends to be more stable as it depends on various factors such as consumption patterns, competition, economic conditions, and energy efficiency measures. **The energy consumption profile of a sector is an essential indicator of how the price fluctuations of energy products may affect overall energy costs within that sector.**

Figure 126 shows the average distribution of energy sources for each manufacturing sector. The graph demonstrates the relative importance of various energy carriers for each sector, based on their contribution to total energy consumption over a period of time. The figure indicates that:

- **Electricity and natural gas emerge as the major energy products consumed across the majority of manufacturing sectors.** Consequently, fluctuations in the prices of these energy carriers have a greater influence on total energy costs compared to others;
- **Natural gas consumption notably influences energy costs, especially in sectors where gas accounts for 50% to over 80% of total energy consumption.** These sectors include: *Fruit and vegetables*, *Glass*, *Refractory products*, *Clay building materials* and *Stone*;
- **There are also sectors where energy costs are mostly influenced by electricity consumption.** Sectors where electricity consumption represents at least 50% of total energy consumption include: *Man-made fibres*, *Plastics products*, *Non-ferrous metals*, *Computer and electronics*, *Electrical equipment*, *Motor vehicles and trailers* and *Other manufacturing*.
- **Coal still plays a significant role in the manufacturing of some industrial sectors,** which are *Cement, lime and plastic*, *Stone*, *Abrasive products* and *Iron and steel*.
- **Oil plays a substantial role in the energy use in sectors where it is also used as a feedstock,** i.e. *Refineries* and *Basic chemicals*. Oil is also a significant energy carrier in *Repair of machinery*. Note that non-energy use (i.e., feedstock) is not included in the figure.
- **"Other" energy carriers, particularly biomass or waste, contribute significantly to energy consumption for selected sectors,** notably *Grain products*, *Sawmills*, *Pulp and paper* and *Cement, lime and plaster*.

It is important to note that the composition of energy sources can differ significantly among subsectors within each sector. For instance, while natural gas consumption in the Basic chemicals sector generally does not surpass 50% of total energy consumption on average, the *Fertiliser* subsector, which falls under Basic chemicals, relies heavily on natural gas. Consequently, fluctuations in natural gas prices significantly affect the *Fertiliser* sector.

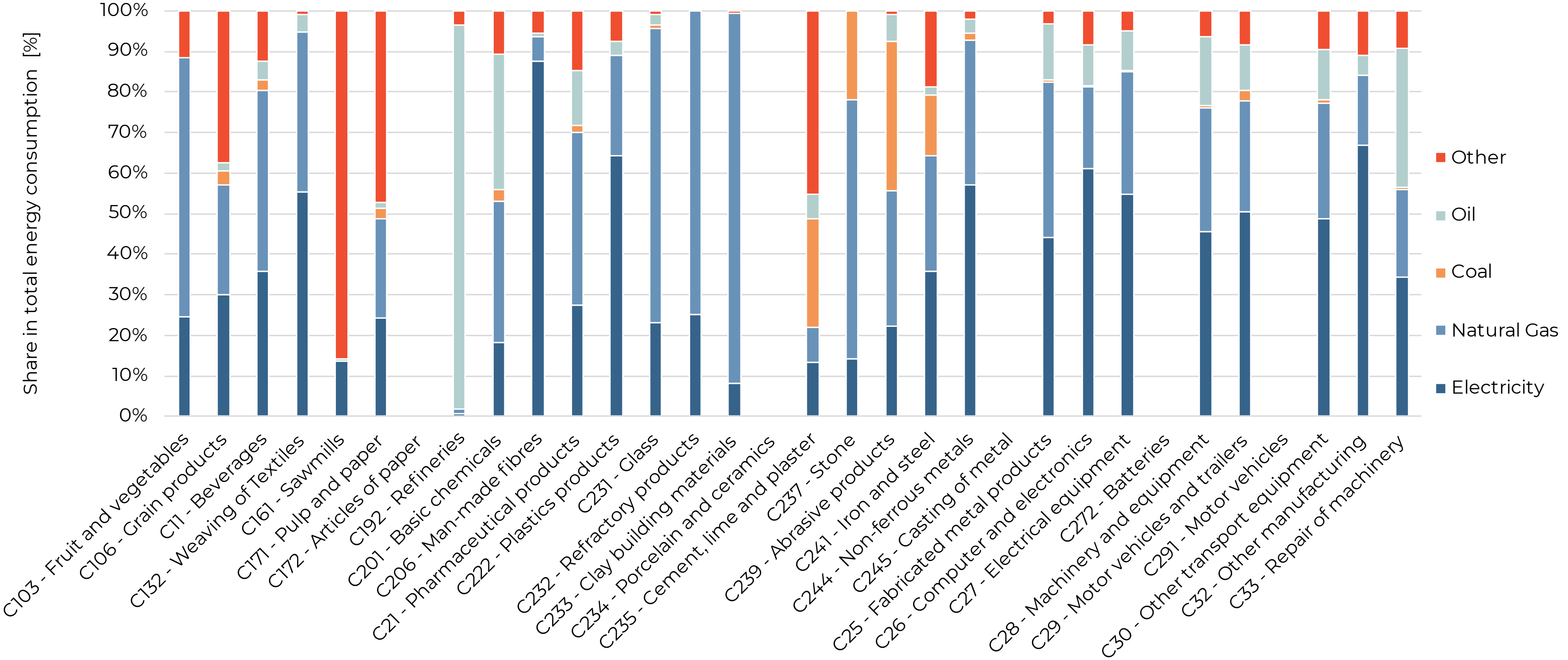

Figure 126: Breakdown of energy consumption by energy carrier for manufacturing sectors, averages across available EU countries, 2014–2021

Source: Own calculations based on data from Eurostat energy statistics and estimations based on national statistics. Note: "other" mainly covers biomass and heat consumption. Consumption per energy carrier could not be calculated for Articles of Paper (C172), Porcelain and ceramics (C234), Casting of metal (C245), Batteries (C272) and Motor vehicles (C291).

Dynamics of the energy cost shares in total production costs

Changes in the proportions of energy costs within production costs are the result of relative shifts in both energy costs and production costs. For example, the share of energy costs decreases when energy costs decline more than production costs during the same period. Similarly, energy cost shares decrease when energy costs rise at a slower rate than total production costs.

Table 18 presents the change of each of these two variables for each sector. The absolute values displayed represent the sum of the EU countries for which energy and production cost data is available per sector, rather than the EU as a whole. These sectors are categorised in Table 19 based on the observed changes in energy and production costs in absolute terms (i.e. in million euros) between 2014 and 2021. It is important to note that energy and production costs fluctuate annually, a detail not captured in the two tables.

The two tables indicate that, on average during the period of 2014–2021, when energy costs increase, production costs also tend to increase. This is the case for 28 out of the 45 sectors that experienced increased energy costs. However, it is worth noting that energy costs are not the only factor that can lead to increased production costs. In fact, even among the 17 sectors that experienced reduced energy costs, 11 of them still saw an increase in production costs during the same period 2014–2021.

Table 18: Drivers of energy cost shares in total production costs, manufacturing and non-manufacturing sectors, averages across available EU countries, 2014–2021

Manufacturing sectors	**Changes in total values across the EU 2014-2021**				**Change in energy cost share 2014-2021**	
	Absolute Δ Energy costs (MEUR)	**Relative Δ Energy costs (%)**	***Absolute Δ Total production costs (MEUR)***	**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	+340	+22.6%	+26 058	+47.4%	-0.5%	-16.8%
C106 - Grain products	-61	-4.3%	+14 727	+39.2%	-1.2%	-31.3%
C11 - Beverages	-34	-1.8%	+27 257	+23.4%	-0.3%	-20.5%
C132 - Weaving of Textiles	-12	-4.3%	-931	-7.0%	+0.1%	+2.9%
C161 - Sawmills	+155	+14.7%	+21 944	+63.5%	-0.9%	-29.8%
C171 - *Pulp and paper*	-718	-10.5%	+14 080	+18.2%	-2.1%	-24.3%
C172 - Articles of paper	+1281	+65.9%	+33 310	+39.5%	+0.4%	+18.9%
C192 - *Refineries*	+3 253	+234.2%	+167 236	+119.1%	+0.5%	+52.6%
C201 - Basic chemicals	+10 730	+65.2%	+79 211	+25.7%	+1.7%	+31.5%
C206 - Man-made fibres	+46	+12.0%	-182	-2.5%	+0.8%	+14.9%
C21 - Pharmaceutical products	-203	-9.9%	+68 502	+30.2%	-0.3%	-30.8%
C222 - Plastics products	+1 069	+23.6%	+90 419	+48.5%	-0.4%	-16.8%
C231 - Glass	+572	+17.5%	+17 922	+44.2%	-1.5%	-18.5%
C232 - Refractory products	+32	+12.1%	+383	+7.5%	+0.2%	+4.3%
C233 - Clay building materials	+496	+31.1%	+10 266	+66.6%	-2.2%	-21.3%
C234 - Porcelain and ceramics	+49	+13.4%	+2 107	+25.3%	-0.4%	-9.5%
C235 - Cement, lime and plaster	-251	-8.7%	+7 351	+40.4%	-5.5%	-35.0%
C237 - Stone	-21	-5.8%	+812	+6.1%	-0.3%	-11.1%
C239 - Abrasive products	+86	+7.7%	+2 794	+12.1%	-0.2%	-3.9%
C241 - Iron and steel	+1 595	+18.2%	+65 458	+51.2%	-1.5%	-21.8%
C244 - Non-ferrous metals	+463	+11.4%	+58 374	+56.0%	-1.1%	-28.6%
C245 - Casting of metal	-136	-7.7%	+4 085	+11.9%	-0.9%	-17.5%
C25 - Fabricated metal products	+633	+8.6%	+145 671	+33.8%	-0.3%	-18.9%
C26 - Computer and electronics	+16	+1.1%	+24 510	+9.1%	-0.0%	-7.4%
C27 - Electrical equipment	-1	-0.0%	+118 442	+42.1%	-0.3%	-29.6%
C272 - Batteries	+61	+54.0%	+7 246	+95.6%	-0.3%	-21.2%
C28 - Machinery and equipment	+224	+4.5%	+184 191	+30.4%	-0.2%	-19.8%
C29 - Motor vehicles and trailers	+350	+6.2%	+235 200	+27.6%	-0.1%	-16.8%
C291 - Motor vehicles	+175	+6.2%	+174 326	+29.7%	-0.1%	-18.1%
C30 - Other transport equipment	+78	+7.9%	+74 013	+46.3%	-0.2%	-26.2%
C32 - Other manufacturing	+149	+17.7%	+42 835	+41.3%	-0.1%	-16.7%
C33 - Repair of machinery	-122	-10.8%	+22 368	+15.6%	-0.2%	-22.9%

Manufacturing sectors	Changes in total values across the EU 2014-2021				Change in energy cost share 2014-2021	
	Absolute Δ Energy costs (MEUR)	Relative Δ Energy costs (%)	*Absolute Δ Total production costs (MEUR)*	Relative Δ Total production costs (%)	Absolute Δ energy costs vs. total production costs (% point)	Relative Δ energy costs vs. total production costs (%)
A - Agriculture	-73	-0.5%	+24 702	+8.9%	-0.5%	-8.6%
B - *Mining* and quarrying	-343	-7.7%	-48 643	-36.7%	+1.5%	+45.9%
B06 - Oil and gas	-402	-80.2%	-56 697	-76.1%	-0.1%	-17.4%
B07 - *Mining* of metal ores	+180	+97.8%	+382	+21.0%	+6.4%	+63.4%
B08 - Other *Mining*	-71	-3.4%	+2 929	+12.6%	-1.3%	-14.3%
D35 - Electricity, gas and steam	-44 517	-40.6%	-255 050	-20.8%	-2.2%	-25.0%
E38 - Waste management	+1 980	+470.1%	+158 230	+757.4%	-0.7%	-33.5%
F - Construction	+3 403	+22.7%	+559 491	+47.5%	-0.2%	-16.8%
G - Wholesale and retail trade	+3 350	+12.2%	+1 745 727	+23.2%	-0.0%	-8.9%
H49 - Land transport	-7 895	+4.5%	+122 728	+29.0%	-2.3%	-18.9%
H51 - Air transport	-13 893	-48.8%	-38 945	-35.4%	-5.4%	-20.7%
I - Accommodation and restaurants	+590	+5.1%	+41 423	+11.0%	-0.2%	-5.3%
J - Information and communication	+2 763	+46.1%	+424 711	+52.4%	-0.0%	-4.1%

Note: The absolute change (Δ) energy costs as a share of total production costs (% point) shows the change in the energy cost shares between 2014 and 2021 as presented in Table 17. 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 17 in 2021 compared to 2014.

Table 19: Categorisation of sectors according to absolute changes in energy and production costs, 2014–2021

	Reduced energy costs (2014-2021)	**Increased energy costs (2014-2021)**
Reduced production costs (2014-2021)	• ***C132 – Weaving of Textiles*** • ***B – Mining and quarrying*** • B06 - Oil and gas • D35 - Electricity, gas and steam • H51 - Air transport	• ***C206 – Man-made fibres***
Increased production costs (2014-2021)	• C106 - Grain products • C11 - Beverages • C171 - *Pulp and paper* • C21 – Pharmaceutical products • C235 – Cement, lime and plaster • C237 – Stone • C245 – Casting of metal • C27 – Electrical equipment • C33 – Repair of machinery • A – Agriculture • H49 – Land transport • B08 – Other *Mining*	• C103 - Fruit and vegetables • C161 - Sawmills • ***C172 - Articles of paper*** • ***C192 – Refineries*** • ***C201 – Basic chemicals*** • C222 – Plastics products • C231 – Glass • ***C232 - Refractory products*** • C233 – Clay building materials • C234 – Porcelain and Ceramics • C239 – Abrasive products • C241 – Iron and steel • C244 – Non-ferrous metals • C25 – Fabricated metal products • C26 – Computer and electronics • C272 – Batteries • C28 – Machinery and equipment • C29 – Motor vehicles and trailers • C291 – Motor vehicles • C30 – Other transport equipment • C32 – Other manufacturing • ***B07 – Mining of metal ores*** • E38 - Waste management • F - Construction • G - Wholesale and retail trade • I – Accommodation and restaurants • J - Information and communication

Note: sectors in bold and italic show an increase in the share of energy costs in production costs between 2014 and 2021. The other sectors show a decrease in energy cost shares. In combination with the quadrant that they are part of, this provides an indication of the drivers for the change in energy costs. For example, in the Refineries sector, the production costs decreased more than energy costs, resulting in an increase in the share of energy costs in production costs. For the Cement, lime and plaster sector, energy costs decreased while production costs increased, resulting in an overall decrease of the share of energy costs in production costs.

Energy cost share estimations for 2022–2023

The energy crisis starting in 2022 has undoubtedly impacted energy demand and costs of the industrial sector, however, data from these recent years is not yet readily available, making it difficult to measure to what extent the crisis has impacted industry. Nevertheless, this is a very relevant period for which to understand the dynamics of energy costs, particularly for industry. Therefore, the impact of energy price changes on the energy costs shares have been estimated for 2022 and 2023. This has been based on indexing the energy costs against annual average energy prices[316] and adjusting other costs by price indexes for industrial goods and labour[317].

Figure 127 shows that in all sectors, energy cost shares are estimated to have increased in 2022 compared to 2021. This is particularly noticeable in the energy intensive industries, (e.g. *Pulp and paper*, *Man-made fibres*, *Glass*, *Clay building materials*, *Cement, lime and plaster*, *Iron and steel* and N*on-ferrous metals*). Further, this can also be noticed in the less energy intensive sectors, such as *Fruits and vegetables* and *Grain products*. In some sectors, such as *Pulp and paper*, *Refineries*, *Iron and Steel* and *Non-ferrous metals*, energy costs shares lower again in 2023 though still remain higher than 2021 levels. However, for other sectors, such as those in the sectors in chemical industry and construction material industry, energy costs shares continue to rise in 2023. The differences between the sectors can be explained by gas and electricity price developments in the different Member States and consumption bands (see Table 17). In most Member States, the annual average gas and electricity prices in the low and medium consumption bands were higher in 2023 compared to 2022. In contrast, the gas and electricity prices in the high consumption bands in most Member States decreased in 2023. This is explained by changes in wholesale prices affecting retail prices of larger energy consumers faster than smaller consumers (see Sections 2.2 and 3.2). For *Pulp and paper*, *Refineries*, *Iron and Steel* and *Non-ferrous metals* most of their energy costs were in Member States where gas and electricity prices in the higher consumption band dropped between 2022 and 2023.

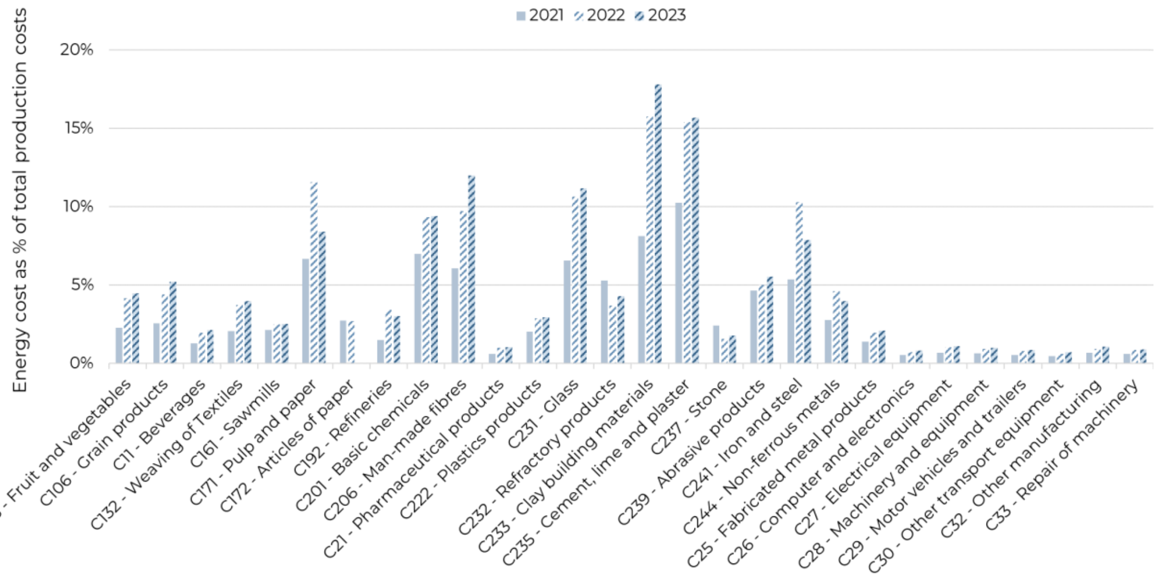

Figure 127 Estimated energy costs (as shares of production costs) for manufacturing sectors in 2021–2023, averaged across the EU.[318]

A similar trend can be seen for non-manufacturing sectors, where energy costs shares spiked in 2022, particularly in the more energy-intensive non-industrial sectors such as *Mining of metal ores*,

[316] *Indexes are based on average energy prices, estimated by weighting energy prices based on energy use.*
[317] *Non-energy industrial goods HICP index is used for goods and services costs and labour cost index used for personnel costs. Indexes are specified at Member State level.*
[318] *Sufficient data was not available to estimate energy cost shares for 2022 and 2023 for the following sectors: Porcelain and ceramics (C234); Casting of metal (C245); Batteries (C272); Motor vehicles (C291).*

Electricity, gas and steam, *Land transport* and *Air transport* (see Figure 128). In 2023, energy cost shares in *Mining of metal ores* and *Land transport* dropped again, albeit to levels higher than 2021.

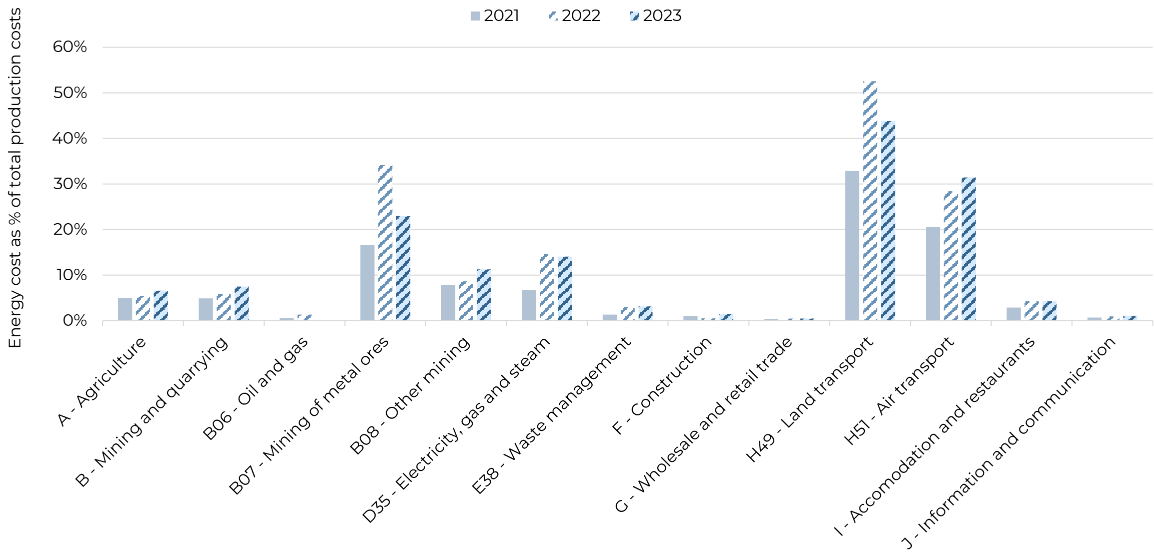

Figure 128: Estimated energy costs (as shares of production costs) for non-manufacturing sectors in 2021–2023, averaged across the EU

5.5.3. Gross Operating Surpluses shares

The competitiveness of industries is influence by the achieved profit margins. In the short term, these margins dictate the flexibility of companies in their pricing strategies and their competitive standing. In the long term, the profitability that can be achieved plays a fundamental role 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[319].** The GOS of the sectors in this study are analysed with respect to total operational production costs, using the following formula:

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

Key takeaways:

- Most EU sectors studied maintained an average gross operation surplus (GOS) share of production costs between 5–15% in the period 2014 to 2021, similar to observed shares in the previous editions of this study.
- From the year 2014 to 2021, the *Pharmaceutical products* and *Cement, lime and plaster* sectors consistently retained the highest GOS as a share of production costs, averaging 24% and 22%, respectively. Conversely, the *Iron and steel*, *Non-ferrous metals* and *Motor vehicles* sectors held the lowest GOS share, averaging 4%, 6% and 5%, respectively.
- On average, non-manufacturing sectors maintain their Gross Operating Surplus (GOS) shares similar to those of manufacturing sectors, typically ranging from 5% to 20%. However, there are some notable exceptions: The *Oil and gas* sector has a GOS of up to 122%, while *Agriculture* has up to 55%, *Mining and quarrying* up to 42%, and *Mining of metal ores* up to 62%. These sectors consistently maintain a significantly higher GOS share compared to manufacturing or other non-manufacturing sectors.

Figure 129 illustrates the average GOS as a share of total production costs among EU countries for which data for all years between 2014 and 2021 is available. The analysis reveals that:

- **The majority of EU sectors maintained an GOS share between 5–15%**, consistent with observations from previous editions of this study;
- **The *Pharmaceutical products* and *Cement, lime and plaster* sectors maintained the highest GOS** as a share of production costs;
- **The *Iron and steel, Non-ferrous metals* and *Motor vehicles* maintained the lowest GOS** as shares of production costs in the 2014-2021 period. The low average for *Iron and steel* is despite the peak in GOS share in 2021 to 14%. The average GOS shares for *Batteries* were also low, except for the year 2019 where there was a huge price spike of 16%;
- **The trend in GOS shares vary significantly across the sectors.** Other than the irregular peak from *Iron and steel* in 2021, *Sawmills* and *Refineries* saw the largest relative increase in GOS shares between 2014 and 2021 with +99% and +63%, respectively. The largest drop in GOS shares in that period were observed for *Grain products* (-40%) and *Batteries* (-31%).

Figure 130 displays the GOS share trends across non-manufacturing sectors, averaged across EU countries with available data from 2014 to 2021. The *Oil and gas*, *Agriculture* and *Mining* sectors

[319] *The key difference is that the GOS does not take costs other than production costs, such as depreciation of capital, into account.*

maintained notably higher GOSs than manufacturing sectors on average. However, the GOS share of the *Mining of metal ores* has decreased starting from the year 2017.

When comparing the increase or decrease of the GOS share with the increase or decrease of energy cost shares as discussed in section 5.5.2. , there is no clear correlation. The increase in energy cost shares did not result in a decrease in GOS share in both the manufacturing and non-manufacturing sectors, except for *Air transport*. This could indicate that these sectors on average were able to pass on the increase in energy cost shares to mitigate the impact on their GOS shares. Further, it can be recognised that the GOS share for *Air transport* was negative in the years 2020 and 2021, and the GOS share for *Accommodation and restaurants* shows a significant drop in 2020. These developments coincide with the years when COVID-19 restrictions were in place, reflecting the impact of these restrictions on the profitability of those sectors.

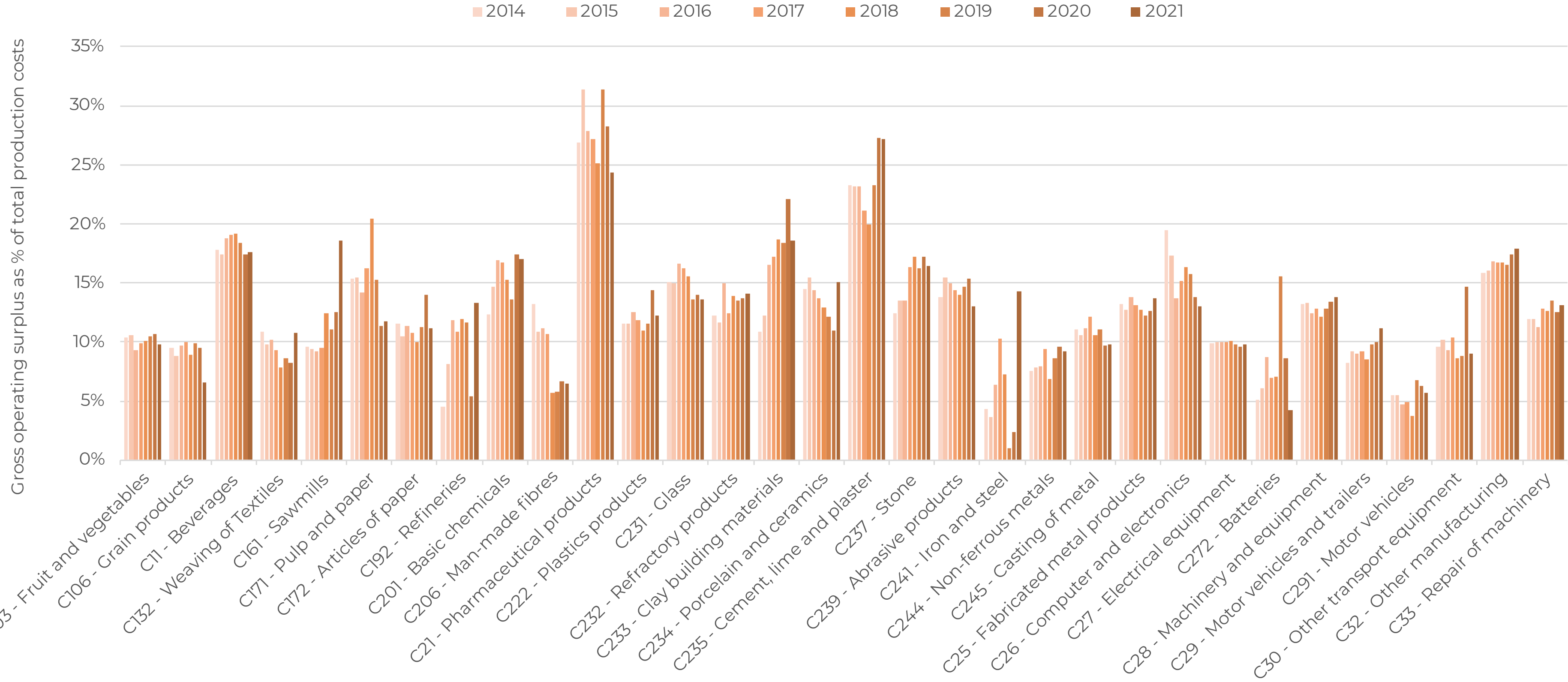

Figure 129: Gross operating surpluses as a share of total production costs for EU manufacturing sectors, averaged across EU countries with available data for 2014–2021

Source: Own calculations based on Eurostat SBS Note: GOS shares in total production costs are calculated as the average across EU countries for which data is available for all years between 2014 and 2021 to ensure comparability between years for each sector. Data is available for at least 15 MSs for almost all sectors except for: C192, C206, C232, C235, C241 and C272.

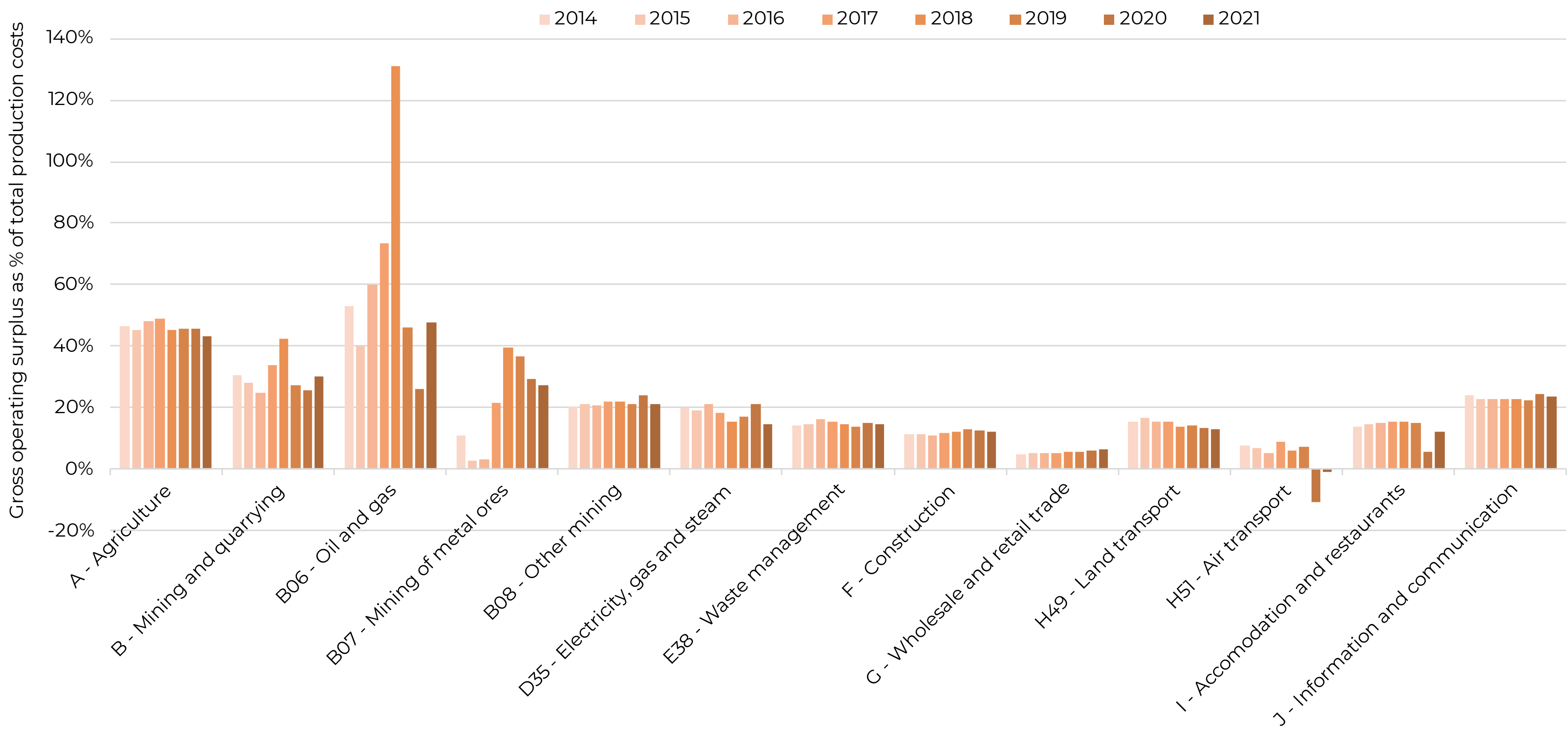

Figure 130: Gross operating surpluses as a share of total production costs for EU non-manufacturing sectors, averaged across EU countries with available data for 2014-2021

Source: Own calculation based on Eurostat SBS. Data is available for all 27 MSs for: Construction (F), Wholesale and retail trade (G), Accommodation and restaurants (I), and Information and communications (J). Data is available for at least 20 MSs for: Mining and quarrying (B), Electricity, gas and steam (D35), Waste management (E38), Land transport (H49)). Data is available for at least 10 MSs for: Agriculture (A), Other Mining (B08), and Air transport (H51). Data is available for less than 10 MSs for the other sectors (Oil and gas – B06; Mining of metal Ores – B07).

In the EU, the average GOS share of the manufacturing sectors examined in this study typically falls withing the range of 10-15% per year. However, there are large differences in the GOS as a share of production costs between Member States, mainly driven by varying distributions of sectors across MSs.

Figure 131 shows the 2014-2021 average GOS shares broken down per EU country. Cyprus, Malta, Ireland, Bulgaria, Denmark, Slovenia, Poland, Latvia and Hungary have the highest GOS shares with at least 15%. The lowest GOS shares are found in Greece and France with a GOS share below 10%. The average countries, where the percentage is thus below 15% but above 10% are: Lithuania, Czechia, Finland, Croatia, Romania, Netherlands, Belgium, Sweden, Slovakia, Austria, Italy, Portugal, Estonia, Spain, Luxembourg and Germany.

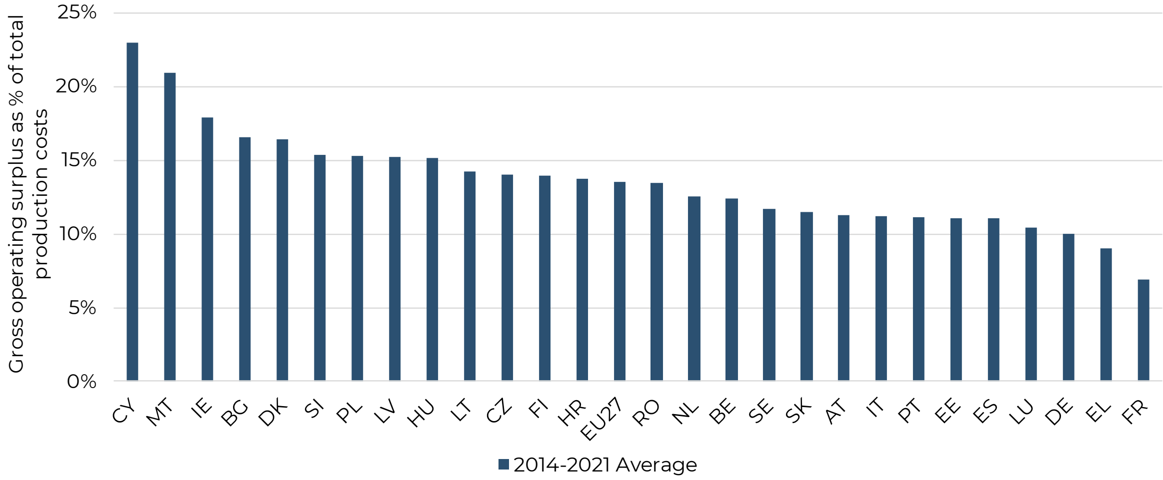

Figure 131: Gross operating surplus as share of total production costs, average across all manufacturing sectors at Member State levels

Source: Own calculations bason on Eurostat SBS

5.6. Exploring energy intensities

5.6.1. 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 data for calculating the energy intensity is based on the same sources as referred in to Section 5.5.1. . 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.

5.6.2. Results

Key takeaways:

- Energy intensity (energy consumption/GVA)[320] varies significantly across different sectors. The most energy-intensive sectors include *Refineries*, *Pulp and paper*, *Cement, lime and plaster*, *Iron and steel*, and *Basic chemicals*.
- The sectors with the highest volatility in energy intensity are *Cement, lime and plaster*, *Basic chemicals* and *Iron and steel*. These sectors experienced significant fluctuations in energy intensity as their value added (at factor cost) periodically rose and fell.
- In non-manufacturing, the highest energy intensity was observed in the following sectors: *Electricity, gas and steam, Air transport* and *Land transport*. Between 2014 and 2021, the energy intensity decreased significantly in the *Electricity, gas and steam* sector, and gradually decreased in *Air transport* sectors. It is worth noting that the *Air transport* sector reached its peak energy intensity, with an outlier of 29 MWh energy consumed / thousand EUR GVA, in the year 2020, parallel to the COVID-19 air travel restrictions.

Figure 132 presents the energy intensities of industrial manufacturing sectors in the EU. The figure reveals that:

- The energy intensity varies considerably across sectors:
  - ***Refineries*, *Pulp and paper*, *Basic chemicals*, *Cement, lime and plaster, Stone* and *Iron and steel* are the most energy intensive sectors.** They typically require more than 10 MWh[321] of energy consumption per thousand Euros of GVA[322];
  - They are followed by *Grain products*, *Clay building materials* and *Non-ferrous metals*, which historically have required more than 5 MWh of energy consumption per thousand Euros of GVA.
  - Out of the 32 manufacturing sectors in this study, at least 9 have had an energy intensity of <1 MWh of energy consumption per thousand Euros GVA.
- A decreasing trend of energy intensities can be recognised in the *Iron and steel*, *Basic chemicals*, *Clay building materials* and *Non-ferrous metals*, which could be an indication of improvements in energy efficiency in these manufacturing sectors.
- The energy intensities of the most energy-intensive sectors are the most volatile: *Refineries*, *Pulp and paper*, *Basic chemicals*, *Cement, lime and plaster*, and *Iron and steel*. 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 was relatively limited. **Fluctuations in value added that caused energy intensity volatility in these sectors can mainly be attributed to changes to gross value added of the produced product.** The impact of changes in energy consumption is more limited.

Figure 133 presents the energy intensities of non-manufacturing sectors in the EU. The highest intensities are consistently observed in *Electricity, gas and steam*, *Air transport* and *Land Transport*, reaching levels similar to the most energy-intensive manufacturing sectors with an energy intensity around 15 to 25 MWh of energy consumption per thousand Euros GVA. The energy intensity of *Electricity, gas and steam* is decreasing, which correlates with an increase in renewables over the

[320] *Gross Value Added*

[321] *Toe = tons of oil equivalent. One ton of oil equivalent is, for example, equivalent to 1 616 kg of coal, 1069 m³ of gas or 954 kg of gasoline. For electricity, 1 toe is worth 11.6 MWh.*

[322] *GVA = Gross Value Added*

years[323]. Energy intensity in *Air transport*—and to a lesser extent *Accommodation and restaurants*—shows a peak in the year 2020. This is the result of a drop in value added in these sectors, which coincides with the period of COVID-19 restrictions. The other sectors show a much lower energy intensity of <5 MWh of energy consumption per thousand Euros GVA with a mixed trend.

[323] *Eurostat (2024). Share of renewable energy in gross final energy consumption by sector*

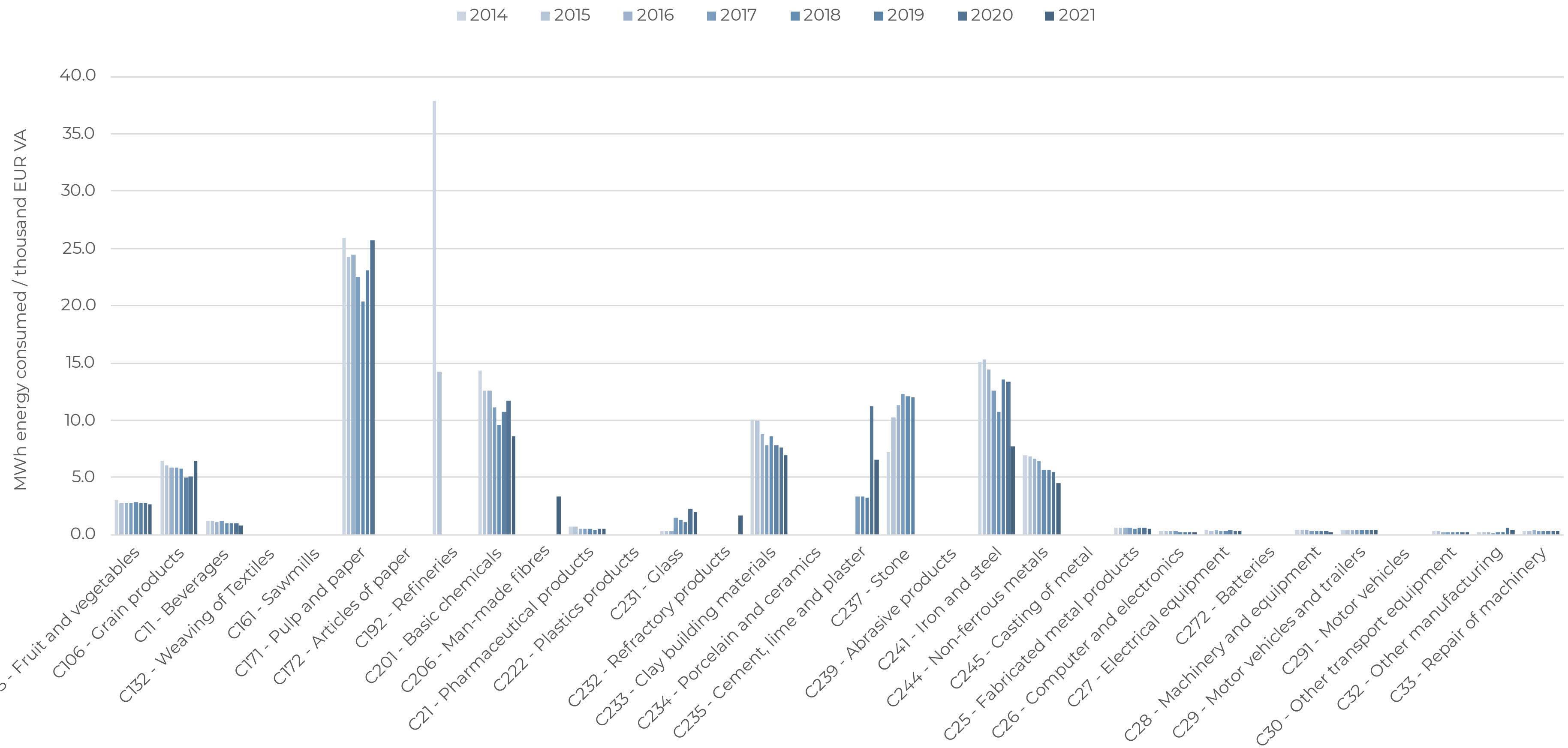

Figure 132: Energy intensities of manufacturing sectors, 2014–2021, averages over a limited number of EU Member States with available data

Source: Own calculations based on Eurostat SBS and national sources. Energy intensity could not be calculated for some years for certain sectors, particularly: Weaving of textiles (C132), Sawmills (C161), Articles of paper (C172), Plastic products (C233), Porcelain and ceramics (C234), Abrasive products (C239), Casting of metals (C245), Batteries (C272) and Motor vehicles (C291).

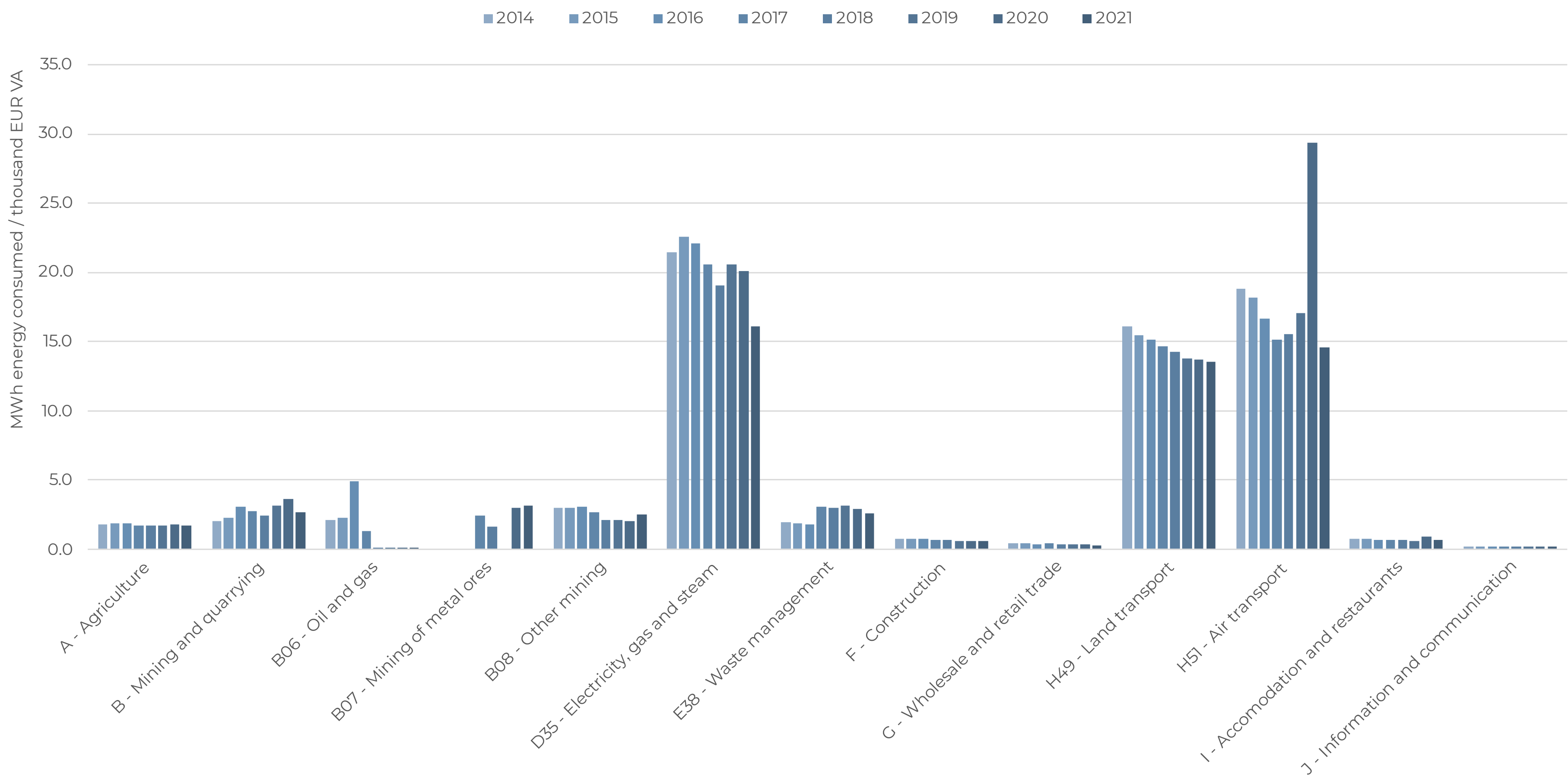

Figure 133: Energy intensities of non-manufacturing sectors, 2014-2021, averages over limited number of EU Member States with available data

Source: Own calculations based on Eurostat SBS, national sources

5.7. Energy cost drivers

This section analyses the drivers behind changes in energy costs of the industries in the EU and selected non-EU countries using a decomposition analysis (LMDI approach). Additionally, it explores how these energy costs influence industrial production costs.

This section is structured as follows:

- **Sub-section 6.7.1**: Methodology used in the analysis.
- **Sub-section 6.7.2**: Key assumptions made in the decomposition analysis.
- **Sub-section 6.7.3**: Findings from the decomposition analysis.
- **Sub-section 6.7.4**: Impact of energy costs on total production costs in the industry.

5.7.1. Methodology

This sub-section outlines the methodology used for the decomposition analysis of energy costs in the industry.

Decomposition analysis of the energy costs in industry

Decomposition analysis shows how changes in energy prices, production, and energy intensity affect energy costs in key industries during for the period 2014-2021 in the EU and selected non-EU countries. We use the Logarithmic Mean Divisia index (LMDI) method to decompose the industrial energy costs and determine the drivers of these 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 affect 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

$$Purchases\ of\ energy\ products_{i,c} = Output(c2015)_{i,c} * \frac{Total\ energy\ consumption_{i,c}}{Output(c2015)_{i,c}} * Energy\ Price_{i,c} * Residual_{i,c}$$

Transformed into

$$\Delta(Purchases\ of\ energy\ products_{i,c}) = Output\ effect_{i,c} + Energy\ intensity\ effect_{i,c} + Energy\ price\ effect_{i,c} + Residual\ effect_{i,c}$$

The index i: stands for the sector and c: for countries.

To conduct the decomposition analysis, the following data was utilised from the sources as described in Section 5.5.1. :

- Production value by sector and country: To calculate the output effect.

- Output deflators: by sector and country: To convert production into production in constant prices.
- Total energy consumption by energy carrier, sector and country: To calculate the fuel mix of the sector and energy intensity effect.
- Energy prices by energy carrier, sector and country: To calculate the energy price effect.

The data used had several missing datapoints for the years 2014 and 2021. In many cases, gap-filling techniques were employed to address these data gaps where possible. Table 20 shows the total cases[324] where data was available for the decomposition analysis. For example, in the decomposition analysis of the year 2021 to 2014 for EU Member States the cases considered without filling gap techniques are 16% and by filling the gaps the number is increased to 71%, while the remaining 29% have not been examined.

Table 20: Total cases where data was available for all four components (with and without gap-filling techniques)

	2014-2021	2019-2021	2019-2020
Total Cases (all countries)	**2898**	**2898**	**2898**
No filling techniques	9%	10%	10%
With filling techniques	43%	44%	49%
Total Cases (EU MS)	**1701**	**1701**	**1701**
No filling techniques	16%	16%	17%
With filling techniques	71%	74%	82%

5.7.2. Key assumptions

The following sub-section discusses the key assumptions made for each element of the decomposition analysis.

Output effect

The production value was converted into production in constant prices (based on the year 2015) to serve as a proxy for physical output and to eliminate price effects, thereby capturing the output effect. To achieve this, we used sectoral output deflators from Eurostat[325]. When these were unavailable, we applied the GDP deflator growth rate[326]. For countries not covered by Eurostat, we used the GDP deflator from the World Bank[327]. The sectoral output deflators from Eurostat were available at the NACE 2-digit level, and for NACE 3-digit data, 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. The gap-filling techniques that were used for the energy intensity are as follows:

1. We estimated the average EU intensity using the energy intensities of the EU Member States for which data was available.
2. When the energy intensity of a Member State was not available (for all years), we used the EU average energy intensity.

[324] *Case in the table refers to the decomposition analysis between two years for one sector and country.*
[325] *([nama_10_a64])*
[326] *[nama_10_gdp]*
[327] *([NY.GDP.DEFL.ZS]).*

3. When the energy intensity of a Member State was available (but not for all years), we used the growth rate of the EU average energy intensity.
4. For non-EU countries, we did not use any filling technique, except for the UK, where we used the same methodology as in the EU.
5. To fill in data that was missing for total energy consumption, the energy intensities after the filling gap techniques was used, where possible.

Energy price effect

The average energy price for each sector within a given country was estimated based on the fuel mix and the prices of coal, light sulphur fuel oil, gas, and electricity. In the analysis, we used energy carrier prices that included taxes and levies (excluding VAT and other recoverable costs). The gap-filling techniques used to calculate the average energy prices are as follows:

1. 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.
2. In the case where the fuel mix of a sector was missing in all years, we used the EU fuel mix of the corresponding sector.
3. For missing data in energy fuel prices, the EU-27 energy fuel price growth rate of the respective sectors was used.
4. Where prices including taxes and levies (excl. VAT and other recoverable costs) were not available, we used the growth rate or the entire series (if prices was missing for all years) from the energy prices including all taxes and levies or energy prices excluding taxes and levies if the others were not available.

Residual effect

The methodology for filling the data gaps involves several assumptions, which can create inconsistencies between the estimated and actual energy costs. The data used as a point of comparison against the estimated energy costs is the EUROSTAT SBS data on "purchases of energy products"[328]. 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 required the use of filling gap techniques, most notably the use of the EU 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).

5.7.3. Results

Key takeaways

- Between 2014 and 2021, total EU industrial energy purchases increased by 19.3% from 2014 levels, with output being the main driver (contributing 18.5 percentage points to the total change).
- Energy prices contributed positively, accounting for a 5.4% increase. Although improvements in energy intensity tended to reduce energy costs by 13%, they were insufficient to offset the increases caused by output and prices. The residual effect contributes to a 8.4% increase in energy costs.

[328] *([sbs_na_ind_r2])*

- Energy intensity in most cases considered is improving – but not everywhere (e.g. in *Cutting, shaping and finishing of stone* and *Other porcelain and ceramic products*). For most countries examined the energy efficiency improvement is not the main driver of reducing energy costs apart from Hungary and Malta and in particular in the total manufacturing sector, where energy intensity is the main driver of the decrease in energy costs.
- The residual effect is strongly influenced by inconsistencies arising from using different data sources and uncaptured variables (i.e., not accounting for all energy carriers in the calculation of the average energy price). Additionally, the techniques used to fill in missing data further contribute to this effect. Indexes have been calculated to examine the residual effect, showing that the different data sources and uncaptured variables account for the majority of the residual effect, while the use of gap-filling techniques increase the residual even more.
- 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 per sector implemented by each Member State, especially since the analysis considers the energy prices after taxes and subsidies.
- Overall, the reduction in production in 2020 due to COVID-19 led to lower energy costs in the manufacturing sector, but rebound effects in production in 2021 and rising energy prices, pushed energy costs up by 24.7%, offsetting the reduction seen in 2020.
- The increase in the energy costs mainly occurred in the last year accounted (2020-2021) with the rise in production and energy prices being the primary drivers.
- In the UK manufacturing sector (excluding sectors with incomplete data), energy costs increased by 65.8% between 2014 and 2021, primarily driven by a 54.1% rise in energy prices.
- In the US, total manufacturing energy costs increased by 23.4% between 2014 and 2021, however, only two sectors were considered due to data limitations. The main drivers were a 28.4% increase in energy prices and a 20.4% rise in output, while energy intensity improvements decreased energy costs by 25.4%.
- The decomposition analysis of the total manufacturing costs shows that energy cost changes have a limited contribution to the changes of the total production costs, contributing 0.4% of the 29.2% total increase of production costs.
- In the EU between 2014 and 2021, output increased by 17%, driven primarily by domestic demand, which contributed 16% to this change. Exports contributed an additional 5% to the increase in output, while imports decreased output by 3%. Among the Member States, Poland experienced the highest increase in output, primarily due to domestic demand.

This section shows the results of the decomposition analysis of the energy costs in industry by sector and for EU-27 Member States While an analysis for non-EU-27 countries has also been conducted, limited data availability has restricted this to the UK and the US. Each of the four main components used in the decomposition analysis has been further examined to understand their impact on energy costs within the EU-27.

Thereafter, the impact of energy costs on total production costs of the industries within EU is also presented.

Decomposition analysis of identified sectors

EU and EU Member State results

Figure 134 shows the contributions of output, energy price, energy intensity and residual effects to the change of the energy costs as the sum of selected manufacturing sectors in the EU between 2014 and 2021. During this period, total EU industrial energy purchases increased by 19.3% from 2014 levels, with output being the main driver of this increase, contributing 18.5%. The average energy price in the manufacturing sector also contributed positively, accounting for a 5.4% increase in energy costs.

Although improvements in energy intensity tended to reduce energy costs in the manufacturing sector by 13%, they were insufficient to offset the increases caused by the other two components. The residual effect accounted for an 8.4% increase in energy costs.

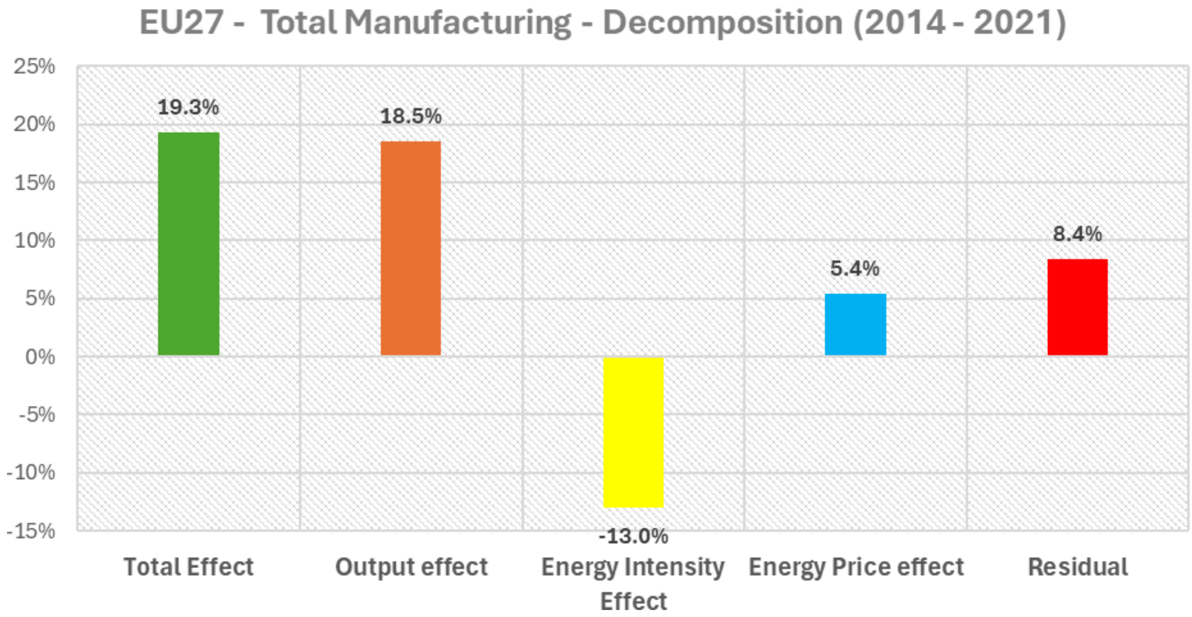

Figure 134: Decomposition analysis of the Total manufacturing in EU for the years 2014 to 2021

Table 21 includes the results from the decomposition analysis of the total manufacturing (sectors available) between the years 2014 and 2021. There is strong divergence in the energy cost evolution across Member States which is also attributed to the difference in sectors that have been included to calculate the total manufacturing case for each Member . In most countries, energy costs in total manufacturing have increased, primarily driven by output and energy price effects.

Energy intensity tends to decrease energy costs in most cases; however, this reduction is generally not sufficient to offset the overall increase in energy costs. Exceptions include Hungary and Malta, where energy intensity is the main driver of the decrease in energy costs.

The residual effect is a significant factor in some cases (highlighted with bold – Belgium, Denmark, Finland, Luxembourg, Latvia, Portugal and Sweden) reflecting mainly two main aspects:

1. **Data Inconsistencies**: residual effect is high due to inconsistencies in database sources.
   - The sector *Basic chemicals* in Belgium drives the high residual in the total manufacturing sector.
   - In Denmark, residual is driven mainly by the sectors *Food products*, *Other non-metallic mineral products* and *Fabricated metal products, except machinery and equipment*.
   - The *Machinery and equipment n.e.c.* in Luxembourg.
2. **Gaps in data and uncaptured variables**: Residual effect is high due to gap-filling techniques and not considering all the energy carries for the calculation of the energy carriers.

The cases of Finland, Latvia, Sweden, and Portugal could fall under both categories. It is important to note that some countries have very limited data. For example, Luxembourg, Latvia, and Cyprus have data available for all four components in only one sector, which also drives the results for the total manufacturing sector in those countries.

Table 21: Decomposition analysis of the total manufacturing (those available) in the period 2014–2021 for each EU Member State (main drivers are in **bold**)

Country	Output effect	Energy Intensity Effect	Price effect	Residual effect	Total effect
EU27	***19%***	*-13%*	*5%*	*8%*	*19%*
AT	**15%**	-13%	10%	-4%	8%
BE	14%	-7%	-3%	**112%**	117%
BG	19%	-18%	**39%**	22%	63%
CY	**450%**	-32%	1%	0%	419%
CZ	25%	**44%**	6%	-52%	23%
DE	12%	-10%	3%	7%	12%
DK	14%	-6%	13%	**-40%**	-19%
EE	25%	-32%	**27%**	11%	31%
EL	**26%**	**-42%**	16%	0%	0%
ES	**27%**	-15%	2%	14%	28%
FI	4%	-1%	8%	**-21%**	-11%
FR	12%	-22%	**13%**	7%	10%
HR	15%	**-19%**	5%	-12%	-12%
HU	**28%**	-7%	7%	10%	38%
IE	**77%**	-64%	9%	11%	32%
IT	**21%**	-14%	-6%	1%	2%
LT	48%	**84%**	-3%	-90%	38%
LU	3%	**4%**	0%	**-106%**	-100%
LV	52%	-13%	1%	**132%**	172%
MT	42%	**-79%**	-14%	13%	-38%
NL	8%	5%	**43%**	-17%	38%
PL	**43%**	-81%	40%	31%	33%
PT	20%	-26%	0%	**23%**	17%
RO	**38%**	-48%	29%	12%	31%
SE	15%	-12%	17%	**-26%**	-6%
SI	**40%**	-40%	3%	6%	9%
SK	26%	**43%**	-3%	-39%	27%

Sectoral level results

Table 22 shows the decomposition analysis for the assessed manufacturing sectors in the order of sectoral energy intensity. It is observed that:

- Overall, output is the main driver of energy costs in 17 out of 32 cases. In these instances, increased industrial production leads to higher energy costs for the industry. The only exception is the Casting of metals sector, where a reduction in energy costs is driven by a decrease in output.
- The top five energy-intensive industrial sectors generally register an increase in energy costs, with the exception of the *Pulp and paper* sector. The main driver of the change in energy costs is output for the *Cement* and *Clay building materials* sectors, while for the *Pulp and paper*, *Basic chemicals*, and *Man-made fibres* sectors, it is the residual effect. The residual effect in the *Basic chemicals* sectors is primarily due to inconsistencies between data

sources. In the *Pulp and paper* and *Man-made fibres* sectors, the residual effect is mainly attributed to the gap-filling techniques used.

- The residual effect is higher in more disaggregated sectors (NACE 3-digit code) compared to aggregated sectors (NACE 2-digit code). Data for NACE 2-digit sectors require fewer gap-filling techniques.
- 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.
- Energy intensity improvements drive a decrease in the energy costs of the industry. Energy intensity is the main driver in sectors such as *Weaving of textiles*, *Basic pharmaceutical products*, and *Repair and installation of machinery and equipment*. Exceptions include *Abrasive products*, *Non-metallic mineral products n.e.c.*, and *Other porcelain and ceramic products*, where an increase in energy intensity has driven energy costs up.
- In the residual effect there are some outliers in the data or inconsistencies and filling gap techniques that drives the residual effect. These outliers for the top five energy intensive industries are:
    - **For *Cement, lime and plaster***: In this sector for France and Poland, inconsistencies in the data sources contribute to an increase in the residual effect. Additionally, an important factor that increases the residual effect in this sector is the omission of all energy carriers in the calculation of average energy prices, particularly due to a significant share of other energy carriers in the fuel mix.
    - **For *Pulp, paper and paperboard***: Several gap-filling techniques were employed to address data gaps in this sector, with Spain, Sweden, and Poland contributing to the negative residual effect.
    - **For *Clay building material***: Italy and Spain drives the residual effect mainly due to the gap-filling techniques.
    - **For *Basic chemicals***: In this sector mainly Belgium drives the residual effect due to outliers in the energy costs from EUROSTAT SBS database.
    - **For *Man-made fibres***: The residual effect is mostly driven by Germany by the gap filling techniques used (mainly due to lack of data in the energy consumption) in this sector and to a lesser extent by outliers in the energy costs from EUROSTAT SBS database (e.g., Italy).

Table 22: Decomposition analysis by sector in EU (2014–2021)

NACE code	Description	Output effect	Energy Intensity Effect	Price effect	Residual effect	Total effect	EI (toe/mn. EUR)
C235	Cement, lime and plaster	**24%**	-15%	17%	-20%	6%	587
C171	Pulp, paper and paperboard	0%	8%	-4%	**-15%**	-10%	494
C233	Clay building materials	**31%**	-16%	-11%	19%	23%	348
C201	Basic chemicals	17%	-25%	2%	**69%**	62%	278
C206	Man-made fibres	-15%	-8%	-2%	**41%**	17%	236
C241	Basic iron and steel and of ferro-alloys	15%	-21%	13%	**19%**	26%	205
C192	Refined petroleum products	-12%	-11%	**-24%**	21%	-26%	184
C237	Cutting, shaping and finishing of stone	-4%	50%	3%	**-54%**	-6%	179
C172	Articles of paper and paperboard	22%	-3%	-2%	**40%**	56%	176
C231	Glass and glass products	**29%**	-11%	3%	-2%	18%	176
C106	Grain mill products	15%	5%	4%	**-31%**	-6%	115

NACE code	Description	Output effect	Energy Intensity Effect	Price effect	Residual effect	Total effect	EI (toe/mn. EUR)
C244	Basic precious and other non-ferrous metals	**24%**	-10%	22%	-1%	35%	88
C161	Sawmilling and planing of wood	**16%**	9%	**16%**	-30%	11%	75
C245	Casting of metals	**-17%**	-6%	6%	4%	-13%	75
C239	Abrasive products and non-metallic mineral products n.e.c.	-5%	**9%**	8%	-9%	4%	59
C103	Processing and preserving of fruit and vegetables	**22%**	11%	4%	-24%	13%	53
C232	Refractory products	-16%	-12%	4%	**32%**	8%	50
C132	Weaving of textiles	-13%	**-36%**	-4%	45%	-8%	33
C234	Other porcelain and ceramic products	-9%	**24%**	4%	-20%	0%	29
C11	Beverages	**17%**	-12%	5%	-6%	4%	26
C21	Basic pharmaceutical products and pharmaceutical preparations	62%	**-86%**	13%	8%	-3%	26
C222	Plastics products	**27%**	-14%	7%	-1%	19%	25
C25	Fabricated metal products, except machinery and equipment	**19%**	-16%	12%	-4%	11%	19
C32	Other manufacturing	**34%**	-20%	-6%	19%	27%	19
C33	Repair and installation of machinery and equipment	-1%	**-15%**	-9%	10%	-15%	12
C27	Electrical equipment	**23%**	-24%	13%	-12%	1%	11
C28	Machinery and equipment n.e.c.	17%	-41%	5%	**25%**	5%	11
C272	Batteries and accumulators	**87%**	-30%	12%	-18%	52%	11
C29	Motor vehicles, trailers and semi-trailers	**16%**	-10%	-1%	1%	7%	8
C291	Motor vehicles	**16%**	-10%	-2%	0%	4%	8
C26	Computer, electronic and optical products	**17%**	-12%	13%	-7%	12%	7
C30	Other transport equipment	**31%**	-21%	13%	-15%	8%	7
TC	Total manufacturing	**19%**	-13%	5%	8%	19%	56

Energy intensity effect

The energy intensity effect shows the effect of changes in energy consumed per unit of output on changes in purchases of energy products for a given industry.

Energy intensity improves in all sectors except the following: manufacture of *Pulp and paper*, *Cutting, shaping and finishing of stone*, *Grain mill products*, *Sawmilling and planing of wood*, *Abrasive products* and *non-metallic mineral products n.e.c.*, *Processing and preserving of fruit and vegetables* and *Other porcelain and ceramic products*.

The results shown in Figure 135 and Figure 136 are calculated using two methods:

1. **Change in energy intensity weighted with 2014 production for both 2014 and 2021 (no weights option):** This approach applies a fixed weight based on 2014 production levels to calculate changes in energy intensity.
2. **Change in energy intensity weighted with actual production of the respective years (with weight option):** This method adjusts weights based on actual production levels for each respective year.

The impact of changing weights among EU Member States (location of production) has a marginal effect on energy intensity.

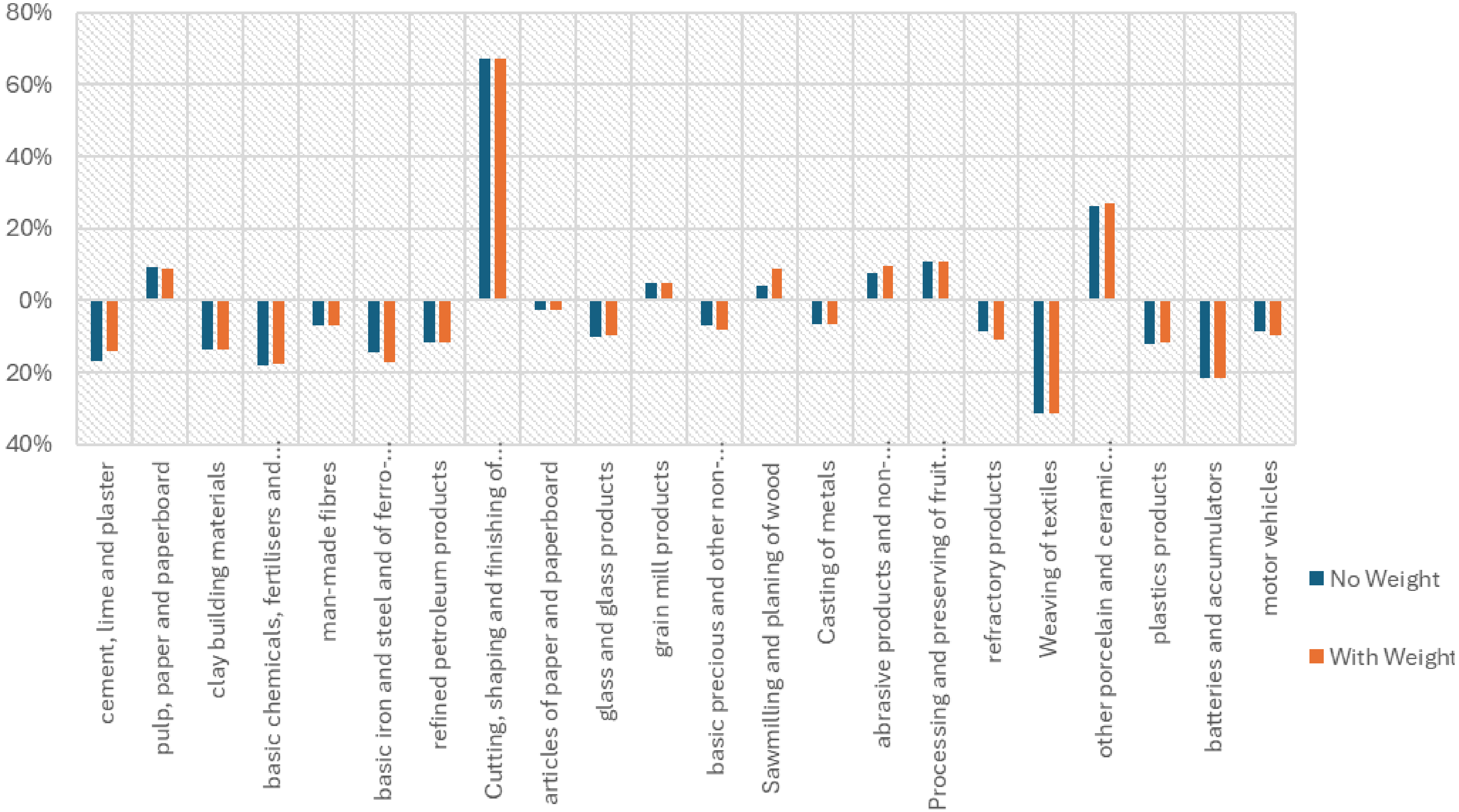

Figure 135: The change in energy intensity for EU with and without weight options (NACE 3–digit sectors)

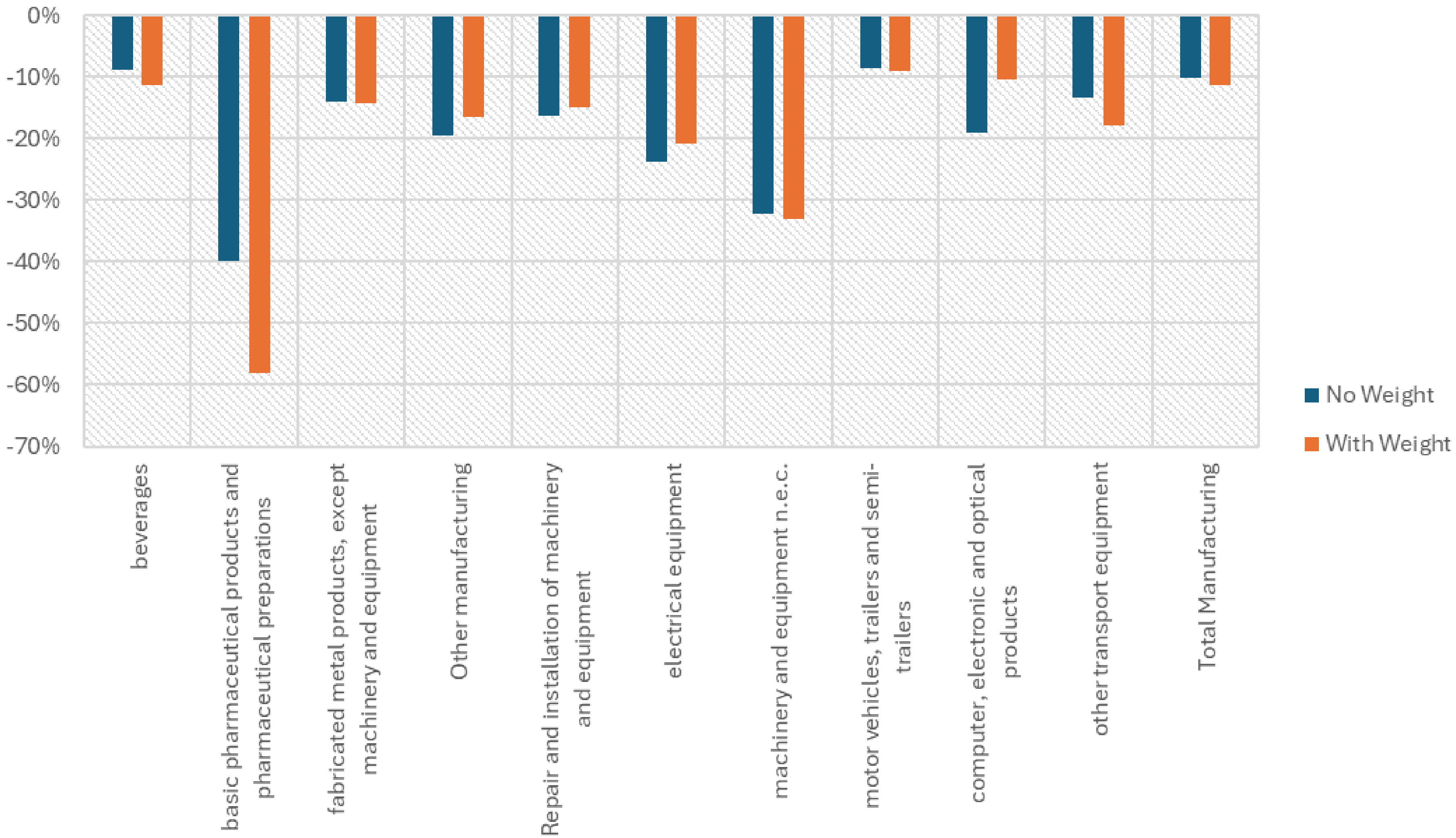

Figure 136: The change in energy intensity for EU with and without weight options (NACE 2–digit sectors)

Energy price effect

The energy price effect shows the effect of changes in cost per unit of energy on 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.

Between 2014 and 2021, the price of coal experienced a higher increase than the rest of the other energy carriers assessed. In the same period, the price of gas and fuel oil decreased for most of the countries and sectors. The price of electricity evolves differently across sectors and member states, some of the sectors face higher electricity prices while others face lower electricity prices due to dedicated policies for taxes and levies (electricity prices are after taxes and levies). In most cases the price of electricity across sectors and countries increased between 2014 and 2021.

On a sectoral level, in the *Cement, lime, and plaster* sector, there has been a substitution of oil consumption towards electricity and gas, leading to an increase in the average energy price of the sector. Conversely, sectors like refined petroleum products, which rely almost exclusively on crude oil, have observed a decline in energy prices.

Other energy-intensive sectors, such as *Clay building materials*, which primarily rely on gas consumption and have increased the gas share in their fuel energy mix between 2014 and 2021 at the expense of electricity, have seen a reduction in energy prices.

In general:

- Sectors with a high electrification rate or a high share of coal in their energy mix have faced increases in energy prices (e.g., *Cement, lime, and plaster*; *Basic precious and other non-ferrous metals*; *Batteries and accumulators*).
- Sectors that rely mostly on oil and gas have experienced reductions in energy prices (e.g., *Refined petroleum products*, *Clay building materials*).

Finally, we calculated the average energy price changes weighted with 2014 production both for the years 2014 and 2021 (no weights option) and the average energy price growth weighted with the actual production of the respective years (with weight option). Figure 137 and Figure 138 show 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.

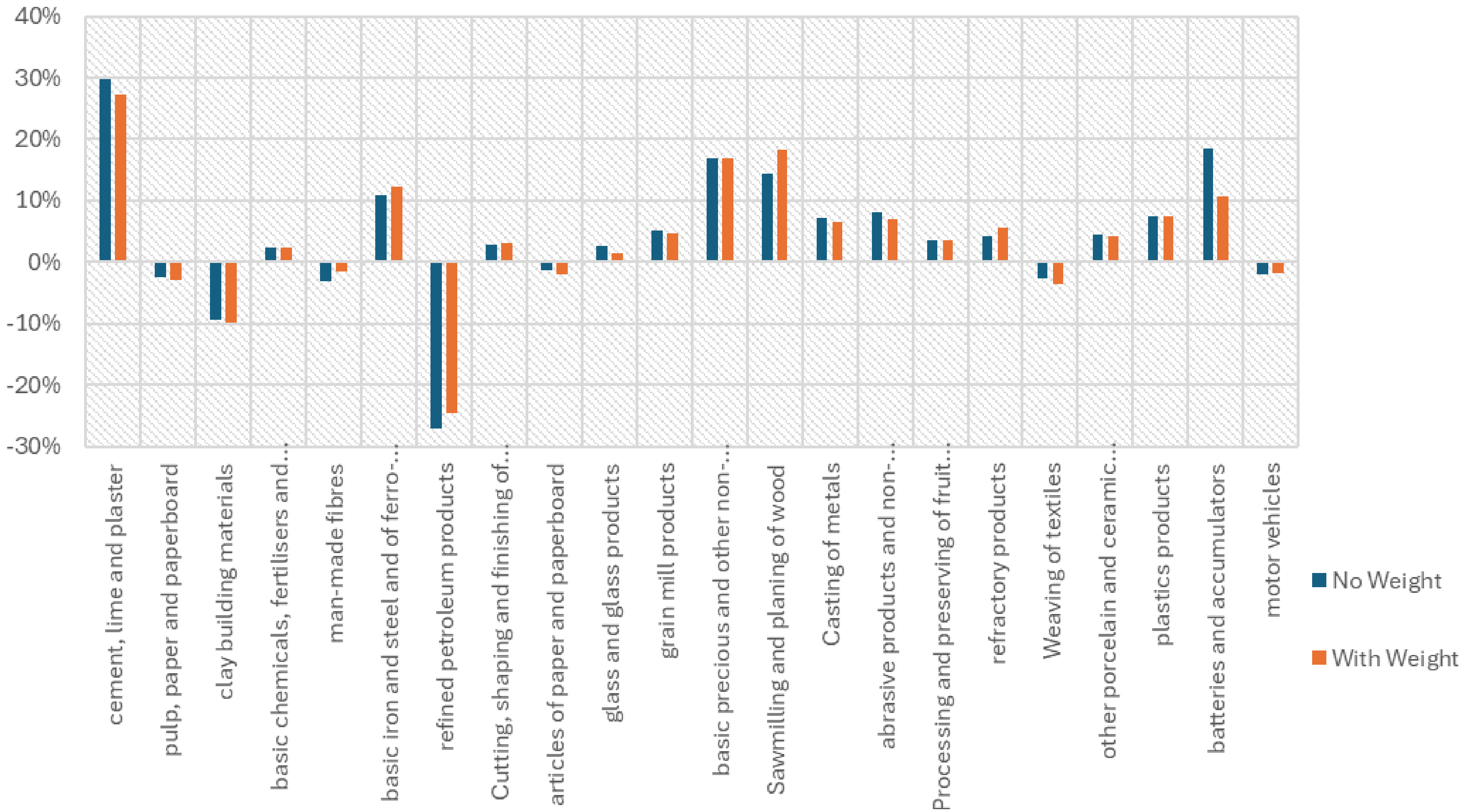

Figure 137: The change in energy price for EU with and without weight options (NACE 3–digit sectors)

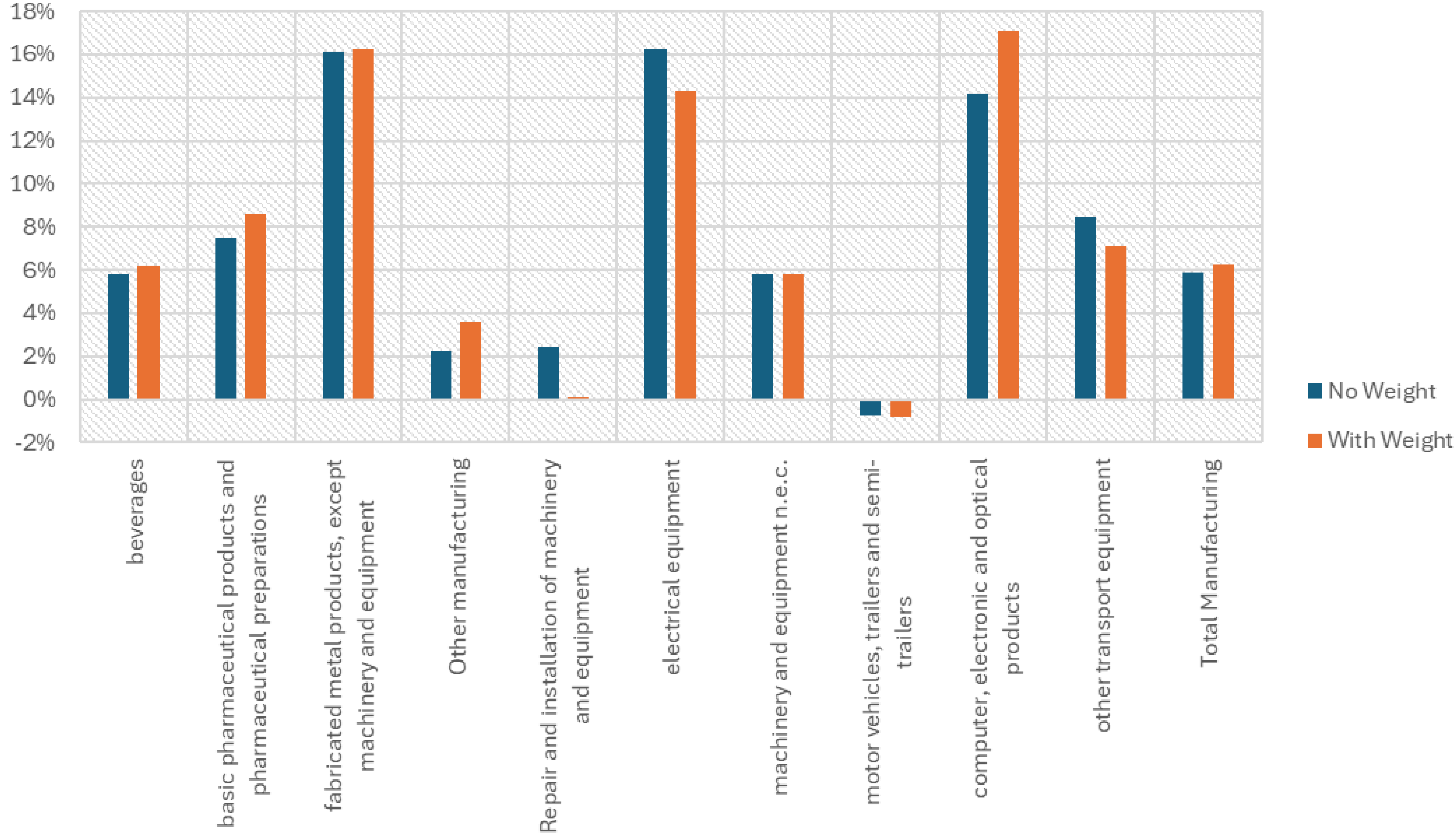

Figure 138: The change in energy price for EU with and without weight options (NACE 2–digit sectors)

Residual effect

The residual effect represents the difference between the estimated energy costs and data collected from the EUROSTAT SBS database. In order to decompose and understand the residual effect the following indexes have been calculated:

1. **With gap filling techniques and with weights**: This index is constructed by summing the absolute residuals weighted by energy costs of the sector and divide this by total cases considered after the gap filling techniques.
2. **With gap filling techniques and without weights:** This index is constructed by summing the absolute residuals and divide this by total cases considered after the gap filling techniques.
3. **Without gap filling techniques and with weights**: This index is constructed by summing the absolute residuals weighted by energy costs of the sector and divide this by total cases considered without any gap filling techniques.
4. **Without gap filling techniques and without weights:** This index is constructed by summing the absolute residuals and divide this by total cases considered without any gap filling techniques.

Table 23 shows the results of the indexes, indicating that the residual effect is primarily influenced by inconsistencies arising from using different data sources and uncaptured variables (i.e., not accounting for all energy carriers in the calculation of the average energy price). This accounts for 32% in the weighted option and 41% in the unweighted option. These indexes of the residual effect increase to 51% and 45%, respectively, after the gap filling techniques are applied.

The weighted indexes are more appropriate to understand the residual in the total manufacturing sector and EU and the non-weighted option for the residual of the disaggregated sectors and member states.

Table 23: Index for decomposing the residual effect

	Weighted	No weighted
Without filling gap techniques	32%	41%
With filling gap techniques	51%	45%

In EU and between 2014 and 2021, the residual effect for all manufacturing sectors was 8.4%. The sectors with the highest residual effects were *Leather and related products* (93%), *Basic chemicals* (69%), and *Tobacco products* (59%). The most strongly negative residual effect was the *Cutting, shaping and finishing of stone* (-54%).

For the sectors with the highest positive residual effect, there was a large variation in the composition of the effects, though all saw a negative impact from energy intensity. For example, in the *Leather and related products* sector, there is a significant negative energy price effect of -78%, while the actual energy costs decline only by 14%. The other two components (output and energy intensity effect) are not able to reduce this gap. This suggests that the uncaptured variables in the calculation of the energy price and data inconsistencies are the main reasons for this high residual effect.

For the *Cutting, shaping and finishing of stone*, the output and price effects were relatively consistent in scale with the -6% total effect, but there was a 50% increase in the energy intensity effect (based on gap-filling techniques due to limited data in energy consumption) that leads to a high residual effect.

The majority of Member States had a relatively low residual effect in the total *Manufacturing* sector. Exceptions were Latvia (132%), Belgium (112%), Luxembourg (-106%) and Lithuania (-90%). Digging into each of these in turn, we can see that data availability for Latvia was very low and the only manufacturing sector for which the decomposition analysis could be undertaken was the manufacture of wood and of products of wood and cork. The total effect between 2014 and 2021 was 172%. Of this, the output effect contributed 52% but this was offset by a corresponding -13% energy intensity effect, and there was a 1% price effect.

In contrast, Belgium's data was significantly more complete, with data only missing and unfilled for four manufacturing sectors. The high residual effect was primarily driven by *Basic chemicals* (406%). In the case of the chemical sector, the total effect was high at 333% and the residual effect is driven mainly by inconsistencies in databases.

For Luxembourg, as with Latvia, data was very limited and the only manufacturing activity for which decomposition analysis could be conducted was *Machinery and equipment n.e.c.*. For this sector, the energy cost changes of -100%, but the output effect, energy intensity effect and price effect can only explain 3%, 4% and -0.5% respectively, leaving a very high negative residual.

Lithuania had data available or filled for all but nine sectors. The sector that contributed primarily in the residual of the total manufacturing sector were in *Chemicals and chemical products* (-288%). That sector saw a significant energy intensity effect (between 2014 and 2021, the energy intensity of the sector increased by 464%) and also positive output and price effects that resulted in significantly higher estimated costs compared to the actual energy costs data from EUROSTAT SBS.

Decomposition analysis with and without the COVID-19 year

Figure 139**Error! Reference source not found.** shows the decomposition analysis in EU for the total *Manufacturing* sector for the periods 2019–2020 and 2019–2021 (periods are separated to account for the rebound effect after COVID-19). In 2020, the energy costs of the *Manufacturing* sector decreased by 14% compared to 2019, primarily due to a reduction in output, which contributed -8%. Conversely, in 2021, energy costs increased by ~25% compared to 2019. The main driver of this increase was the rise in energy prices, contributing ~12%. Overall, the reduction in production in 2020 due to COVID-19 led to lower energy costs in the *Manufacturing* sector, but rebound effects in 2021, rising energy prices, pushed energy costs up by ~25%, offsetting the reduction seen in 2020.

Based on the decomposition analysis, the higher decline in energy costs occurred in the *Refined petroleum products* (-42%) in 2020 compared to 2019. The main driver of this decrease in energy costs is attributed to the energy price effect (-25%) followed by the output effect (-13%) that could be explained by the reduced demand for oil from reduced industrial activity and less travel.

Comparing these results with the decomposition analysis in the period 2014–2021 we conclude that the increase in the energy costs mainly occurred in the last year accounted (2020–2021) with the rise in production and energy prices to be the primary drivers.

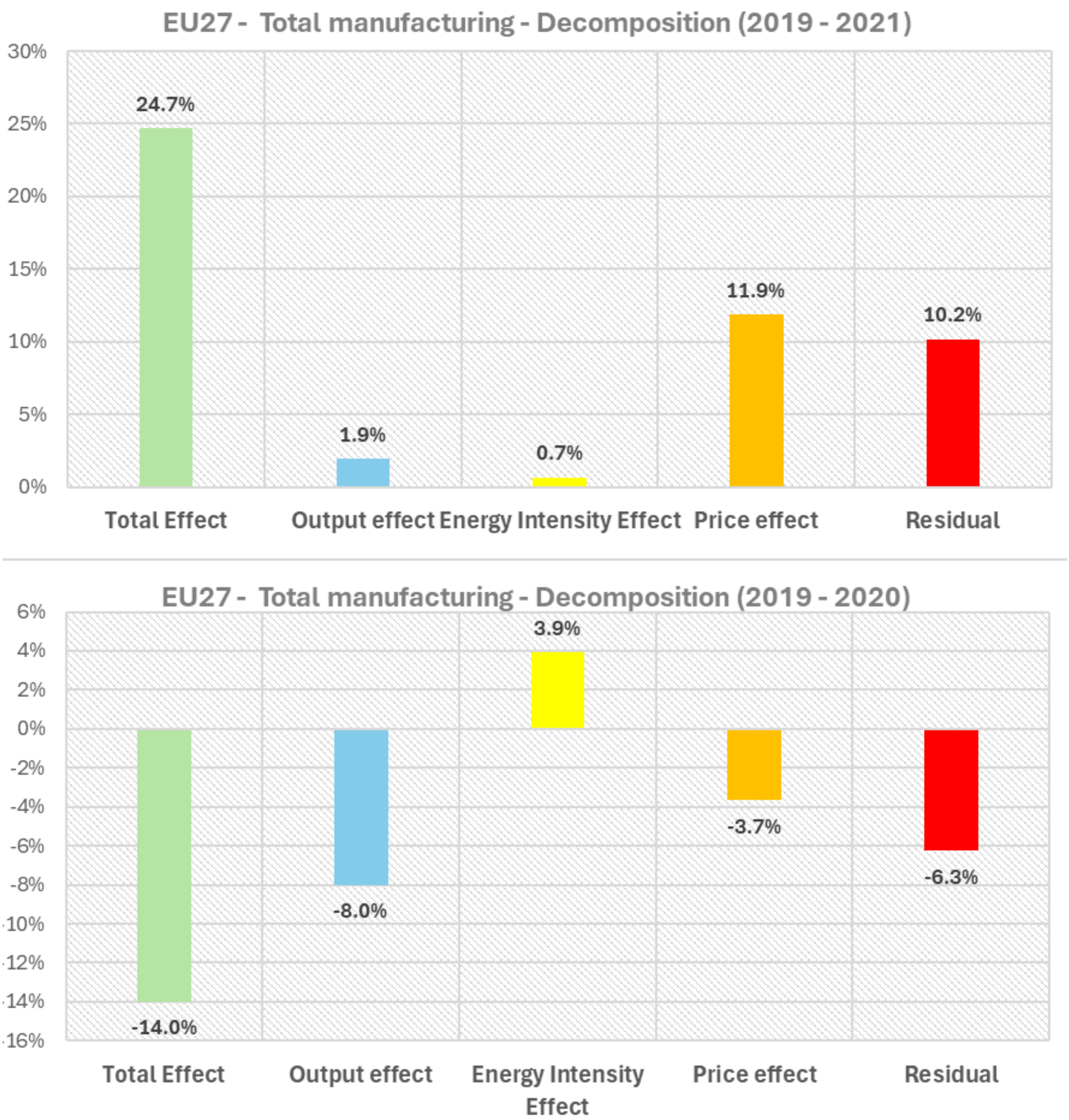

Figure 139: Decomposition analysis in total manufacturing in EU for the periods 2019–2021 and 2019–2020

Non-EU countries results

This section focuses on the results of the decomposition analysis of energy costs in industries in non-EU countries. Due to significant data limitations, the analysis in this subsection is limited to selected sectors and is conducted exclusively for the UK (United Kingdom) and US (United States). No gap-filling techniques were used for non-EU countries; therefore, in the US, only sectors with complete datasets were considered.

In the UK manufacturing sectors (excluding sectors with incomplete data), energy costs increased by 65.8% between 2014 and 2021. The primary driver of this change is the increase in energy prices, contributing 54.1% to the total energy cost change. This increase is largely attributed to the electrification of the chemical industry, which reduced the share of gas in the fuel mix.

Output also played a significant role, increasing energy costs in the *Manufacturing* sector by 20.7% in the UK. On the other hand, improvements in energy intensity tended to decrease energy costs, contributing -9.0% to the total change in energy costs for the total manufacturing sector.

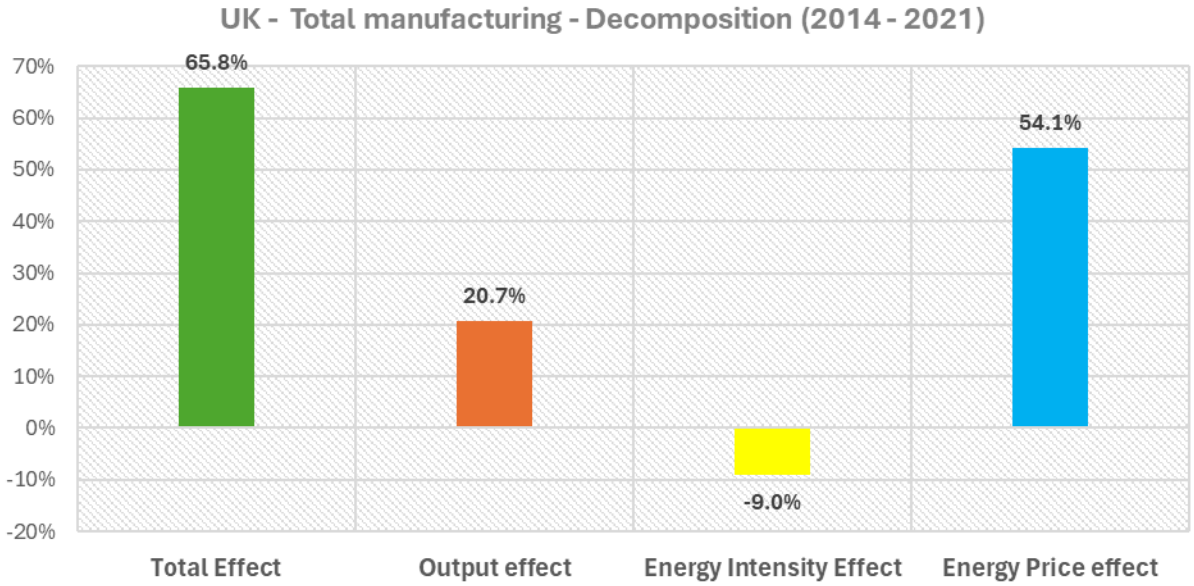

Figure 140: Decomposition analysis of the energy costs in UK

In the US the total manufacturing energy costs have increased by 23.4% in the period 2014-2021, however, it is important to note that only two sectors (Other non-metallic mineral products and Wood and products of wood and cork) have been considered due to data limitations. The main drivers that tend to increase energy costs are the energy price by 28.4% and output by 20.4%, while energy intensity improves and tends to decrease the energy costs by 25.4%.

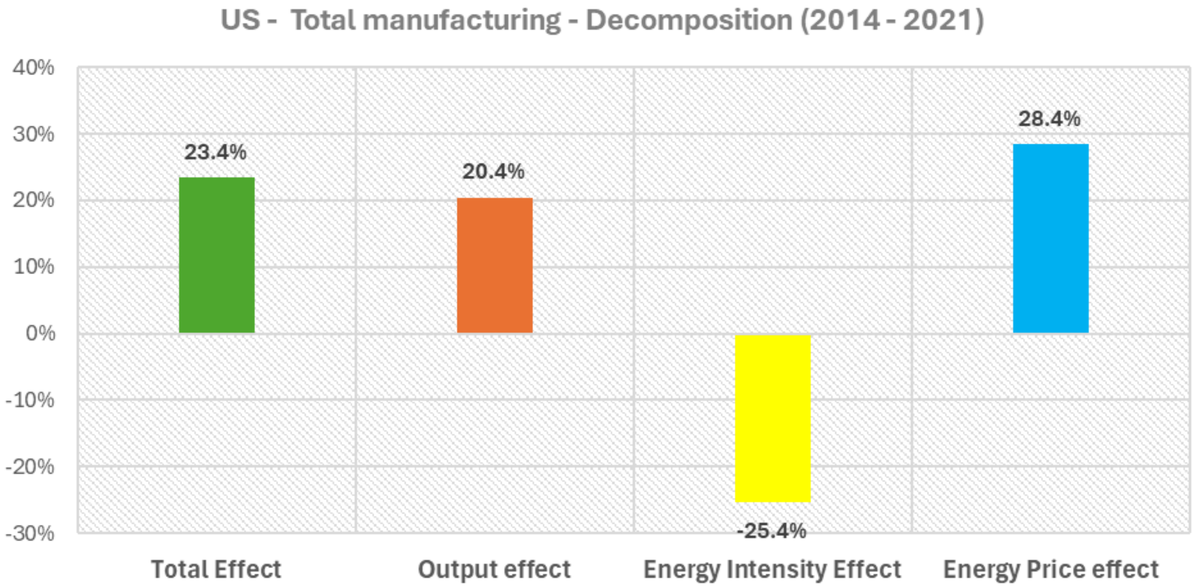

Figure 141: Decomposition analysis of the energy costs in the US

As shown in Table 24, the energy price is the main driver of the increase in energy costs across sectors in the UK. Increases in output drive up the energy costs especially in Basic iron and steel and of Ferro-alloys and *Textiles* sectors. In the *Wearing apparel* sector, the energy intensity worsened which also tended to increase the energy costs. Finally, in the Leather and related products sector, improvements in the energy intensity reduce the energy costs of the industry.

Table 24: Decompostion analysis of the energy costs in the UK by sector (2014–2021)

NACE code	Description	Output effect	Energy Intensity Effect	Price effect	Total effect	EI (toe/mn. EUR)
C23	Other non-metallic mineral products	36%	-21%	**37%**	51%	151
C241	Basic iron and steel and of ferro-alloys	**58%**	-81%	23%	1%	147
C192	Refined petroleum products	-10%	-6%	**36%**	20%	120
C244	Basic precious and other non-ferrous metals	-5%	12%	**37%**	44%	73
C13	Textiles	**51%**	-67%	36%	20%	54
C20	Chemicals and chemical products	2%	135%	**213%**	350%	45
C14	Wearing apparel	-60%	**50%**	30%	20%	42
C15	Leather and related products	5%	**-37%**	29%	-2%	27
C27	Electrical equipment	25%	-39%	**26%**	12%	24
C26	Computer, electronic and optical products	23%	-25%	**33%**	31%	19
TC	Total manufacturing	21%	-9%	**54%**	66%	52

In the US, the only cases that have been considered are the Other non-metallic mineral products and Wood and products of wood and cork. For the rest of the sectors there was a lack of data for calculating at least one of the three components required for the decomposition analysis. In the non-metallic mineral product sector, the energy price is the main driver of the energy costs in the industry which increases the energy costs by 26%. In the wood products sector the output is the main driver of the change in energy costs followed by the energy price and energy intensity.

Table 25: Decompostion analysis of the energy costs in the US by sector (2014–2021)

NACE code	Description	Output effect	Energy Intensity Effect	Price effect	Total effect	EI (toe/mn.EUR)
C23	Other non-metallic mineral products	10%	-27%	**26%**	9%	171
C16	Wood and of products of wood and cork	**36%**	4%	11%	52%	59
TC	Total manufacturing	20%	-25%	28%	23%	124

5.7.4. Impact of energy costs on total production costs

This section presents the decomposition analysis for:

1. Total production costs of the EU industries, split into 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 the 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 sectors that are included in the analysis are listed in Table 26 and Table 27 sorted by the energy intensity of the sector and including NACE code classification.

Table 26: Sectors at NACE 2 level – production cost decomposition analysis in EU-27 (sorted by energy intensity)

NACE code	Description	EI (toe/mn.EUR)
C20	Chemicals and chemical products	229
C17	Paper and paper products	177
C23	Other non-metallic mineral products	176
C19	Coke and refined petroleum products	170
C24	Basic metals	147
C16	Wood and of products of wood and cork	68
C13	Textiles	33
C10	Food products	32
C22	Rubber and plastic products	30
C11	Beverages	26
C18	Printing and reproduction of recorded media	26
C21	Basic pharmaceutical products and pharmaceutical preparations	26
C25	Fabricated metal products, except machinery and equipment	19
C32	Other manufacturing	19
C33	Repair and installation of machinery and equipment	12
C27	Electrical equipment	11
C31	Furniture	11
C28	Machinery and equipment n.e.c.	11
C29	Motor vehicles, trailers and semi-trailers	8
C26	Computer, electronic and optical products	7
C12	Tobacco products	7
C30	Other transport equipment	7
C15	Leather and related products	6
C14	Wearing apparel	0
TC	Total manufacturing	56

Table 27: Sectors at NACE 3 level – production cost decomposition analysis in EU-27 (sorted by energy intensity)

NACE code	Description	EI (toe/mn.EUR)
C235	Cement, lime and plaster	587
C171	Pulp, paper and paperboard	494
C233	Clay building materials	348
C201	Basic chemicals, *Fertilisers* and nitrogen compounds, plastics and synthetic rubber in primary forms	278
C206	Man-made fibres	236
C241	Basic iron and steel and of ferro-alloys	205
C192	Refined petroleum products	184
C237	Cutting, shaping and finishing of stone	179
C172	Articles of paper and paperboard	176
C231	Glass and glass products	176
C106	Grain mill products	115
C244	Basic precious and other non-ferrous metals	88
C161	Sawmilling and planing of wood	75
C245	Casting of metals	75
C239	Abrasive products and non-metallic mineral products n.e.c.	59
C103	Processing and preserving of fruit and vegetables	53
C232	Refractory products	50
C132	Weaving of textiles	33
C234	Other porcelain and ceramic products	29
C222	Plastics products	25
C272	Batteries and accumulators	11
C291	Motor vehicles	8
TC	Total manufacturing	56

Results

The decomposition analysis of the total manufacturing costs shows that changes in energy costs provide for a very small contribution to the changes of the total production costs, contributing 0.4% of the 29.2% total increase of production costs between 2014 and 2021.

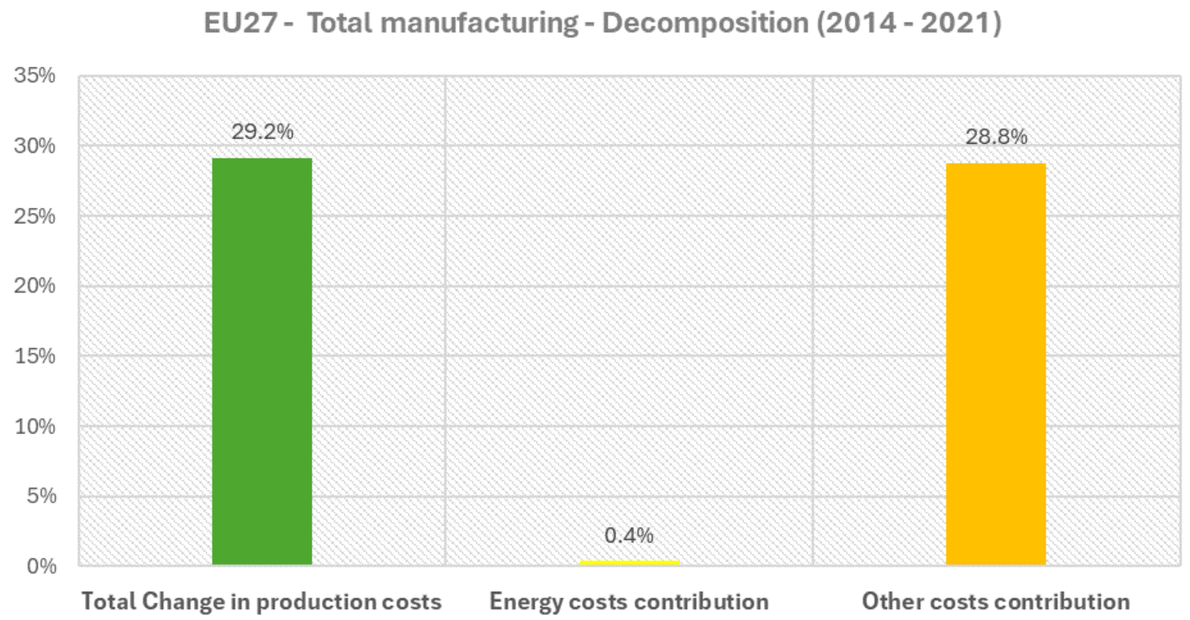

Figure 142: Decomposition of total production costs for total manufacturing in EU-27

Table 28 shows the results of the decomposition analysis of total production cost changes in EU by sector. Energy intensive sectors experience a higher contribution of energy costs to the changes of the total production costs than other sectors. However, also in energy intensive sectors, the energy cost contributions are small compared to other cost increases. The highest increase in total production costs is in non-energy intensive sectors such as *Tobacco products*, *Basic pharmaceutical* and *Other manufacturing products* where the contribution of energy cost increases to the total production cost increases is very small.

Table 28: Results of the decomposition analysis in total production costs in the EU by sector.

Nace code	Description	Total change in production costs	Energy costs contribution	Other costs contribution
C20	Chemicals and chemical products	32.6%	2.3%	30.2%
C17	Paper and paper products	23.6%	0.5%	23.2%
C23	Other non-metallic mineral products	31.2%	1.0%	30.2%
C19	Coke and refined petroleum products	3.8%	-0.1%	3.8%
C24	Basic metals	46.2%	1.1%	45.2%
C16	Wood and of products of wood and cork	48.1%	0.7%	47.4%
C13	Textiles	12.7%	0.0%	12.7%
C10	Food products	23.0%	0.3%	22.8%
C22	Rubber and plastic products	31.4%	0.4%	30.9%
C11	Beverages	28.2%	0.1%	28.1%
C18	Printing and reproduction of recorded media	-10.3%	-0.2%	-10.1%
C21	Basic pharmaceutical products and pharmaceutical preparations	53.6%	0.0%	53.7%
C25	Fabricated metal products, except machinery and equipment	35.3%	0.2%	35.1%
C32	Other manufacturing	55.4%	0.2%	55.2%
C33	Repair and installation of machinery and equipment	12.2%	-0.1%	12.3%

Nace code	Description	Total change in production costs	Energy costs contribution	Other costs contribution
C27	Electrical equipment	42.2%	0.0%	42.2%
C31	Furniture	27.7%	0.1%	27.6%
C28	Machinery and equipment n.e.c.	30.8%	0.0%	30.8%
C29	Motor vehicles, trailers and semi-trailers	28.0%	0.0%	28.0%
C26	Computer, electronic and optical products	14.3%	0.0%	14.2%
C12	Tobacco products	71.2%	-0.3%	71.5%
C30	Other transport equipment	46.3%	0.1%	46.3%
C15	Leather and related products	0.0%	-0.1%	0.1%
C14	Wearing apparel	2.4%	0.0%	2.4%
TC	Total manufacturing	29.2%	0.4%	28.8%

Figure 143 and Figure 144 shows the share of energy costs in total production costs by industry in 2014 and 2021. Figure 143 shows the shares in NACE 2-digit code while Figure 144 shows the shares in the more disaggregated NACE 3-digit code.

The analysis show that in all sectors except Chemical we observe a reduction in the share of energy costs to total production costs. As mentioned in the previous sub-section, in this sector Belgium experienced a high increase in energy costs (EUROSTAT SBS database.) that contributes to this increase of share in 2021 compared to 2014. The energy intensive sectors experience the highest decline in the share of energy costs to total production costs. Among the energy intensive sectors Cement, lime and plaster faces the highest share in energy costs but also a significant decline of this share in the year 2021.

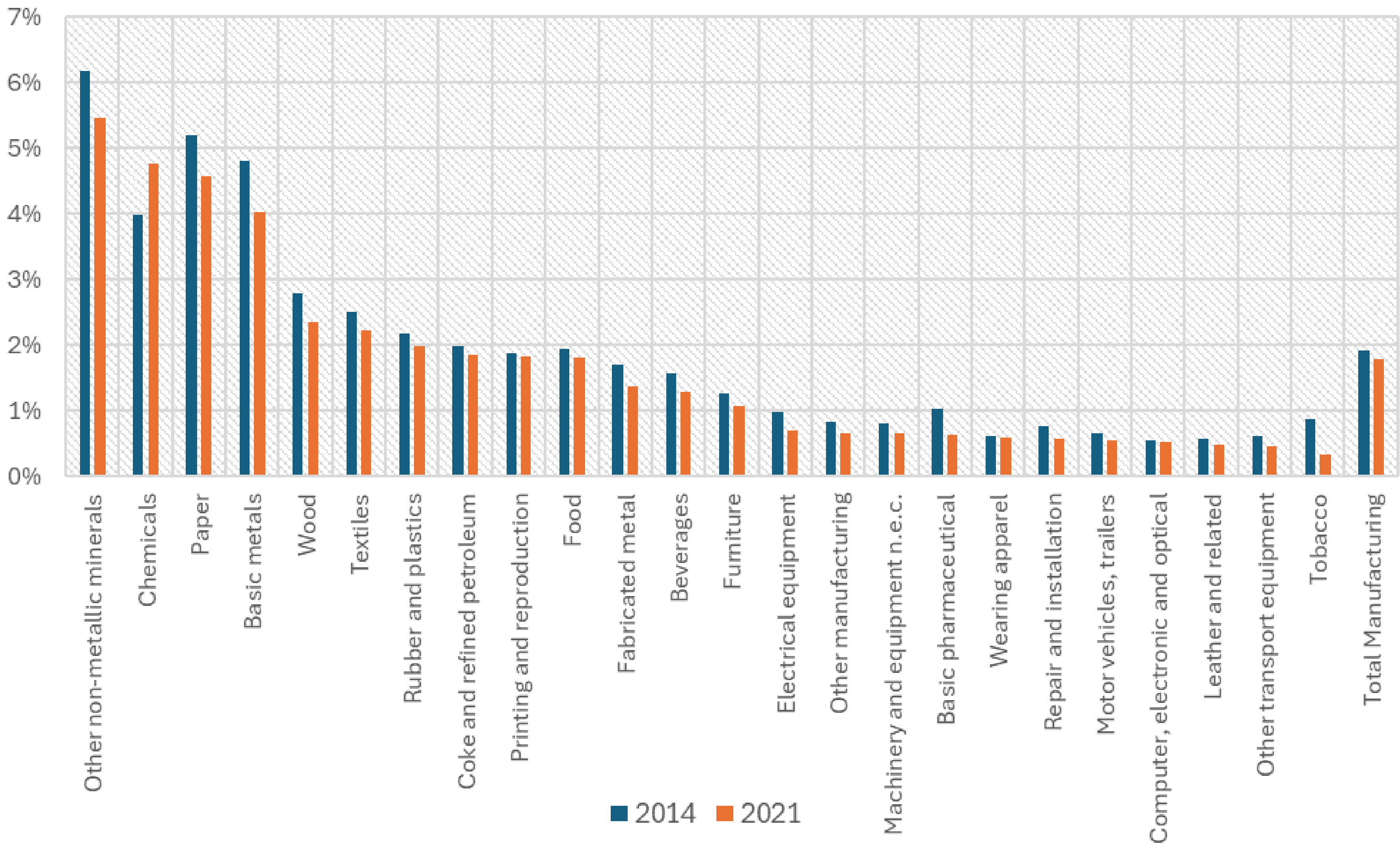

Figure 143: Share of energy costs in total production costs in EU by NACE 2-digit sectors (sorted by share 2021)

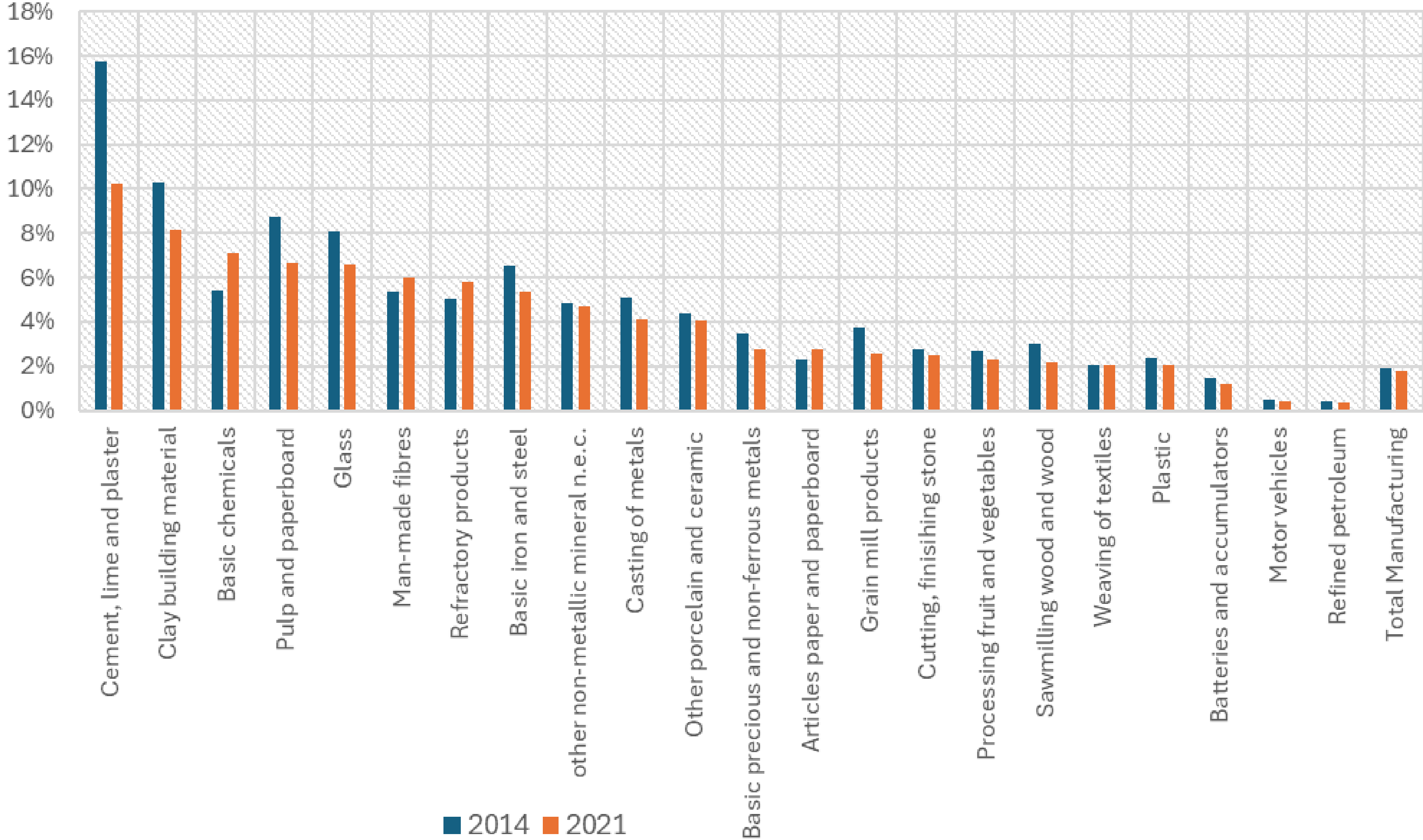

Figure 144: Share of energy costs in total production costs in EU by NACE 3-digit sectors (sorted by share 2021)

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:

- We used sectoral level deflators (as in the previous section) to deflate prices into constant prices for 2015.
- We calculated EU 27 output data based on the data that was available per sector and country, removing any intra EU-trade.
- No gap-filling techniques were used and only NACE 2-digit sectoral classification was used.
- As we could not find data for any non-EU country from the same source and for all components required for the analysis, the sub-section is focused solely on the EU and Member States.

Results

Figure 145 shows the decomposition analysis of output change in the EU and for each Member State where data was complete for all sectors. The EU registered an increase in output by 17% where the domestic demand was the main driver of this change contributing by 16% followed by exports with 5% and the increase in imports driving the output downwards by 3%. Among the Member States that are depicted in Figure 145, Poland experienced the highest increase in the output primarily driven by domestic demand.

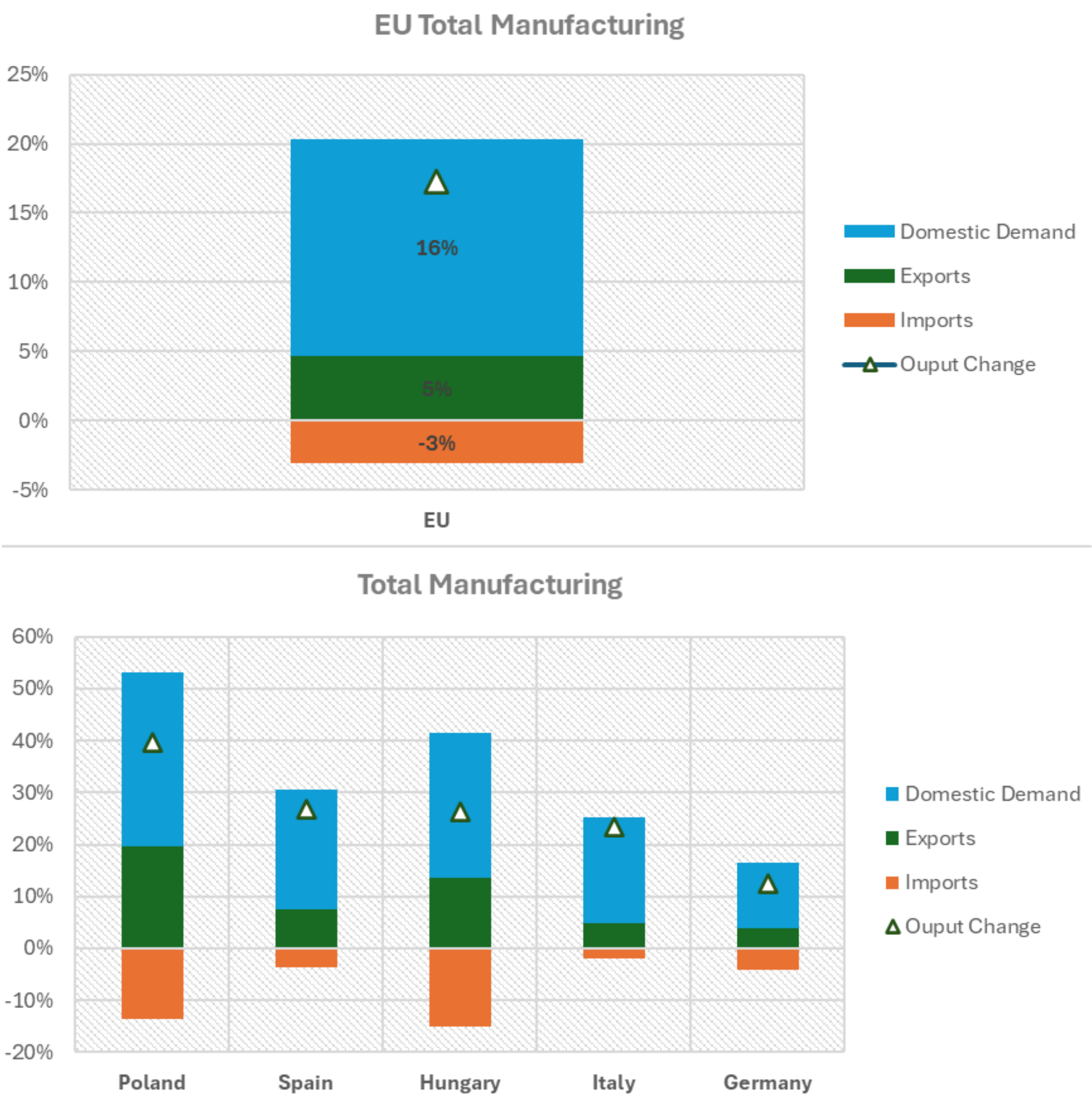

Figure 145: Decomposition analysis of output changes in 2021 compared to 2014

As shown in Figure 146, on a sectoral level, *Basic pharmaceutical products* have experienced the highest increase in production, primarily driven by domestic demand. Across all sectors, the main driver of output is domestic demand. Exceptions include *Wearing apparel*, where exports are the primary driver, and *Coke and refined petroleum*, which have seen a decline in imports.

Tobacco products show the highest decline in output, corresponding to the sector's highest increase in production costs as described in the previous subsection. Conversely, *Basic pharmaceuticals* and *Other manufacturing* sectors have seen an increase in output but also a significant rise in production costs over the same period.

Further analysis and data collection would be required to disaggregate these effects. Increases in the prices of labour, capital, and materials tend to decrease output, whereas an increase in output tends to raise total production costs.

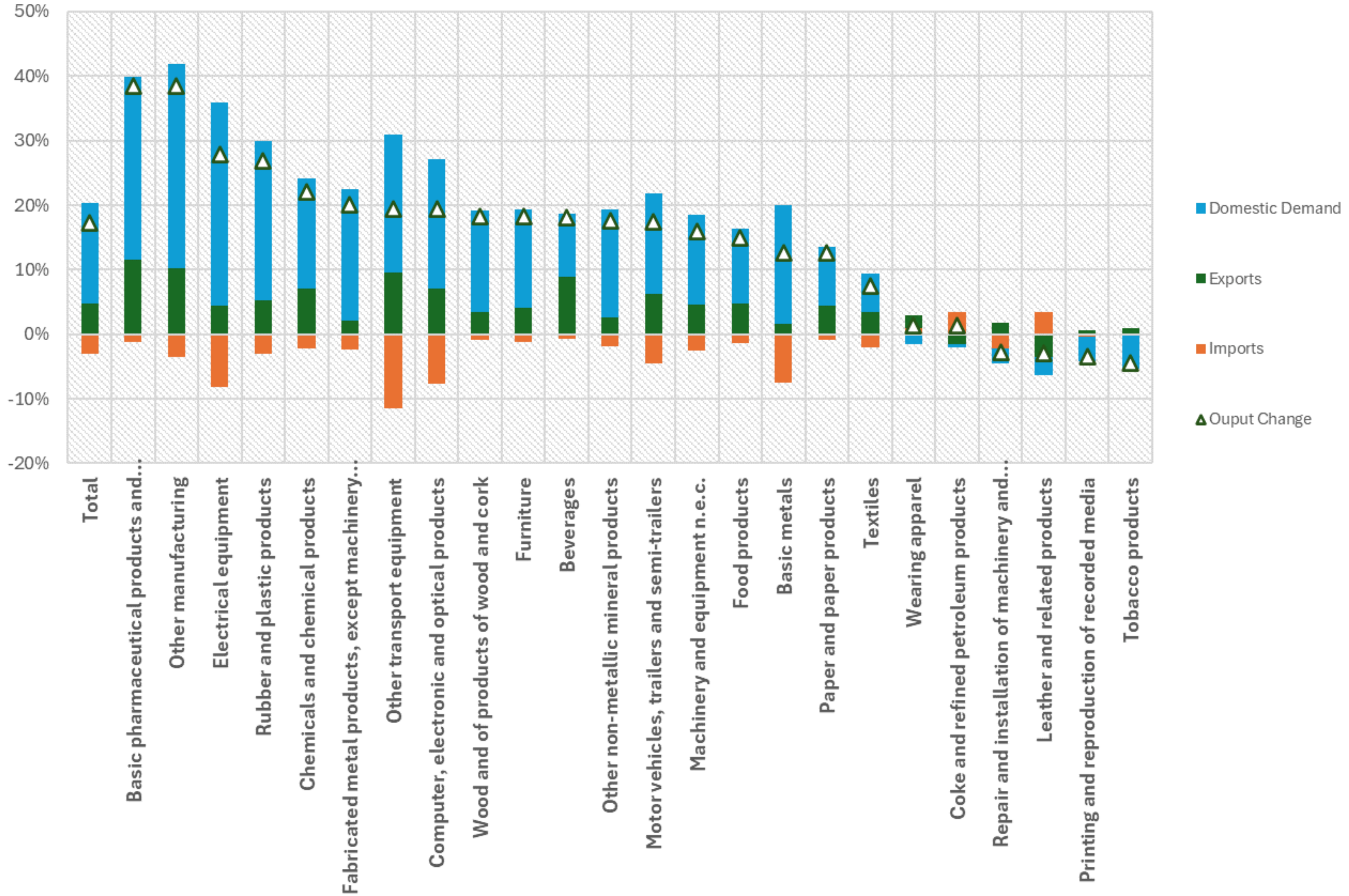

Figure 146: Decomposition analysis of output changes by sector in EU in 2021 compared to 2014

5.8. International comparisons of energy costs and intensities

Key takeaways

- The United States of America, China and the United Kingdom are the top trade partners of the EU in terms of total trade value.
- Energy cost shares from 2014 to 2021 tend to be similar or lower to those of most international trade partners. However, energy cost shares are relatively high in the EU in the *Man-made fibres* and *Cement, lime and plaster*.
- Based on gross operating surplus as a share of production costs, profitability of EU manufacturing sectors tends to be lower than those of the EU's main trading partners. However, profitability tends to be more volatile in most non-EU G20 countries.
- Energy intensities of EU Member States tend to be lower than in other countries with the exception of *Pulp and paper* as well as *Refineries*, where the EU is one of the most energy intensive. This is due to higher energy consumption levels on average in EU plants.

This section examines factors influencing the international competitiveness of the EU industry, specifically focusing on energy costs compared to non-EU G20 countries alongside Switzerland, Norway and Iceland. These nations constitute the primary trading partners of the EU, as indicated in Table 29. Based on data from 2023, the United States of America, China and the United Kingdom emerge as the foremost trade partners of the EU.

Table 29: EU trade in goods by partner (2023)

Country	Group	Total Trade Value (bln EUR)	Share
USA	G20	848.9	16.7%
China	G20	738.4	14.6%
UK	G20	515.0	10.1%
Switzerland	Non-G20	327.1	6.4%
Türkiye	G20	207.0	4.1%
Norway	Non-G20	180.9	3.6%
Japan	G20	134.5	2.6%
South Korea	G20	130.9	2.6%
India	G20	113.5	2.2%
Russia	G20	89.0	1.8%
Brazil	G20	87.5	1.7%
Mexico	G20	81.7	1.6%
Canada	G20	76.4	1.5%
Saudi Arabia	G20	70.7	1.4%
Australia	G20	52.1	1.0%
South Africa	G20	49.2	1.0%
Indonesia	G20	29.7	0.6%
Argentina	G20	16.8	0.3%
Iceland	Non-G20	8.8	0.2%
Other partners	Non-G20	2165.3	42.7%

Source: Eurostat (2024) DS-059328 - EU trade since 2002 by BEC/rev.4.:

To understand the reasons behind the differences in energy costs, a comparison is made between the amount of energy costs in the production cost, the GOS as a share of production costs and the energy intensity. This analysis is specifically carried out for the manufacturing sectors, as non-manufacturing sectors are less subject to direct international competition. However, due to the limited availability of data on energy costs and energy intensity, the findings should be approached with caution.

In this section, we have analysed the differences in energy product prices across countries for which sufficient data was available. These prices play a crucial role in determining short-term energy expenses and cost variations. The analysis will focus mainly on the retail prices of industrial electricity and gas, as these two energy sources are often the primary factors contributing to industrial energy costs.

5.8.1. EU energy costs vs other G20 countries

It is possible to assess the impact of energy costs on the competitiveness of EU industries by comparing the amount of production costs that go towards energy in the EU sectors against those of other G20 countries. However, there is limited data available on energy cost shares in production for non-EU G20 partners, making it difficult to make a comprehensive comparison. Energy cost shares for trade partners where data on energy product purchases, personnel costs and total purchases of goods and services are available have be shown. In cases where data is not available, gaps have been estimated using the methods explained in 5.7.2.

Figure 147 displays the energy cost shares of the most energy-intensive manufacturing sectors for which data is available. Among the non-EU G20 countries, energy cost shares could only be calculated or estimated for sectors in the United States, United Kingdom, Türkiye, Norway, Japan and Mexico, based on data from one or more years between 2014 and 2021. For the remaining non-EU G20 countries, data on energy consumption, energy prices, or both, was not available from public statistics.

International trends in energy cost shares show sector-specific variation, generally aligning with the findings of the previous edition of the study. Particularly noteworthy are the observations across the most energy-intensive subsectors in Figure 147:

- On average, the energy cost shares of the EU in the period 2014–2021 are similar or lower to those of most international trade partners;
- When analysing the energy costs share in the most energy-intensive manufacturing sectors among the trading partners where information is available, the EU only ranks highest in *Man-made fibres*. The EU also had a relatively high energy costs share in the *Cement, lime and plaster* sector. On the other hand, the EU has relatively low average energy costs shares in *Refineries* and *Basic chemicals* as well as *Stone* and *Non-ferrous metals*.
- Norway has the highest energy costs shares in the Basic Metals industry – *Iron and steel* and *Non-ferrous metals* sectors. This is attributed to their comparatively higher energy consumption.
- Energy costs shares are significantly higher in Japan for the *Pulp and paper* sector than in the other countries covered. Energy costs shares are also relatively high in Japan in the *Basic Chemicals* sector compared to other countries.
- There is no sector where the United Kingdom has the highest energy costs as percentage of total production costs, even though the country has a relatively high-cost share in *Man-made fibres*, *Refineries*, *Glass* and *Clay building materials*.
- The United States and Mexico seem to have a significantly higher energy cost share in fossil fuel-intensive sectors like *Weaving of textiles*, *Sawmills*, and *Basic chemicals* compared to the EU. In other words, on average, this implies that sectors within the EU would be less

impacted by fluctuations in energy prices relative to other production costs compared to the same sectors in Mexico and the United States. However, studies comparing products costs in subsectors *Basic chemicals* indicate that the average total energy costs in the EU are higher than those in the United States and Middle East for the same subsector[329]. Thus, the energy costs shares are lower in the EU not because absolute energy costs are lower, but because other production costs (particularly costs for non-energy use of energy products as feedstock) in the EU are much higher compared to other countries. This would mean that these sectors are actually more affected by changes in fossil fuel prices compared to their counterparts in the main trading countries.

The energy cost shares in the less energy-intensive manufacturing sectors show a similar pattern for the EU as the most energy-intensive sectors, as illustrated in Figure 148. For most sectors, the EU's energy cost shares fall around the average of the countries analysed. For *Refractory products* and *Abrasive products*, the EU ranks highest in terms of energy costs shares compared to the other trading partners. Namely, Mexico records the highest energy cost shares in *Plastic products*, *Porcelain and ceramics*, *Stone* and *Casting of metal*. Additionally, Japan has the highest energy cost shares of the countries where data is available for *Other transport equipment*.

It is important to note that the sectors that are analysed are made up of various subsectors, so observation might not hold true for specific subsectors within these sectors. Additionally, the impact of energy costs in the production costs of a sector in a country is strongly influenced by the composition of the sector.

[329] *See e.g. Boulamanti and Moya (2017). Production costs of the chemical industry in the EU and other countries: Ammonia, methanol and light olefins; CEFIC (2024). 2023 Facts And Figures Of The European Chemical Industry – Growth and competitiveness.*

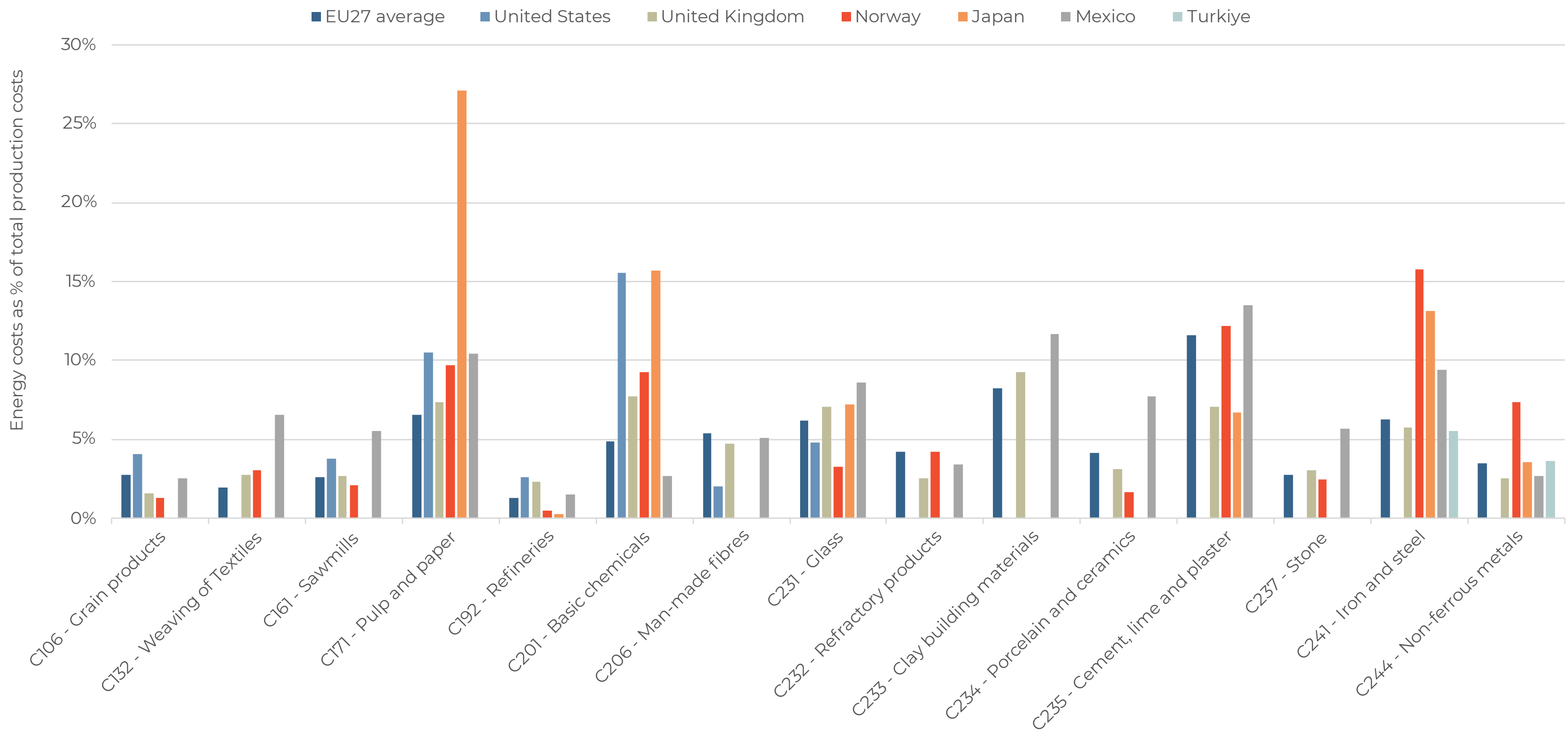

Figure 147: Energy cost shares in production costs of the most energy-intensive manufacturing sectors in the EU and main trading partners with available data, 2014–2021 average

Source: Own calculations based on Eurostat SBS, National data sources, S&P database and OECD SISS database

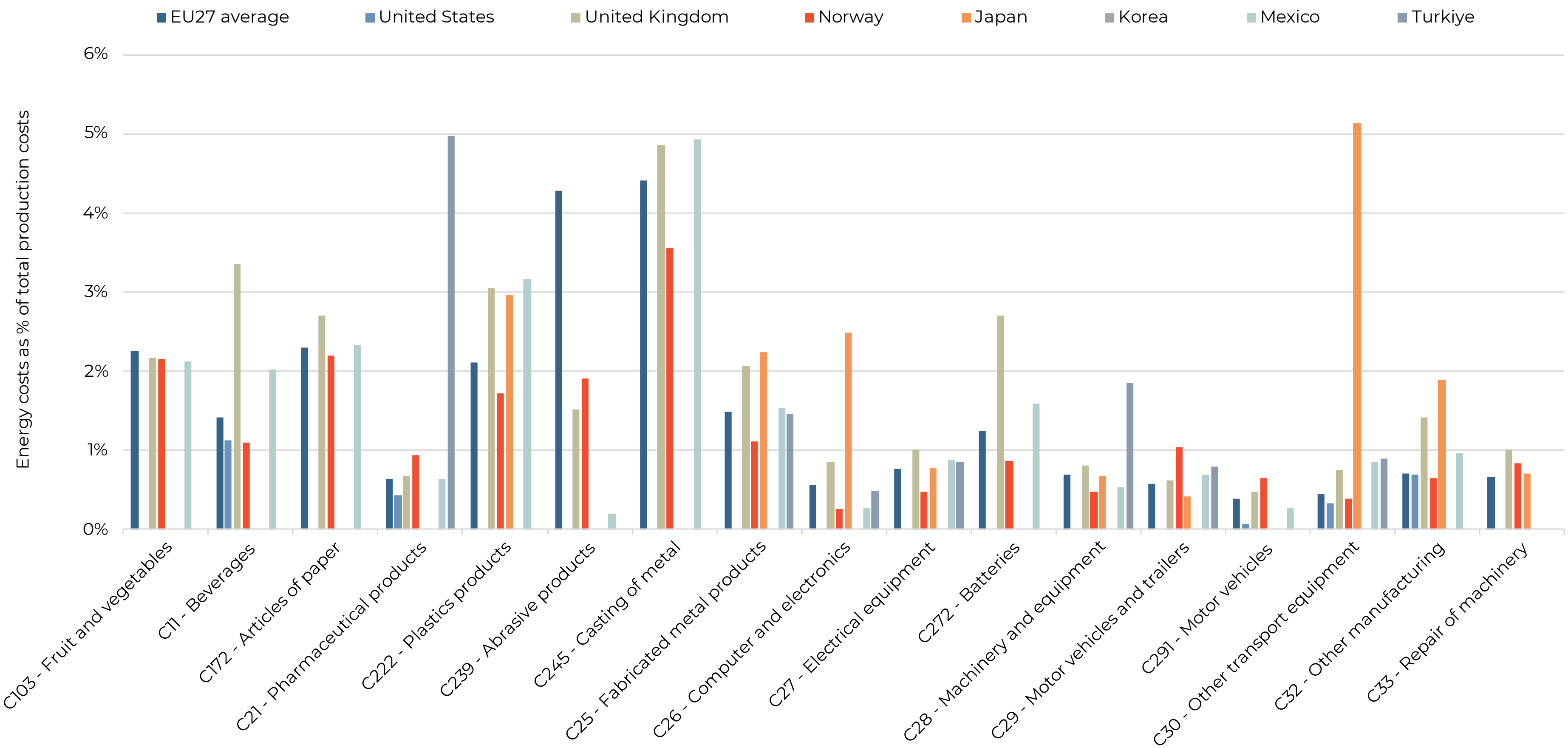

Figure 148: Energy cost shares in production costs of the less energy-intensive manufacturing sectors in the EU and main trading partners with available data, 2014–2021 average

Source: Own calculations based on Eurostat SBS, National data sources, S&P database and OECD SISS database

5.8.2. Gross Operating Surpluses of EU sectors vs other G20

Comparing the EU's share of GOS in production costs with that of the main trading partners offers insight into sector profitability and competitive positioning. Figure 149 illustrates the average GOS share for the EU across all manufacturing sectors compared to the average GOS share of the manufacturing sectors of the main trading partners for which data is available.

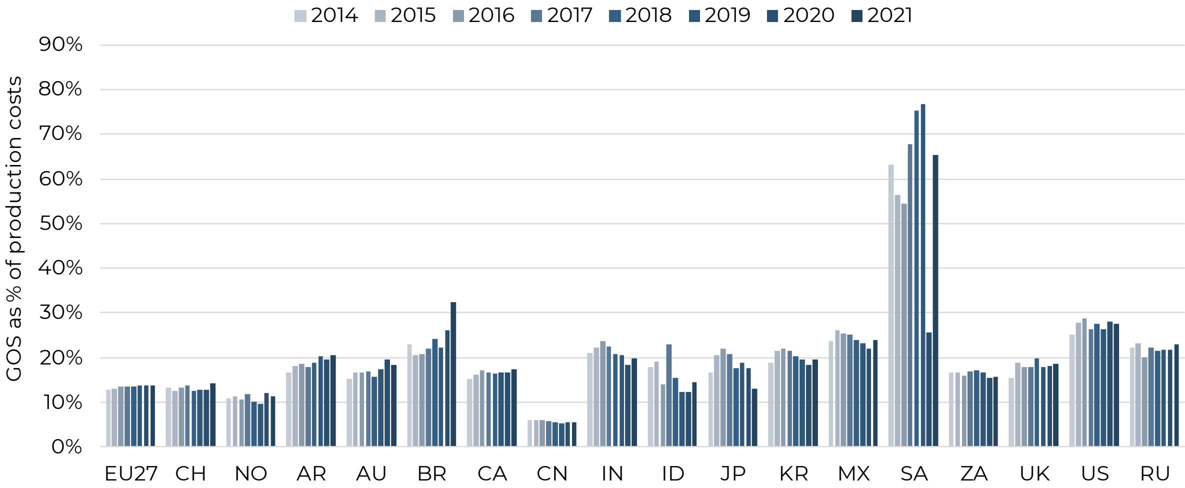

Figure 149: Gross Operating Surplus as a share of production costs, averaged across all available manufacturing sectors

Source: Own calculations based on Eurostat SBS and S&P database.

The analysis results indicate that the average profitability of the EU ranges between 10% and 15% in the time period 2014 to 2021. This is lower than some of EU's main trading partners, which have an average GOS share between 15% and 25% (e.g. Brazil, India, Japan, South Korea, Mexico, The United Kingdom and the United States). In the figure, Saudi Arabia stands out as a top outlier, with an average GOS share between 50% and 80%. This is primarily due Saudi Arabia's concentration in *Refineries* and *Basic chemicals* sectors, which are exceptionally profitable for the country. China stands alone with a proportional lower GOS share for its manufacturing sector, ranging between 5% and 10%, primarily due to the elevated costs in 'Total purchases of goods and services' across all sectors with available data.

On average, the profitability of manufacturing sectors in the EU tends to be less volatile than that of most G20 countries. Since 2014, the GOS share of the EU has gradually increased, similar to that of Argentina, Australia and Brazil. However, the GOS of Japan, India, South Korea, and Mexico has decreased gradually over the same period. Notably, Saudi Arabia has the highest overall GOS share by far in the 2014-2021 period, with the exception of 2020, the year with the COVID-19 restrictions at its height.

5.8.3. Energy intensity of EU sectors vs G20 countries

Energy efficiency affects the international competitiveness of companies and provides valuable insights into drivers of energy cost shares. Greater energy efficiency leads to lower relative energy consumption and associated costs compared to competitors. By comparing energy intensities across sectors and countries, we gain insights into energy efficiency levels within these sectors and countries. Additionally, international data on energy intensity is often limited, especially for recent years. Therefore, for international comparisons, energy intensity has been calculated as an average over 2014–2021.

Figure 150 shows the energy intensities of the most energy-intensive manufacturing sectors, averaged over time in both the EU and main trading partners for which sufficient data is available.

The energy intensities within these manufacturing sectors show significant variation across countries. Similar to finding in previous editions of this study:

- Energy intensities of EU energy intensive industries tend to be comparable or lower than in other countries with the exception of *Pulp and paper* as well as *Refineries*, where the EU is one of the most energy intensive. This is due to higher energy consumption levels on average in EU plants. For *Refineries*, Türkiye has the highest energy intensity;
- The EU has the lowest intensity levels of all international counterparts for which data was available in *Cement, lime and plaster*. The United Kingdom has very high intensity levels, which could be explained by the relative low value added.

Figure 151 illustrates the comparison of energy intensities of the less energy-intensive manufacturing sectors. The analysis highlights that data for comparison is unavailable for many sectors. Among the sectors with available data for international comparison, the EU shows higher- intensity levels compared to countries where data is available for *Fruits and vegetables* and *Stone*.

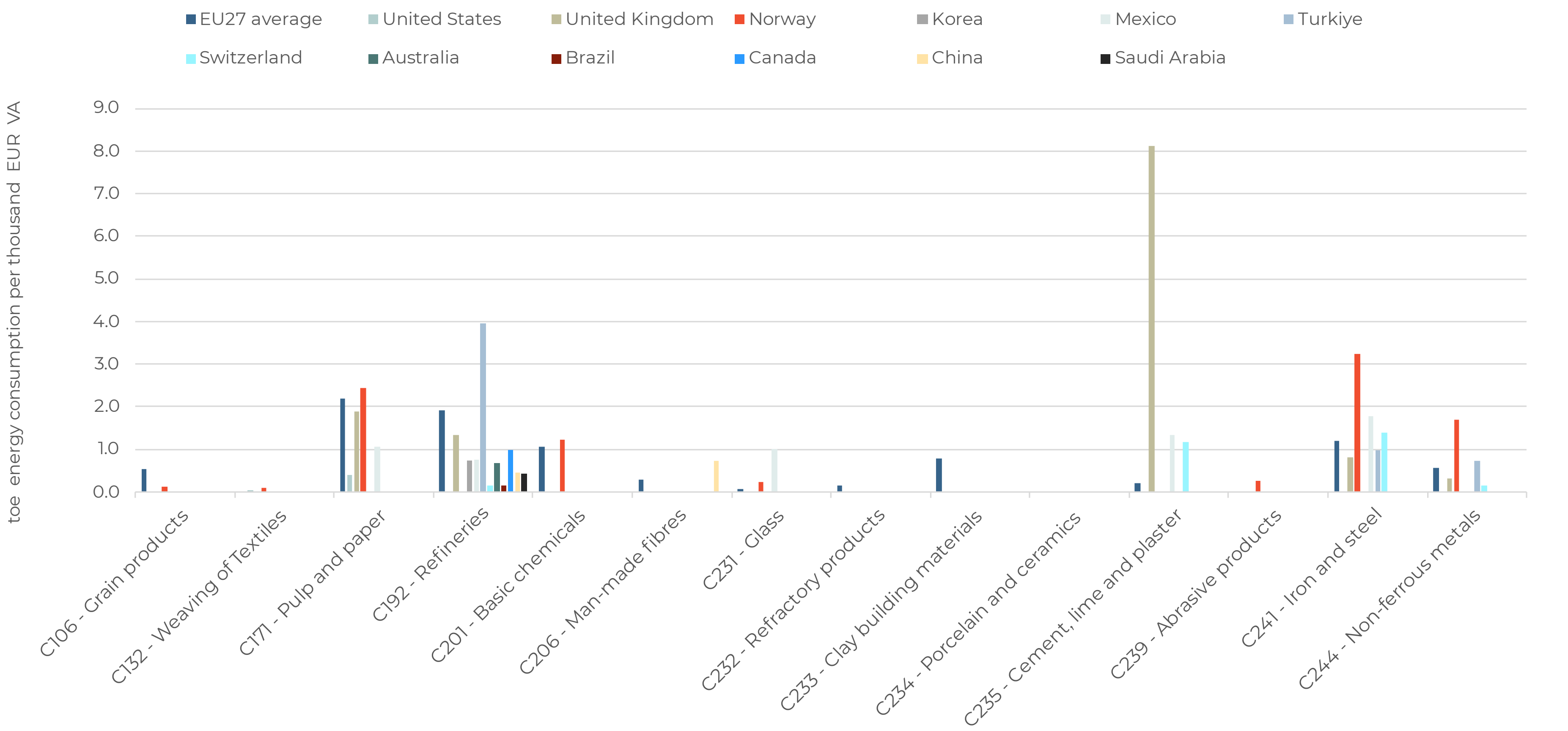

Figure 150: Energy intensities of the most energy-intensive manufacturing sectors in the EU and main trading partners with available data, 2014-2021 average

Source: Own calculations based on S&P database and national sources

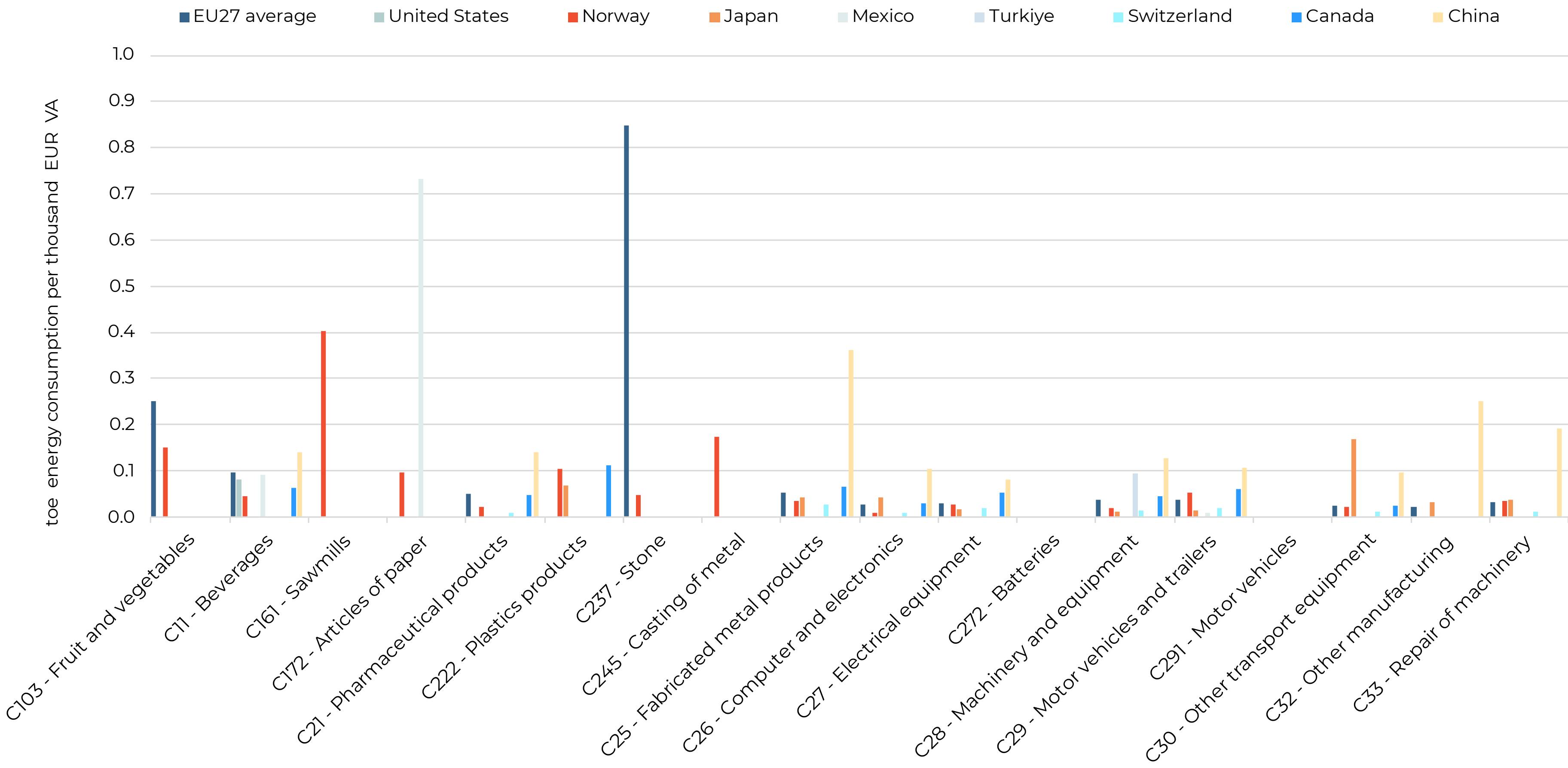

Figure 151: Energy intensities of less energy-intensive manufacturing sectors in the EU and main trading partners with available data, 2014–2021 average

Source: Own calculations based on S&P database and national sources

5.8.4. Industrial electricity prices: EU vs G20 countries

Please refer to analysis in Section 2.22.

5.8.5. Industrial gas prices: EU vs G20 countries

Please refer to analysis in Section 3.2.2.

5.9. Price hedging and other arrangements in energy-intensive industries

Key takeaways

- The European PPA market has grown at an annual growth rate (CAGR) of 37% in the period 2018–2023.
- Key regions for RES PPA in the EU are Spain, with 22% of the total contracted capacity, Germany with 13%, and Sweden with 12%.
- Successful hedging (that essentially leads to risk reduction) requires transactions where the contracting parties involved have opposite risk profiles. PPAs become increasingly popular as they are quite flexible since they can be structured in several different ways depending on which party is willing to accept risk relating to volume or pricing requirements.
- Solar PV deals accounted for the majority of contracted PPA capacity, rising from 30% to 60% between 2022 and 2023. This change is driven by increased wind power equipment costs due to high inflation, causing off-takers to hesitate on wind PPAs.

5.9.1. Introduction to price hedging

Hedging is a strategy to reduce the risk of price fluctuations in the energy market. It involves the fixing of prices at a set level for a period of time, so that buyers are protected from price rises, particularly when the market is highly volatile, while producers are guaranteed a stream of income. There are a number of instruments that can be used for hedging, including bilateral contracts between energy producers and buyers or through access to energy markets. The parties involved in hedging will take on varying levels of risk depending on the characteristics of the agreement, but effective hedging should involve parties with opposite risk profiles.

There are a number of different strategies for hedging. The most common of these are:

- Hedging Tolling Contracts
- Energy forwards
- Energy futures: swaps
- Contract for Differences (CfDs)
- Spreads
- Options
- Structured power purchase agreements (PPAs)

5.9.2. PPA Contracts

A common hedging agreement takes the form of PPAs, which are becoming key tools for promoting the expansion of renewable energy. A PPA is a bilateral contract between an energy producer and a buyer of that energy[330] and involves the setting of a fixed price for the supply of energy for the

[330] *By regulating who can engage in RES PPAs, the aim is to create a level playing field where all market participants operate under the same rules, thus fostering fair competition. Direct PPAs between producers and buyers promote transparent pricing*

duration of the contract (usually at least one year). This provides a guarantee of revenue for the producer to invest in the expansion of their operations and of price stability for the buyer to reduce the volatility of their operations. PPAs can take a variety of forms depending on the requirements and characteristics of the contracting parties. These various contract structures also entail a range of different risks for both the buyer and producer, including potential over/underproduction, large fluctuations in the market, or a length of contract that results in prices becoming unfavourable over time. The following chapter will explore the different types of PPA structure, and the main risks and challenges associated with the development of the PPA market.

Physical vs virtual PPAs

Corporate PPAs can be physical or virtual (otherwise known as synthetic or financial). Physical PPAs involve an actual physical connection between the producer and buyer, and depending on the location of the producer and buyer, can take different forms:

- **Classic 'off-site':** when the producer and buyer are on the same grid network. The corporate buyer pays the renewable energy generator for the electricity generated as per the PPA terms. Additionally, the corporate buyer pays the local utility or grid operator for the use of the grid infrastructure (transmission and distribution charges). This is the most common type of physical PPA as it allows for a degree of flexibility in location.
- **'On-site':** this is where a producer's renewable energy (RES) plant is immediately next to the buyer, such as a solar PV system installed on a factory roof.
- **'Near-site direct wire'**: when the RES plant is near but not immediately next to the buyer, power can be transmitted via a dedicated direct line to the buyer[331].

In contrast, virtual PPAs do not involve any actual transmission of power between the buyer and producer. Instead, the buyer and producer agree a price for power purchased through the PPA and for the purchase of renewable certificates (Guarantees of Origin). The producer then supplies energy to the grid in return for payment from the grid operator. The producer and buyer settle the difference between the sale price and the agreed PPA price[332], following which the buyer receives its renewable certificates and buys energy from the grid as usual[333].

Virtual PPAs by nature are more flexible than physical PPAs as there is no need for the contracting parties to be connected to the same grid network. Due to the lack of complexity of virtual PPAs compared to physical ones, the popularity of virtual PPAs is increasing in Europe[334]. Virtual PPAs also offer buyers and producers an increased pool as well as the ability to more easily aggregate supply from multiple locations, improving the financial prospects of the PPA. However, there are also some complexities associated with virtual PPAs.

PPA accounting standards

Virtual and physical PPAs are treated differently in IFRS. Physical PPAs are usually treated "as a supply of electricity contract and ongoing cost (i.e., an executory contract under International Accounting Standard 37 (IAS 37) on provisions, contingent liabilities and contingent assets), without the contract being recognised on the balance sheet"[335]. In contrast, virtual PPAs must be treated as derivative contracts and depending on the choice/use of accounting system adopted (national accounting system or IFRS) can be recognised as fair value. Derivative contracts must be revalued in each

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and contractual conditions, ensuring that renewable energy is sold at fair market rates. Allowing RES PPAs between traders and buyers without stringent regulations could lead to market manipulation. Also ensuring that the supply of renewable energy is stable and predictable is crucial for grid stability. Contracts between producers and consumers (or end buyers) are more straightforward in terms of matching supply with demand and managing grid operations.

[331] *wbcsd (2023). Innovation in Power Purchase Agreement Structures*

[332] *This could also be achieved through the use of 'call' and 'put' options. For example, a put option would allow the producer to sell its energy at a higher strike price in the event that wholesale prices fall below this level.*

[333] *wbcsd (2016). Corporate Renewable Power Purchase Agreements*

[334] *wbcsd (2016). Corporate Renewable Power Purchase Agreements*

[335] *wbcsd (2022). Pricing structures for corporate renewable PPAs*

reporting period and any changes in value accounted for as profit/loss, adding potential volatility to the buyer's earnings[336].

Cross-border PPAs

An additional complexity associated with PPAs arises when the agreement involves parties from multiple countries. These cross-border PPAs are useful when buyers are operational in countries with unfavourable RES development, enabling them to take advantage of markets that are more mature and better regulated. It can also allow customers to take advantage of climates that are more suitable for the generation of renewable electricity (for example, a company based in Finland could enter into an agreement with a producer of solar power in Spain, yielding significantly better results than an equivalent producer in its home country).

Energy prices can differ significantly between countries, and so for cross-border PPAs, a decision must be made as to which wholesale prices will be used for settlements. This will have a significant impact on the contract's financials and requires a good level of understanding of the wholesale energy market[337]. Energy markets across different countries may also be subject to different regulations that make contract negotiations challenging, though the more market participants, the more competitive rates become, and so governments are being encouraged to facilitate the development of PPA markets[338]. According to publicly available information, all cross-border PPAs to date have been virtual[339]. While physical cross-border PPAs are theoretically possible, physical transmission rights (PTRs) and financial transmission rights (FTRs) must be acquired at auction first[340]. These additional requirements may be why no confirmed physical cross-border PPAs have been signed to date.

PPA volume structures

PPAs can be structured in several different ways depending on which party(ies) are willing to accept risk relating to volume requirements. The main types of volume structure are as follows[341,342,343]:

- **As produced:** the off-taker pays a fixed price for the energy produced in this "pay-as-produced" (PAP) PPA structure, regardless of fluctuations in the market or in the amount of energy actually produced. This arrangement can cover all or a fraction of a given PPA agreement. Under this structure, the producer faces no risk for volume or delivery (how much and when energy is delivered to the off-taker) while the off-taker only faces the risk that the producer may not generate sufficient quantities of energy. These contracts are relatively common in Europe, however, prices for producers are generally lower as they do not assume a significant amount of risk. Typical buyers of PAP PPAs are economic entities or traders that have teams that can manage the risk and that are driven by a need to maximise their clean energy utilisation.
- **Baseload:** these contracts are more popular in regions with strong renewable growth. Unlike PAP PPAs, baseload PPAs require a certain volume of energy (specified at the contract stage) to be delivered in a given time interval, typically hourly. The off-taker pays a fixed price for this energy, which is typically higher than for PAP PPAs due to the risk that the producer faces in the event that they cannot deliver the agreed volume. The producer needs to find off takers that take the over-production, which may entail very low price. In the event of this happening, the producer would be responsible for procuring the shortfall from the market.

[336] *Bowden (2023). Accounting for Power Purchase Agreements (PPAs)*
[337] *Pexapark (2022). Virtual PPAs: the shift from hassle to bustle | Pexapark*
[338] *Stanitsas and Kirytopoulos (2023). Sustainable Energy Strategies for Power Purchase Agreements (PPAs)*
[339] *Pexapark (2022). Virtual PPAs: the shift from hassle to bustle | Pexapark*
[340] *Stanitsas and Kirytopoulos (2023). Sustainable Energy Strategies for Power Purchase Agreements (PPAs)*
[341] *Aquila capital (2019). Power Purchase Agreements: A European Outlook*
[342] *Stanitsas and Kirytopoulos (2023). Sustainable Energy Strategies for Power Purchase Agreements (PPAs)*
[343] *The Oxford Institute for energy studies (2021). Nordic PPAs – Effects on renewable growth and implications for electricity markets*

- **Fixed volume for defined period:** this is a type of fixed volume PPA, similar to a baseload structure but with an extended time interval of months, quarters, years, etc. This reduces the risk for the producer, who is still subject to a fixed volume obligation, but which can be delivered at any point during the longer intervals. As this risk is lower, prices are also generally lower in turn.
- **Route-to-market:** under these contracts, electricity is sold at the current market price. This means that the off-taker must be an organisation that either has an in-house trading department or an agreement with a third party. There is no delivery or volume requirement, making this a lower-risk option for the producer as they are able to achieve higher prices than fixed volume contracts, though they are more highly exposed to fluctuations in market prices.

PPA pricing structures

Alongside a variety of volume structures, PPA contracts also involve a number of different pricing structures, outlined below[344]:

- **Fixed-price:** fixed price PPAs are contracts in which the price the off-taker pays is locked in for the duration of the contract, with no inflation added. This benefits the off-taker when wholesale prices are higher than the fixed price, but if the market falls significantly, the buyer could be locked into a financially disadvantageous position for several years, depending on the contract's duration. Fixed price PPAs are the most common contract type, particularly in Europe and the USA.
    - **Fixed with escalation:** under this structure, the buyer still locks in a starting price, but over the course of the contract, this will either increase or (uncommonly) decrease in steps. This can be with or without inflation, and is designed to allow the producer to try to predict future prices and for the buyer to obtain lower prices than the wholesale price as early as possible.
    - **Fixed with inflation indexation:** the locked-in price in this arrangement rises annually with inflation. This is commonly used in the UK, and minimises initial prices relative to wholesale prices.
- **Floating price, discount to market with caps and floors:** in these contracts, the off-taker pays a lower price to the producer than the market rate, but also accepts caps and floors on that price, meaning that prices cannot rise or decrease beyond these set limits. This contract structure is most commonly used for physical PPA agreements, though it is also employable for virtual PPAs. Typically, buyers will select a floating price PPA when they are subject to high energy costs and more elastic prices for their products. It is uncommon to use floating price structures in situations where price visibility is highly important, for example when the off-taker intends to secure external financing.
    - **Discount to market with floor:** in this contract, the off-taker is only subject to a minimum price limit.
    - **Discount to market with collar:** the off-taker is subject to both minimum and maximum price limit. As this is less beneficial to the producer, the floor price may be higher to reduce their risk.
- **Collar:** this is similar to the discount to market with collar structure but without any discount to market. Provided the market price does not rise above the cap or drop below the floor, no settlement is needed.
- **Reverse collar:** the same structure as a collar PPA, where there is both a cap and floor to prevent spikes in pricing. In the reverse collar structure, there is a set strike price, unlike the collar structure in which the strike price can fluctuate within the market boundaries. The contract for difference (CfD) settlement is the market price minus the strike price when the market is within the cap and floor.

[344] wbcsd (2022). Pricing structures for corporate renewable PPAs

- **Hybrid:** hybrid PPAs involve a mixed approach. A fixed percentage of the energy volume is sold to the off-taker at a fixed price, while the remaining output takes the form of a discount to market contract. This allows the producer and off-taker to share the risks of the contract, while also limiting the impact of price fluctuations for the buyer. A hybrid contract could also involve a fixed price for a set number of years followed by a variable price structure for the remainder of the contract.
- **Clawback:** in clawback contracts, a fixed price is locked in but if the market price decreases, the locked-in price will similarly decrease. When the price rises again, the buyer pays the increased cost until the producer has 'clawed back' its losses. The producer also has a loss cap which, if reached, will revert the price back to that outlined in the contract, and an extension can be added to the contract to extend the clawback in order for the producer to continue to recoup its losses.

PPA risks and challenges

As has been discussed, PPA contracts involve varying degrees of risk for the different contracting parties. A summary of a range of these risks, developed by the European platform for corporate PPAs, RE-Source, can be seen below[345].

- **Balancing:** RES producers are required to forecast their predicted production levels in advance of scheduled production. When there are errors in weather or production forecast, there will be a deviation between predicted and actual production.
- **Basis:** when PPA contracts are cross-border or in markets with zonal pricing, local electricity prices can differ between the buyer and producer. The choice of which market the contract is based in could have a significant financial implication.
- **Cannibalisation:** renewable energy prices are negatively correlated with the volume of supply of energy. This means that during periods of high supply (for example, during periods of high wind) energy enters the grid at very low cost, reducing prices. This effect is likely to increase as RES capacity and interest in PPAs increase.
- **Changes in law/regulation**: the European legislative landscape can change rapidly. Regulatory and legislative changes could impact the balance of risk between parties.
- **Credit – settlement/replacement:** the buyer may be late to make a payment or not pay for the generated electricity. The buyer could also default[346] / go bankrupt and a replacement arrangement be required.
- **Development:** there may be problems with RES plant permits or construction that delay or prevent their operation.
- **Force Majeure:** uncontrollable events like natural disasters (e.g. COVID19, Russia-Ukraine War) could impact construction of RES plants or generation of electricity.
- **Legal**: contract negotiation involves a number of key clauses including Credit Support, Force Majeure, Change of Control, Termination and Conditions Precedent.
- **Liquidity:** there may be cases where swift trading of electricity can avoid a change in price. However, some parties may be unable to trade quickly enough to avoid price spikes.
- **Merchant risk:** particularly for variable contracts, the producer of electricity must try to project its earnings based on unknown volumes and prices of electricity.
- **Performance/operational:** there could be issues with the plant's operations that mean it does not perform as expected in the PPA contract.
- **Price:** a significant risk in PPA contracts involves the locking in of pries. If a buyer locks in a price based on an incorrect projection of future wholesale prices, they may incur significant losses.

[345] RE-Source (2020). Risk mitigation for corporate renewable PPAs
[346] Fail to meet the legal obligations of the loan

- **Shape/profile:** differences in hourly production levels in a 24-hour period will lead to varying prices which can lead to higher or lower values than the standard baseload delivery of electricity.
- **Tenor (length of contract):** the length of PPA contract determines the length of time for which contracting parties are 'locked in' to an electricity price. Depending on fluctuations in the market, this price could be favourable or unfavourable to either party.
- **Volume:** differences in long-term resource levels from modelled estimates (e.g., average wind speeds or solar radiation levels) could result in lower-than-expected energy volumes.

PPA development in Europe

The European PPA market has grown significantly in recent years; in particular, 2023 saw a 22% increase in disclosed PPA capacity from 2021 levels and 41% from 2022 levels. Overall, the European PPA market has grown at a compound annual growth rate (CAGR) of 37% since 2018. This can be seen in the graph below.

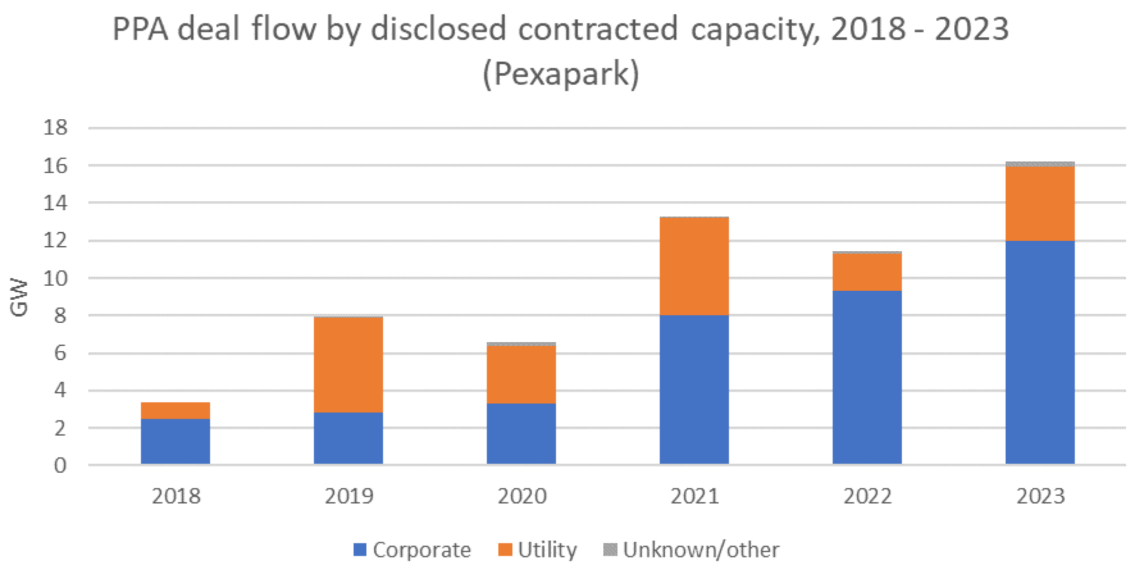

Figure 152: PPA deal flow by disclosed contracted capacity, 2018–2023[347]

Potential reasons for this include reduced volatility in gas and electricity prices, which consistent trended downwards in 2023 from peaks caused by the war in Ukraine. It should be noted that volatility in energy markets is still historically high but the lower levels compared to recent years, compounded with high demand for renewable energy from corporations, has led to reduced risk for PPA contracts.

In addition, Pexapark's market outlook report highlighted an increasingly favourable regulatory landscape: a number of windfall tax mechanisms expired in 2023, while new regulations that are supportive of the PPA market were introduced, including an EU Delegated Act that set out the rules for green hydrogen and its inclusion within PPA agreements[348]. Market reform activities have also led to increased clarity in the market and the strengthening of PPAs as a tool for decarbonisation – reporting requirements for corporations are becoming increasingly strict, further increasing the appetite for PPAs in Europe.

Finally, some countries have begun to adopt government credit guarantee schemes, reducing the potential risks associated with PPAs and therefore encouraging their uptake by more organisations. Details on these schemes are as follows[349]:

[347] *Pexapark (2024). European PPA Market outlook 2024*
[348] *Note that hydrogen PPAs are currently very limited in scale and only have a small impact on the PPA market.*
[349] *Pexapark (2024). European PPA Market outlook 2024*

- **Spain**
  - Operated by CESCE (public sector)
  - Eligible to energy intensive industries that consumed more than 1 GWh per year for two of the previous three years, and that consume more than 50% of that energy during off-peak hours
  - Contracts of more than 5 years and which cover more than 10% of the buyer's energy demand
  - Can indemnify up to 80% of the contract termination value and step in to become the buyer
- **Norway**
  - Operated by Export Finance Norway (Eksfin) (governmental body)
  - Eligible for buyers registered in Norway, active in timber, wood products and processing, chemical or metal industries, with a yearly consumption of more than 10 GWh and a PPA volume of more than 35 GWh
  - Contracts of between 7 and 25 years
  - Difference between PPA and annual average spot market price paid in case of default, up to a maximum of 80% of remaining payments/loss
- **France**
  - Operated by Bpifrance (public sector)
  - Eligible for buyers in extractive and manufacturing sectors and with a head office and consumption in France
  - Physical PPAs only with a length of more than 10 years and yearly volume of more than 10 GWh
  - Covers difference between value of monthly production on the market and 80% of the PPA's price

Delving further into the figures on PPA capacity, the monthly profile of PPA activity in 2023 in terms of disclosed contracted capacity can be seen in Figure 153 below.

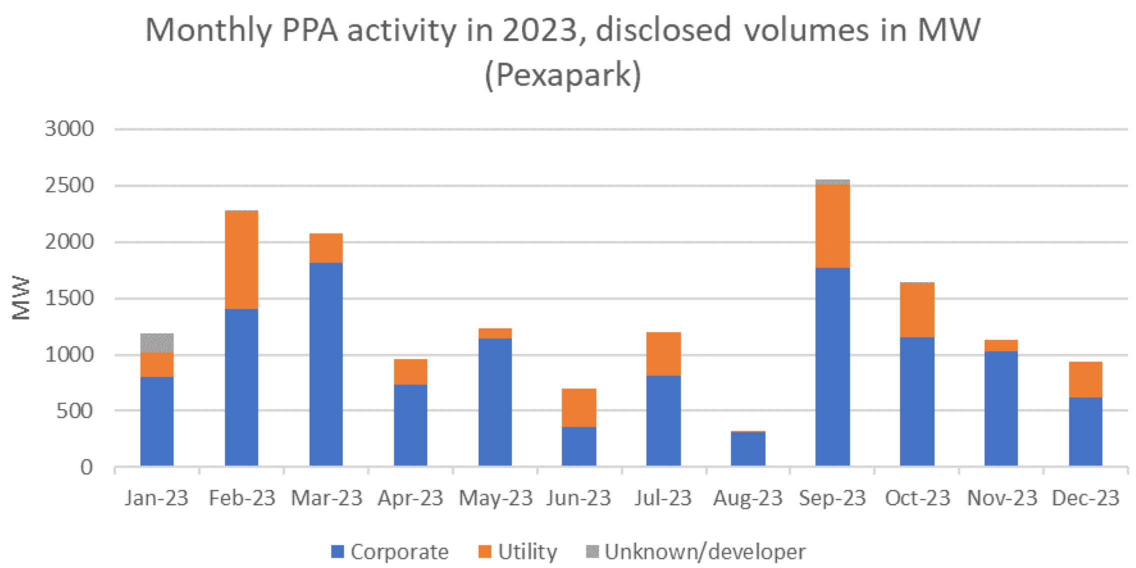

Figure 153: Monthly PPA activity in 2023, disclosed volumes in MW[350]

According to Pexapark's analysis, Q4 is typically the most active quarter for PPA deals, however 2023 saw Q1 as the quarter with the most activity. It is believed that this is because deals were delayed in 2022 due to high volatility of prices as a result of long lead times related to the COVID-19 pandemic and Russia-Ukraine war, leading to a surge as this volatility reduced.

[350] *Pexapark (2024). European PPA Market outlook 2024*

Wood Mackenzie has broken down the total contracted capacity of PPAs per year and per technology type. It found that in 2023 for the first time, solar PV deals were responsible for the majority of contracted capacity. It jumped from roughly 30% to 60% between 2022 and 2023, reducing the high share that wind power has typically had in PPA capacity. Wood Mackenzie highlighted that equipment prices (particularly wind power equipment) have increased over recent years due to high inflation, meaning that off-takers have been more hesitant to sign wind PPAs until the market resettles. For this reason, there may be a return to more wind-based deals in future years, as there is an expectation that costs will begin to reduce in the short-medium term[351].

RE-Source, a platform for corporate RES sourcing, further breaks down annual PPA capacity by sector[352].

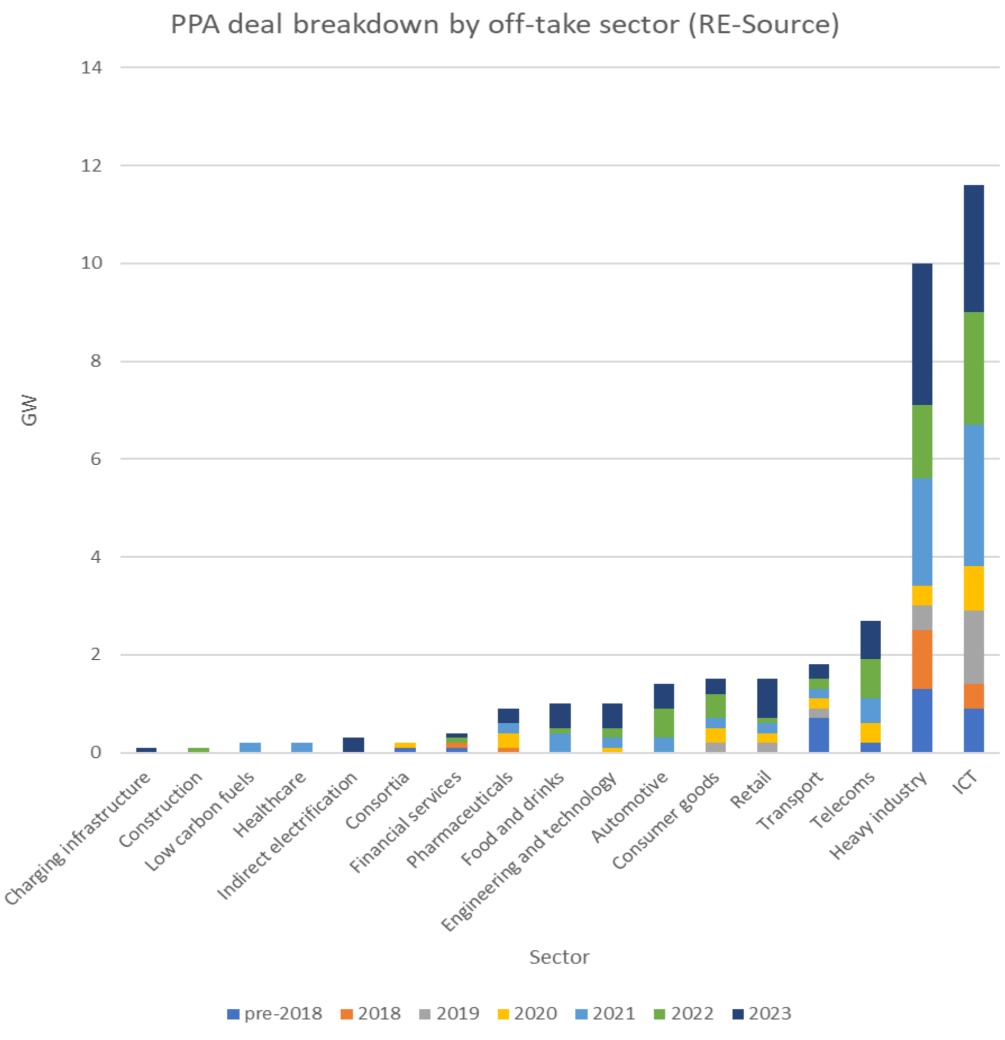

Figure 154: PPA deal breakdown by off-take sector (RE-Source) [353]

[351] *Wood Mackenzie – Exploring Europe's Renewables PPA Landscape in 2024*

[352] *It should be noted that Pexapark and RE-Source figures for overall capacity differ somewhat, though the trend remains the same. For this reason, the total capacity broken down by sector does not match the total capacity by year.*

[353] *RE-Source (2024).* PPA deal tracker

As can be seen in Figure 154, energy-intensive industries and the ICT sector make up the bulk of PPAs by capacity, though interest in other sectors is increasing, particularly as of 2023, which saw the food and drink sector, for example, double its total capacity in a single year (though this is still significantly smaller than the capacity of energy-intensive industries). According to RE-Source, the key regions for RES PPA in the EU are Spain, with 22% of the total contracted capacity, Germany with 13%, and Sweden with 12%.

Energy prices

Though electricity prices have dropped from their 2022 peak, rates still increased on average by 15-20% since before the Russia-Ukraine war. This is one reason behind the rise in demand for corporate PPAs, as they offer buyers the chance to lock-in low prices, however the increased demand has also led to a large jump in PPA prices. Between February and September 2022, PPA prices increased by 50%, and though rates have dropped from the September peak of 108 EUR/MWh to 52 EUR/MWh in November 2023, these are still higher than pre-war levels (though notably, below wholesale prices for all of 2023 meaning that PPAs continue to be appealing to consumers).

Another reason for the increased demand for corporate PPAs is their favourable economic position compared to competitive auctions. Auctions have been undersubscribed in a number of markets because a lack of inflation-indexed contracts combined with low ceiling prices has meant that producers were able to achieve higher prices in the PPA market. Raising the ceiling price of these auctions should help to revitalise the market, though this may also reduce the demand for PPAs.

Demand for PPAs may further decrease due to the risk of price cannibalisation, as described above. Future demand for RES PPAs is not guaranteed, as there is a limited pool of large consumers that can take on high levels of risk, while smaller companies with lower electricity demand may not be able to take the same risk, or have the capacity to track and adapt to wholesale markets. These smaller companies may benefit from alternative structures of PPAs that make them less vulnerable to risk[354]. The EU aims to facilitate the increased adoption of these alternative structures, including the pooling of demand into multi-buyer PPAs, and by implementing state-backed guarantee schemes.

As a response to the increased risk of cannibalisation, buyers are increasingly seeking extra shaping discounts on their pay-as-produced deals. There was a significant increase in the use of negative day-ahead prices in 2023 compared to 2022, particularly in Germany and the Nordic companies. This comes as the cost of renewable projects has increased over recent years due to pressures on the supply chain and due to inflation. While the cost for new energy projects is expected to reduce, the rate of reduction will also reduce, leading to a stabilised floor price for PPAs[355].

Wood Mackenzie summarised the following as upward and downward price pressures on the PPA market.[356]

Table 30: Upward and downward pressures on the PPA market

Upward pressures	Downward pressures
New electrification vectors, driving new demand for PPAs	Renewable expansion increasing supply
Voluntary and non-voluntary corporate disclosure is increasing through the EU's ESRS/CSRS and initiatives, such as RE100	Price cannibalization risk leading to lower pay-as-produced PPA prices
Data center 24/7 operational ambitions	Benign conditions for buyers in retail energy markets and/or price subsidises
Unattractive alternative routes-to-market, for example overly onerous auction requirements or low ceiling prices	Falling interest rates

[354] *IEA (2023). Renewables – Analysis and forecast to 2028*
[355] *Wood Mackenzie - Exploring Europe's Renewables PPA Landscape in 2024*
[356] *Idem*

Increased hedging requirements	Governments lowering auction ceiling prices in the future
Windfall taxes and revenue caps	Offtaker's benefit from improved flexible capabilities
Improved forecasting technologies	Falling wind & PV levelised costs
Guarantees of Origin price trend (if upwards)	Alternative sources offering controllable low carbon supply: CCUS equipped gas, SMR nuclear deployment
Hourly demand matching requirements	

Regulatory updates

One reason for the increase in PPA activity could be the introduction of EU Sustainability Reporting Standards. Large companies including Amazon, Statkfraft and Vodafone are subject to increasingly stringent climate mitigation reporting requirements which require all renewable energy purchase and consumption to be certified via PPAs or market instruments. In particular, beginning in 2024, companies are required to report on their emission reduction plans. Public interest companies with more than 500 employees are subject to these requirements, driving large firms to sign high volume deals to ensure their position in the market[357]. It is also important to note that further sector-specific reporting requirements are due to be introduced in 2026, meaning that the appetite for PPA deals is likely to continue to increase[358].

In 2023, the European Commission published a proposal that would reform the EU's energy markets. This was formally signed off in May 2024 and is intended to streamline legislation and facilitate the increase of RES capacity and contracts[359]. The package would make amendments to five legislative acts: Regulation (EU) 2019/943 (Electricity Regulation), Directive (EU) 2019/944 (Electricity Directive), Regulation (EU) No 1227/2011 (REMIT Regulation), Regulation (EU) 2019/942 (ACER Regulation), and Directive (EU) 2018/2001 (Renewable Energy Directive). The most relevant updates are as follows[360]:

- **Electricity Regulation**
  - Clarification of trading principles for day-ahead and intraday markets
  - New rules for transmission system operators (TSOs) and distribution system operators (DSOs) for procurement and monitoring
  - Provisions to improve the liquidity of forward electricity markets
  - **More incentives for PPAs and bilateral CfDs**
  - Increased transparency requirements for TSOs
  - New rules to assess the flexibility needs of Member States
- **Electricity Directive**
  - Consumer protection and empowerment rules
  - Requirement for suppliers to have risk management strategies e.g., hedging
  - New requirements for DSOs on grid capacity for new connections
  - Provisions for Member State interventions in price-setting during electricity price crises
- **REMIT Regulation**
  - Expansion of data reporting scope to electricity balancing and coupled markets
  - Improved cooperation between energy and financial regulators regarding wholesale energy products
  - Improved supervision of reporting parties and data sharing
  - Strengthened powers for investigation of cross border breaches of regulation
- **ACER regulation**
  - Clarification of roles regarding single allocation platform, forward markets and flexibility support schemes
- **Renewable Energy Directive**

[357] *The majority of top ten sellers signed deals within a single market. Contrastingly, Statkraft, the number one PPA seller in 2023, diversified its sales across seven markets, and was also the only seller in the top ten list to sign hydro deals in 2023.*
[358] *Wood Mackenzie - Exploring Europe's Renewables PPA Landscape in 2024*
[359] *Pexapark (2023). Interview: Pexapark sees 'golden era' for European PPA market, 350 deals forecast for 2024*
[360] *European Parliament (2023). Improving the design of the EU electricity market*

- Clarifies application of rules on national RES direct price support schemes
- It should be noted that PPAs for RFNBO production are handled more strictly under RED II than in the market. Uncertainty in interpretations of the functions of different contracting/facilitating parties should be addressed via harmonisation in EU legislation.

The new regulations will enable Member States to set out their own measures to support PPA development and are hoped to spur further innovation in the market moving forward[361].

Trends in contract structure

Pexapark's EU PPA market analysis identified a number of trends regarding the types and structures of contracts that became most popular. Some of these key trends are discussed below[362]:

- **Multi-buyer PPAs:** as discussed above, small companies entering into PPA agreements take on comparatively higher amounts of risk compared to large corporations. One strategy for mitigating this risk is multi-buyer (aggregated) PPAs, which allow multiple buyers to enter into an umbrella agreement to pool both production volumes and risk. These first entered the European market in 2016 but have since increased in popularity, in part due to increased regulatory support.
- **PPAs-plus-storage:** many producers in the PPA market are exploring either including storage in their portfolio or increasing their capacity. The aim of these hybrid PPAs is to combine grid services and generation asset performance boost through profile shaping.
- **24/7 energy purchasing:** currently, most PPA contracts involve annual consumption matching. However, studies have shown that hourly matching can improve the price certainty of the contract and reduce exposure to the spot market and may entail price hedging benefits.
- **Hydrogen PPAs:** 2023 saw fast growth of PPAs that will be used to power forthcoming green hydrogen and ammonia plants, with projects announced in Norway, France and Germany. This was aided by the EU's Delegated Act which gave industry clarity on the requirements for green hydrogen, which is hoped to have removed the regulatory barriers to similar projects. It is projected that the trend towards green hydrogen PPAs will continue into 2024, however this is dependent on investors being convinced by project business cases and financials.

Wood Mackenzie's analysis found that there were different dynamics between different types of PPA. On average, corporate PPA deals involved smaller volumes than route-to-market[363] contracts, but longer contract lengths. In particular, Germany drove the high-volume RTM PPA market, with many utilities entering RTM contracts for a total capacity of more than 1 GW. Spain retained its position as the country with the most contracted capacity in 2023, primarily driven by solar contracts, while countries like Italy and Greece experienced a surge in PPA capacity due to supportive market activities like low auction ceiling prices and priority grid connections.

The average length of PPA deal has stabilised over recent years, with an average tenor in 2023 of 11 years. Wood Mackenzie highlighted a number of considerations that must be made when considering contract length:

- **Business cycle:** longer business cycles, typical of the heavy industry and technology sectors, favour deals of more than 15 years, though other sectors prefer short-term flexibility.
- **Industry margins:** sectors with tighter profit margins are more exposed to long-term risks.
- **Financing:** banks generally seek deals of more than 10 years to finance their projects, though there is some more flexibility in the sector due to high wholesale prices. Lenders are generally also now more familiar with the renewables market.
- **Energy trading capabilities:** established buyers with trading teams will be more able to take on short term deals.

[361] https://go.pexapark.com/l/891233/2024-02-06/hd4y8/891233/1707212342jlEFslZb/European_PPA_Market_Outlook_2024_HighR.pdf
[362] Pexapark (2023). *Interview: Pexapark sees 'golden era' for European PPA market, 350 deals forecast for 2024*
[363] *A PPA in which the producer deals energy with a buyer who will then market and trade the energy of an in-development energy project instead of consuming the electricity.*

- **Start date:** increasingly, PPA deals are signed prior to the energy project becoming operational due to shorter construction periods and to guarantee their access to power and financing[364].

[364] *Wood Mackenzie - Exploring Europe's Renewables PPA Landscape in 2024*

6. Household energy expenditure

6.1. Summary of main findings

In this chapter household expenditures on energy both in the residential and transport sector are analysed across all EU Member States and for various income groups.

Based on the available data for 2022, the households within the lowest income decile in the EU spent an average of EUR 1250 on energy products[365]. This is around 7.5% of their total expenditure. This average is based on data from the following Member States (MS): Belgium, Bulgaria, Denmark, Finland, Croatia, Italy, Luxemburg, and Portugal. The average is weighted based on the number of households reported by the MS.

The share of energy expenditures of total expenditures has decreased between 2010 and 2022, most notably for low-income households by 2.5%. In comparison to 2020 the share increased very slightly for low and low middle-income groups, but not for middle-income groups.

Table 31: Share of energy and transport exenditure for different income groups by year

	2010	2020	2022	2010-2022	2020-2022
Share of expenditure on energy					
Low-income households	9.9%	7.3%	7.5%	-2.4%	0.2%
Low middle-income households	7.6%	6.4%	6.9%	-0.7%	0.6%
Middle-income households	6.9%	6.4%	6.4%	-0.5%	0.0%
Share of expenditure on transport energy					
Low-income households	2.2%	2.4%	3.2%	1.0%	0.8%
Low middle-income households	3.6%	3.6%	4.3%	0.7%	0.6%
Middle-income households	4.1%	3.8%	4.3%	0.1%	0.5%

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

An additional sensitivity analysis was conducted to study the effects of high energy prices on income groups. From this the following insights can be drawn:

- The share of energy expenditure (including and excluding transport) in total consumption expenditure has substantially increased compared to pre-crisis years (i.e. pre-2022), linked to the fact that energy prices substantially increased.
- For countries with recent data for 2022/2023: Comparing 2024 energy expenditure share to 2022/2023 values shows a significant decline in energy cost burden. However, only a few countries so far have reported data for 2022 or 2023.
- Comparing the harmonized price index for 2024 to 2020 values shows that 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 33). Which of the energy carriers mainly drive inflation varies by Member State, as does the extent of the price increase[366]. Austria, Czechia, Germany, Italy

[365] *This includes electricity, gas, liquid and solid fuels, and heating.*

[366] *It should be noted that come governments introduced tax adjustments as a means to protect consumers (mainly households) which would have an effect here as well. For adjustment of taxes and effects on energy prices please also see chapter 2*

and Latvia experienced a nearly doubling in natural gas prices between May 2020 and May 2024. Liquid fuels showed the highest price increases in 13 Member States and increased by more than eighty percent in 6 Member States, and increased more than twice in 7 Member states.

- For energy expenditure *excluding* transport fuels, higher prices present a substantially higher burden for households with low income, i.e. they lead to more negative distribution effects 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.

6.2. Introduction

Energy is a basic need for all households. If either their consumption or retail prices increase, households spend a larger share of their total consumption expenditures on their energy needs (all other spending assumed to remain unchanged). These household energy expenditures give an indication of the financial pressures households face and give an indication of households' ability to cover their energy needs.

In the first part of this chapter, energy expenditures related to heating and transport[367], differences across income groups, and changes in energy expenditures over time are shown. This is based on data provided by national statistical offices for the most recent years and up to 2022.

In the second part of this chapter, expenditures are shown and/or extrapolated up to 2024. Due to rising energy prices energy expenditures have increased significantly creating additional financial stress for households. By conducting a sensitivity analysis for these more recent years, this burden can be shown.

6.2.1. Methods and data on household expenditure

In this chapter both absolute and relative household expenditures are shown. In the display of relative expenditures, absolute expenditures are shown in relation to total consumption expenditures on products and services. This offers valuable insights into the challenges households face in meeting their energy expenses. It also shows the disparities among Member States in terms of the financial burden experienced by households with varying income levels. Residential energy expenditure typically encompasses costs associated with heating, lighting, cooking, cooling, and the operation of electrical appliances. Additionally, changes in energy and transport expenditures since 2008 are analysed.

This chapter primarily relies on data sourced from national statistical authorities. The Household Budget Survey Working Group (comprising EU Member States and representative of their national statistical offices) was mandated by the Commission to provide data on energy expenditure, enabling a more detailed understanding of expenditure patterns across income brackets and facilitating evidence-based policymaking by the Commission on energy affordability.

To illustrate variations across income levels, consumption expenditure data for three household categories—low-income, low-middle income, and middle income—are included. Low-income groups are defined as those in the lowest income decile i.e. the poorest 10% of households. Low middle-income groups are those in the third income decile and middle-income groups those in the 5th income decile. For MS where the is only data available for quintiles, the first, second, and third quintile are used to display this data.

[367] *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.*

It is important to note that the collected data is not standardized across Member States and is not consistently reported for the year 2022. The most recent available data for each Member State is used for the figures presented in this report, all of which are based on data provided by the Member States.

The reported data from MS is in the form of the ECOICOP 2013 format as specified by Eurostat for the 2020 HBS. Although some MS have switched to the more recent classification system of the COICOP2018 for post-2020 data, this data was converted to the ECOICOP2013 system where necessary.

6.2.2. Context: The share of types of fuels and use in households

To gain deeper insights into the changing patterns of energy consumption and expenditures across different EU Member States, variations in residential energy usage can be analysed. First, the share of fuels in final energy consumption in the residential sector are shown, followed by a break-down of end-use energy consumption in the residential sector. EUROSTAT releases yearly data detailing the final energy consumption by households in the residential sector, providing valuable insights into these dynamics.

Figure 155 shows the share of energy fuels in final energy consumption in the residential sector. Across the EU, natural gas makes up the largest share (31%), with derived heat (25%) and renewables and waste (23%) also playing a significant role.

Natural gas plays an important role in a number of MS. This is particularly true for the Netherlands (66%), Italy (50%), Luxemburg (47%), and Hungary (49%), but also Belgium (39%), Germany (38%) and Slovakia (41%). High shares of oil and other petroleum products are found in Ireland (41%), Cyprus (30%), Greece (30%), Belgium (30%), and Luxemburg (28%). The share of renewables and wastes in the share of fuels in energy consumption in the residential sector is also significant. For a large number of MS (17 out of 27) it makes up at least a quarter of energy consumption. Particularly high shares can be found in Hungary (45%), Estonia (42%), Slovenia (41%), Latvia (40%), Portugal (39%), and Romania (39%). Electricity continues to play a significant role for some MS in the northern regions including Denmark (40%), Estonia (35%), Latvia (33%9, Lithuania (29%), Finland (28%) and Sweden (36%).

Derived heat refers to 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. In Sweden (49%) and Bulgaria (49%) it makes up almost half of all residential energy consumption; in Malta it is the main source with 76%. Significant shares are also found in Finland (35%), Portugal (40%), Cyprus (42%), and Spain (44%).

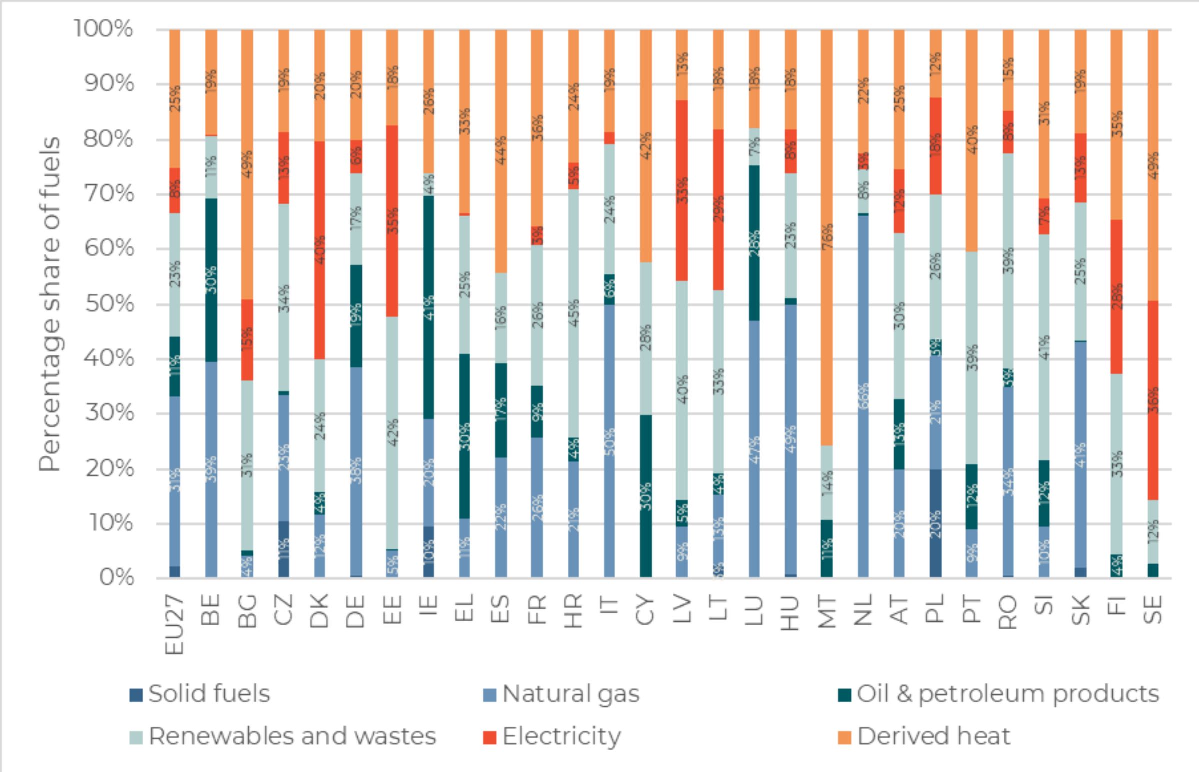

Figure 155: Share of fuels in final energy consumption in the residential sector of Member States in the EU27 (2022)

Source: Eurostat (nrg_bal_c)

6.2.3. Overview: Consumption expenditures 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.

Across the EU the majority of energy consumption are related to space heating. Only in Malta, Portugal, Spain, and Cyprus is the share of space heating below 40%. Space cooling, on the other hand, makes up a very small share of energy consumption. It is only notable in the data in Malta (15%) and Cyprus (11%). Water heating makes up between 10-25% of energy consumption across the EU and cooking between 5-10%. A notable exception is Portugal, where cooking accounts for 31% of residential energy consumption. Lighting and other appliances account for 14% of residential energy consumption across the EU. High shares are notable in Spain (33%) and Malta (29%). The high percentage of energy use for lighting and other appliances in Malta is attributable to the lack of built in central heating systems and the low percentage of space heating associated with it, meaning that other consumption categories are larger, e.g. "lighting and other appliances". because portable space heaters might be used instead of central heating systems.

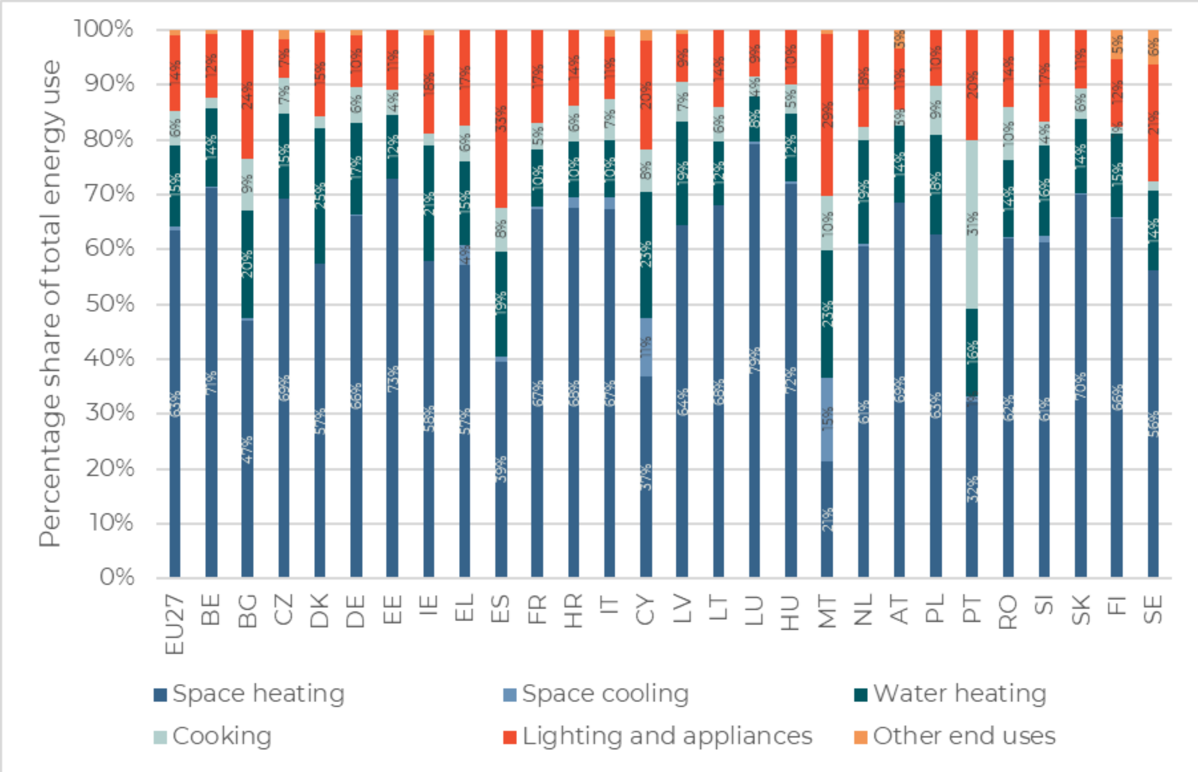

Figure 156: Share of end-use energy consumption in the residential sector of Member States in the EU27 (2022)

Source: Eurostat (nrg_bal_c)

6.3. Household energy expenditures for residential use

Before assessing the role of energy-related expenditures for various income groups, Figure 157 shows overall consumption expenditures. This puts energy expenditures into relation with other expenses such as those related to housing, food, and transport. These make up between around 40-60% of total expenditures for all households across EU MS.

Expenditures for food and non-alcoholic beverages account for around 15%-25% of total expenditures. Its particularly high in Bulgaria (32%), where housing costs are comparatively low (5%). High food-related expenditures are also relevant in Romania (32%), Poland (27%), Hungary (26%), Lithuania (24%), Latvia (23%), Slovakia (23%), and Estonia (23%). This indicates that in Central and Eastern Europe as well as in the Baltic states this is a significant part of the average household's expenditures.

Costs for transport are differentiated between mobility services and fuels for personal transport. Mobility services make up between 10-30% of consumption expenditures, while spending on transport fuels ranges between 3-14%.

A high share of expenditures on housing can be found in Portugal (34%), Luxemburg (33%), Ireland (30%), Spain (30%), and Finland (29%). The average household in these MS spends a third of their expenditures on housing costs. High housing costs are often associated with a lower share of energy-related expenditures. These costs vary not only across income groups but also regionally. In Portugal and Spain, for example, high absolute expenditures on housing are found especially along the coastline and in the bigger cities due to tourism.

The average share of expenditures on energy varies between 3% and 13%. Its particularly high in Central and Eastern Europe and particularly low in Sweden and Luxemburg. The average household in Bulgaria (13%) and Slovakia (12%) have the highest energy-related consumption expenditures.

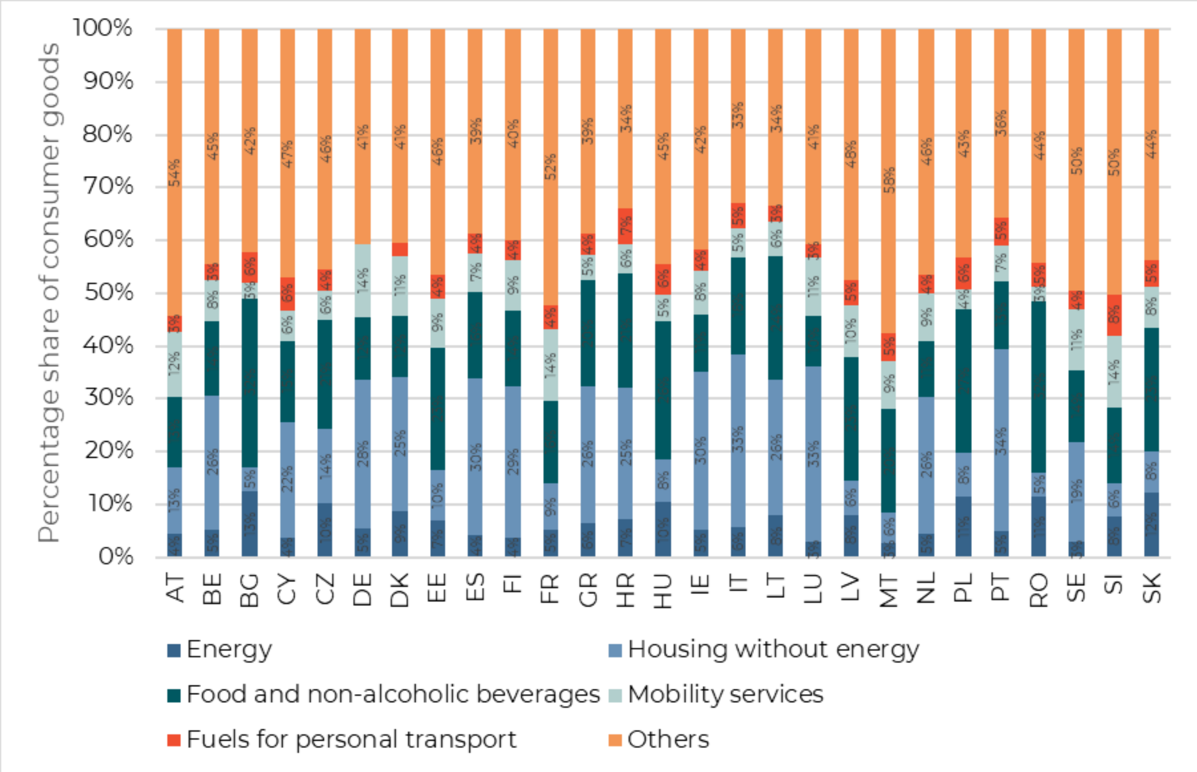

Figure 157: Shares of consumer goods in household expenditure of Member States in the EU27[368]
Source: DG ENER ad hoc data collection on household consumption expenditures

Although the share of total consumption expenditures spent on energy is relatively small on average, this share varies significantly by income and also across the MS. Figure 158 shows the percentage share of total expenditures related to energy for low-income, low-middle income, and middle income groups.

Generally, low-income groups spend a higher share on energy than middle-income groups[369]. This can be seen in the EU-average for example. Notable exceptions can be seen in Sweden, Finland, Belgium, Ireland, Estonia, Poland, and Bulgaria. This may be because of social welfare payments that support the most income-poor households in these MS or because these households will self-regulate their energy consumption to keep their overall bills low when other financial constraints are high. This is sometimes referred to as "hidden energy poverty", where households underspend on their energy.

The highest share of expenditures related to energy are found in central and eastern Europe, including Slovakia, Romania, Bulgaria, and Czechia. Overall, the higher the share spent, the bigger the differences between income groups as well. In Slovakia middle-income households spend 15% of their total consumption expenditure on energy, with low-income households spending 22%.

[368] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available. Germany and Sweden did not report any data on fuels for personal transport, meaning this data is not fully comparable.

[369] *For definitions oft he categories low income, low-middle income and middle income please see section 6.2.1. .*

Figure 158: Energy share in total consumption expenditure by income group of Member States in the EU27[370]

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

6.3.1. Energy expenditure (excluding transport) in households with low income

In 2022, low-income households spent an average of 1250 EUR per year on energy, corresponding to around 8% of their total consumption expenditure. In absolute terms this is higher than previous years, but the share of expenditures on energy did not increase. This of course varies greatly across MS.

Absolute expenditures were particularly high in Denmark at over 3000 EUR per year making up 11% of total consumption expenditures. In comparison to other Nordic countries this is relatively high, both in absolute and relative terms. This may be related to high energy taxes on electricity, for example, which also makes up the highest share of spending after heating energy, which is also related to electricity. It should be noted that income from these energy taxes is used to finance the social welfare system which supports these low-income households as well.

High absolute expenditures can also be seen in Luxemburg and Belgium although the share spent on energy is relatively low at 4% and 6% respectively. Low absolute expenditures for low-income groups are seen in Latvia and Romania. These households spend around 280 EUR and 340 EUR on energy. This corresponds to a high share of their total expenditures, however, at 14% and 15%.

High share of consumption expenditures on energy in low-income groups can also be found in Hungary (14%), Bulgaria (14%), Slovenia (13%), with the highest share in Czechia (17%) and Slovakia (22%). Generally, there is a regional trend to these absolute and relative energy expenditures, where

[370] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available.

The EU 2022 average is based on expenditure data from those Member States that reported for 2022 and where the number of surveyed households were reported. This includes Belgium, Bulgaria, Finland, Denmark, Croatia, Italy, and Luxemburg. The average was weighted according to the number of households.

in MS with a higher GDP absolute spending on energy is also higher. This often means that households have higher income as well, hence the relative cost-burden of these high energy spendings is relatively low.

On the other hand, when absolute expenditures are relatively low, the share of expenditures spent on energy is generally higher. Lower income in these MS means that even low absolute expenditures are a significant cost-burden for the poorest households.

Household income plays a significant role in the overall share that energy costs play in total consumption expenditures, while the state of the housing stock and energy efficiency as well as energy prices influence the absolute energy expenditures. Low energy efficiency in MS mentioned above with high energy cost-burdens will play a significant role especially for low-income groups, who are more likely to live in these inefficient buildings. On the other hand, social welfare systems in the Nordic MS as well as in Germany, for example, will lower the overall cost-burden of these households.

It should be noted that in some MS energy costs are reported as housing costs, meaning that the energy costs shown in this data may not accurately reflect energy expenditures per se. In Finland and Sweden, energy costs are not listed separately but are included as part of the. This model simplifies billing for tenants and encourages energy efficiency, as landlords are incentivized to maintain well-insulated properties to manage overall costs.

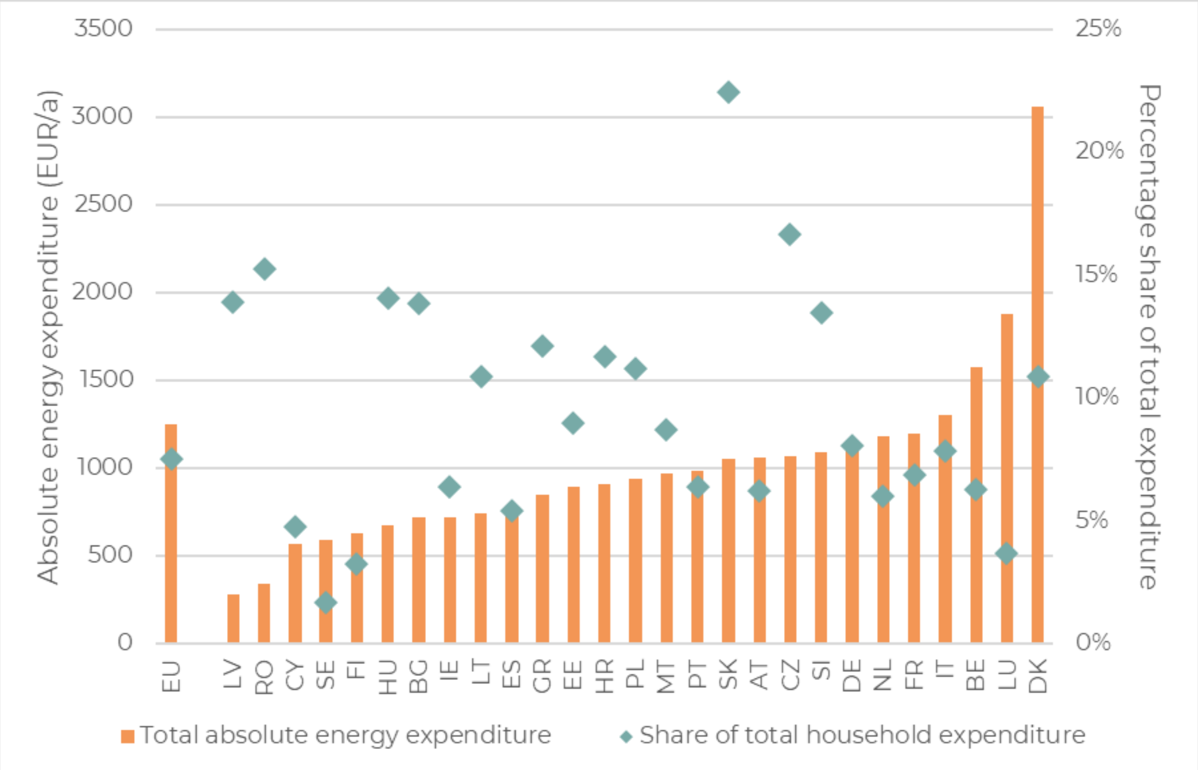

Figure 159: Absolute energy expenditures and share of energy expenditures for low-income households for Member States in the EU27[371]

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

[371] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available.

The EU 2022 average is based on expenditure data from those Member States that reported for 2022 and where the number of surveyed households were reported. This includes Belgium, Bulgaria, Finland, Denmark, Croatia, Italy, and Luxemburg. The average was weighted according to the number of households.

The share of household energy products within energy consumption expenditure is shown in Figure 160 for low-income households. This also varies across the MS and helps to explain trends in expenditures.

In Denmark, a high share of energy expenditures is related to heat energy (50%), which is related to their extensive district heating network. This is also relevant for Lithuania, where 38% of heating expenditures is related to heat energy. For most MS, gas and electricity expenditures play the most significant role. In Sweden 100% of energy expenditures is attributed to electricity. This is likely a reporting error, as in previous years expenditures were also related to gas. Nonetheless, Sweden has a significant emphasis on renewable energy, particularly hydropower and wind power, which primarily generate electricity which is consequently also used more frequently in households. In Finland 89% of energy spending is related to electricity, as well as 70% in France (likely related to high shares on nuclear energy production), 73% in Estonia, and 73% in Cyprus.

Spending on gas plays a significant role in the Netherlands (70%), Italy (44%), and Poland (38%). Spending on liquid fuels in the form of heating oil is relevant for households in Luxemburg (26%), Belgium (19%), Greece (20%) and Ireland (20%). This also indicates that in these MS there is a still a high reliance on fossil-fuel intensive heating in the residential buildings stock that needs to be addressed. It may also be related to infrastructural aspects, such the lack of a natural gas distribution grid in Greece for example. Finally, solid fuels still make up a large share of energy expenditures for low-income groups in Croatia (45%), but also in Bulgaria (32%) and Hungary (31%). This is also because low-income households are more likely to rely on wood and coal for heating. There is a strong connection between solid fuel use and energy poverty that has also become a central part of social policies in numerous Member States (MS). For example, the Croatian Recovery and Resilience Plan indicates a stronger focus on the accessibility of renewable energy, aiming to improve energy affordability while reducing reliance on solid fuels.

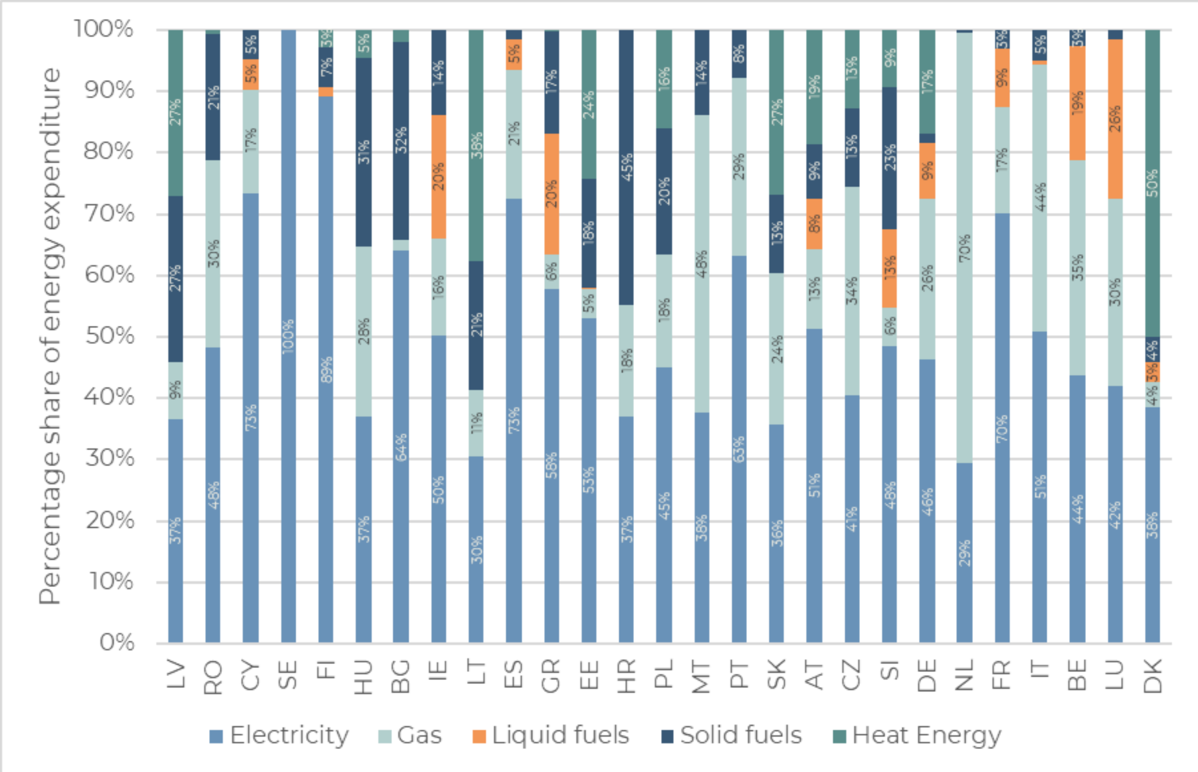

Figure 160: Share of energy products in energy expenditures for low-income households of Member States in the EU27[372]

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

6.3.2. Energy expenditure (excluding transport) in households with middle income

As already seen in Figure 158, relative energy expenditures vary by income. Households with low-middle income or middle-income on the whole are more likely to spend a lower share of their total expenditures on energy. Figure 161 and Figure 162 below show the relationship between relative and absolute energy expenditures for these two middle income groups.

Overall, absolute energy expenditures are higher for both of these groups. Low-middle income groups spend around 1500 EUR on energy, while middle-income groups spend 1650 EUR per year on energy. This corresponds to 7-6% of total consumption expenditure compared to the 8% spent by low-income groups.

Trends in absolute energy expenditures remain relatively similar across these three income groups, with Denmark, Luxemburg and Belgium showing very high expenditures, and Latvia, Romania, Estonia, and Bulgaria showing lower absolute energy expenditures. A notable difference is that Maltese households in the low-middle income and middle-income groups have very high absolute energy expenditures in the EU comparison and also in comparison to low-income households. The share of these costs in total expenditures is also relatively high for low-middle income households at 16%. In comparison, other MS with high absolute expenditures show much lower shares 4-9%.

Overall, there is not a clear trend for low-middle income groups between absolute and relative energy expenditures. In Slovakia the share spent on energy of total expenditures is very high (17%) although absolute energy expenditures are not high. This may be due to lower levels of average income in

[372] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available.

comparison to Austria, France, and the Netherlands, who have similar levels of absolute expenditures. Lower absolute expenditures tend to correlate to a high share of expenditures on energy, as is the case in Latvia (11%), Romania (15%), Estonia (10%), and Bulgaria (15%). A notable exception is Ireland where low absolute expenditures also correspond to a relatively low cost-burden at 6%. This may be due to the older data from 2015 that is shown here that does not reflect the rising energy prices within the EU due to inflation and geopolitical conflicts from 2021-2022. In 2023 Irelands electricity prices, for example, were the second highest in the whole EU.[373] More recent data was not available in the frame of this project.

A similar trend can be observed for middle-income groups. Notable high shares of spending on energy can be seen in Poland (13%), Slovakia (15%), Bulgaria (14%), and Romania (14%). All of these figures were ranked by absolute expenditures. The position of countries in this ranking does not change significantly across the three income groups.

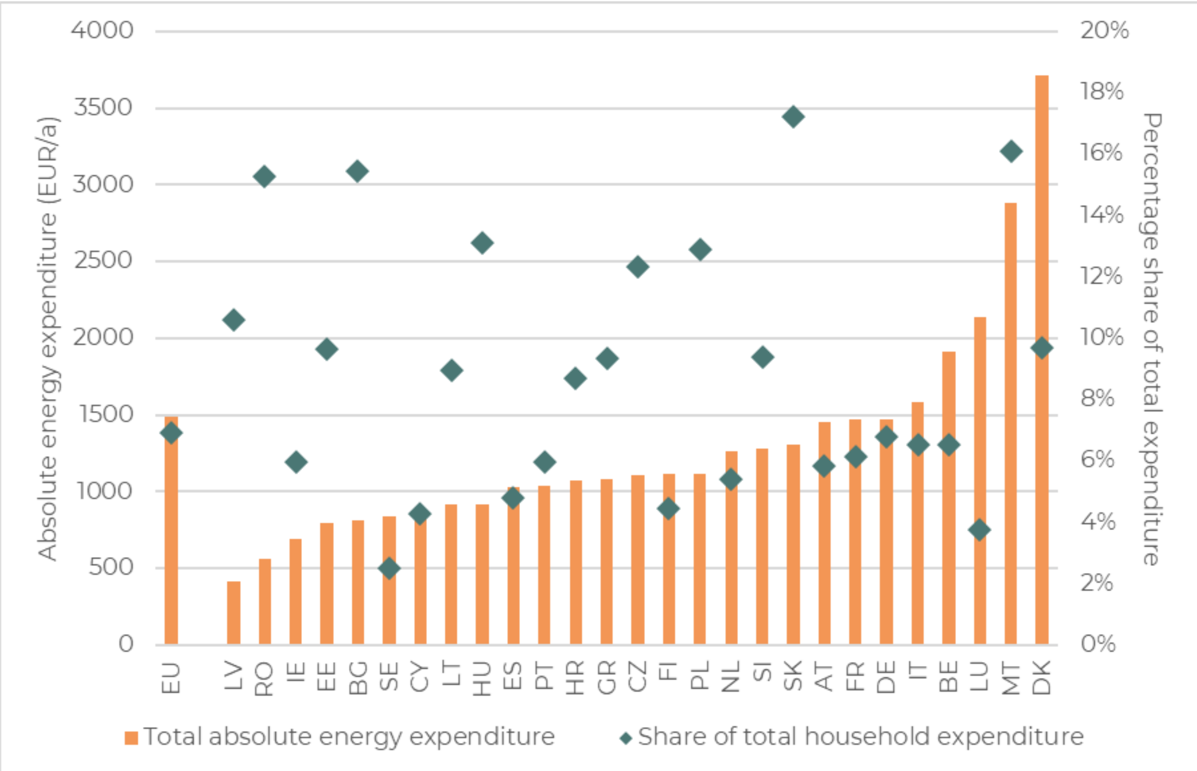

Figure 161: Absolute energy expenditures and share of energy expenditures for low-middle income households for Member States in the EU27[374]

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

[373] *QERY (2024). Consumer Energy Prices in Europe: Electricity Prices for Households*

[374] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available. The EU 2022 average is based on expenditure data from those Member States that reported for 2022 and where the number of surveyed households were reported. This includes Belgium, Bulgaria, Finland, Denmark, Croatia, Italy, and Luxemburg. The average was weighted according to the number of households.

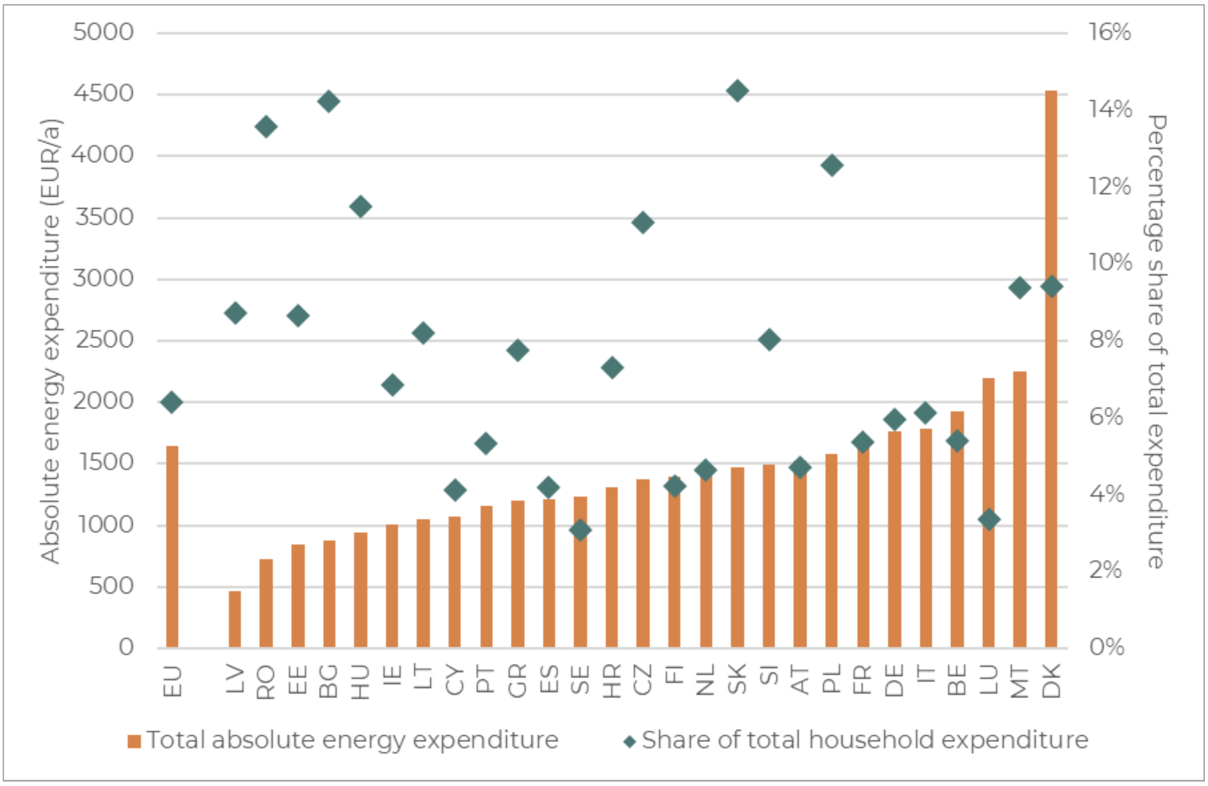

Figure 162: Absolute energy expenditures and share of energy expenditures for middle-income households for Member States in the EU27[375]

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

Figure 163 and Figure 164 show the distribution of spending on household energy products for low-middle and middle-income groups. This does not vary significantly from that of low-income groups. Notable differences include the shift away from liquid fuels with higher income. For low-middle income groups it made up around 60% and only around 40% for middle-income groups. This may be related to the housing stock and that low-income households are more reliant on oil for heating, while higher income groups in more efficient or modern housing is more likely to heat with gas or electricity. It should also be mentioned that higher income groups tend to live in more urban areas with a better connection to natural gas networks.

The share of expenditures on electricity decreases from the lowest income group to the middle-income group by 10-15% percentage points in Bulgaria, Finland, Malta, and Romania. There is an increase from 37% to 47% in spending on electricity in Croatia. Notable jumps in the expenditures on gas can be seen in Cyprus and Malta, where the share decreases as income increases. In Denmark, Croatia, and Denmark the share increases with income. The share of expenditures on solid fuels tends to decrease with higher income. Significant shifts are observed in Croatia, Latvia, and Malta. Finally, for heat energy expenditures these decrease from 50% to only 36% in Denmark and increase from 27% to 38% in Latvia. All of these shifts are likely to be connected to the building stock and the types of buildings the poorest households live in where poorly insulated houses and outdated heating systems are more common. The shifts between energy carriers are thus closely linked to national specificities.

[375] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available. The EU 2022 average is based on expenditure data from those Member States that reported for 2022 and where the number of surveyed households were reported. This includes Belgium, Bulgaria, Finland, Denmark, Croatia, Italy, and Luxemburg. The average was weighted according to the number of households.

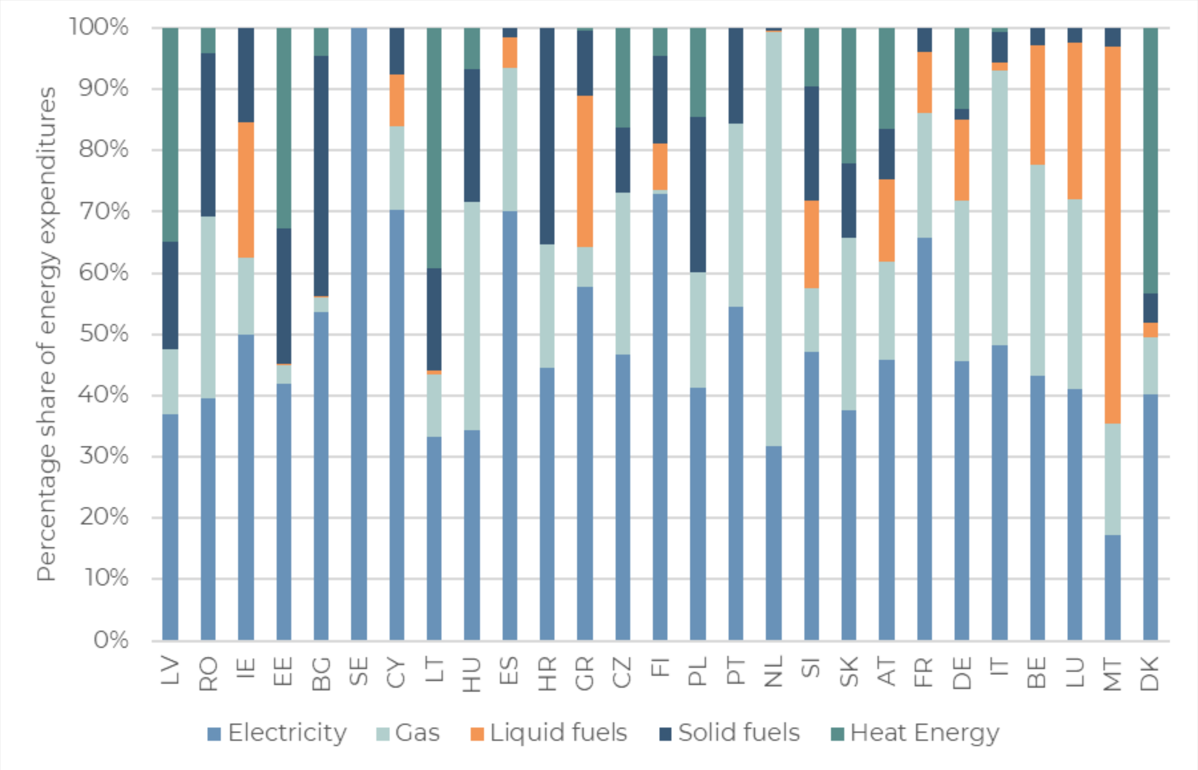

Figure 163: Share of energy products in energy expenditures for low-middle income households of Member States in the EU27[376]

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

[376] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available.

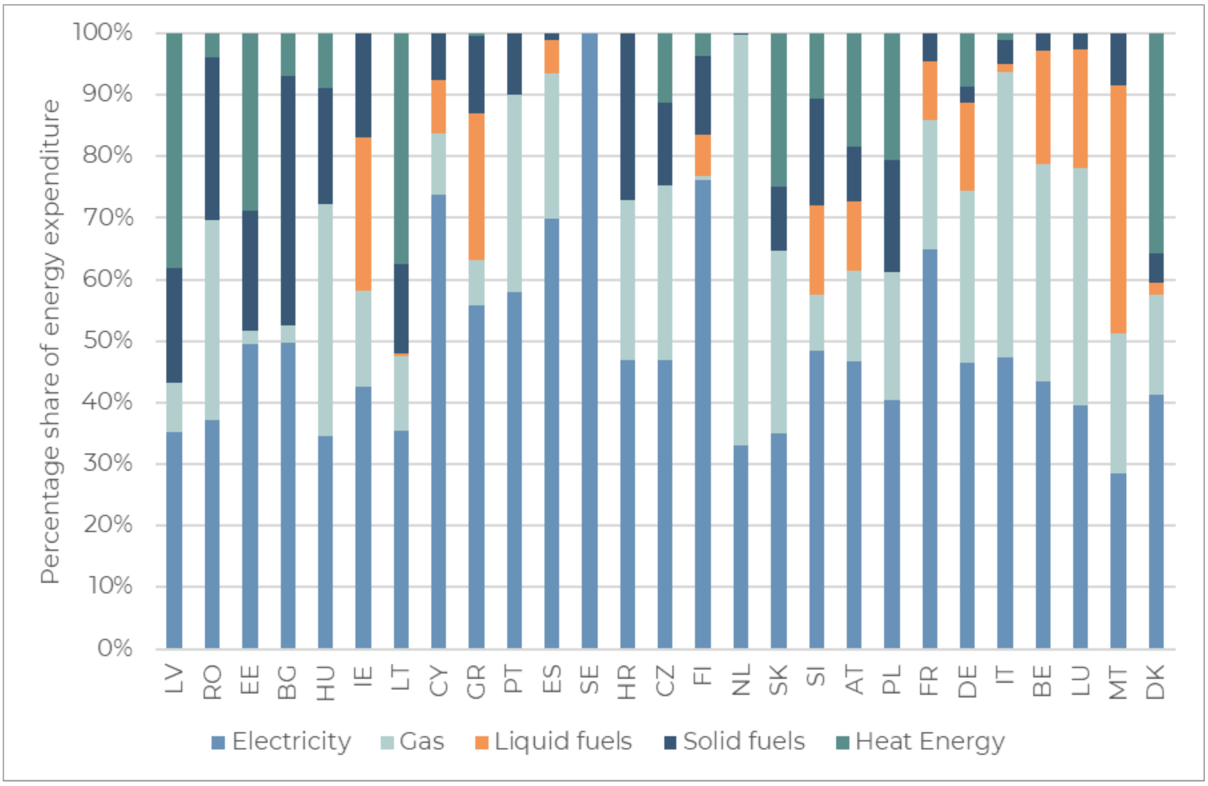

Figure 164: Share of energy products in energy expenditures for middle-income households of Member States in the EU27[377]

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

6.3.3. Share of energy in the household expenditure by income and Member State

In order to identify regional trends, this section clusters MS based on their geographical location and comparability of expenditures. There are six regional clusters: North West MS, Southern and Mediterranean MS, Central and Eastern European MS, Baltic MS, and South Eastern MS. In each figure the share of energy expenditures in total expenditures across all three income groups (low-, low-middle, and middle-income).

Seven countries are clustered as North-Western MS including Germany, France, Ireland, Belgium, Austria, the Netherlands, and Luxemburg. Of these, German low-income household shave the highest share of energy expenditures at 8%. This is also higher than the EU-average. Households in Luxemburg in all three income groups spend the lowest share of their expenditures on energy. In Belgium, the share of energy expenditures is higher for low-middle income households than low-income households. This may be related to a social welfare system that supports low-income groups with their energy costs. This may also explain the high share of energy expenditures for Irish middle-income groups in comparison to the other MS, but also in comparison to the other lower-income households. At almost 7% it is also a higher share than the EU-average at 6,4%. This may be related to social welfare payments received by low-income groups that help to reduce their energy costs such as the annual Fuel Allowance between October and April.[378]

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[377] Year of data is as follows: Portugal (2015), Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available.
[378] Citizens Information Board (2015). Relate – The journal of developments in social services, policy and legislation in Ireland

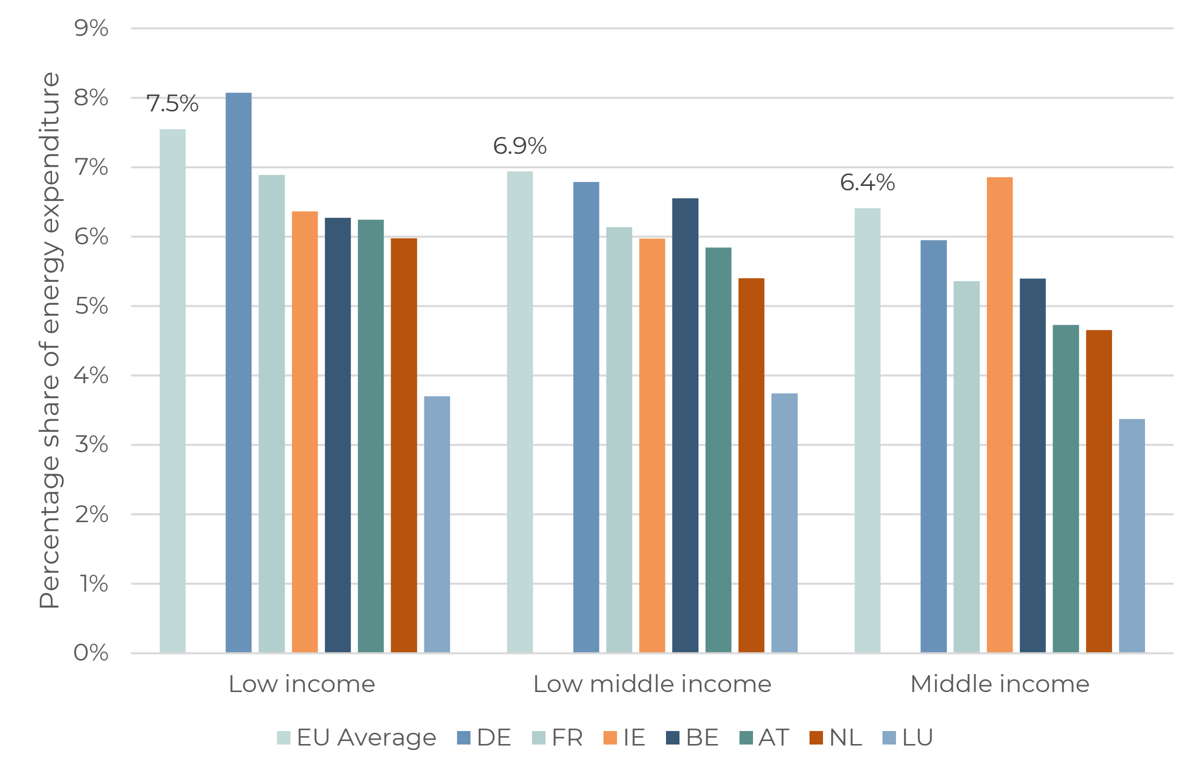

Figure 165: Share of energy expenditure in total expenditure by income groups for Germany, France, Ireland, Austria, Belgium, the Netherlands, and Luxemburg[379]

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

When looking at the South European and Mediterranean island MS, Greece stands out with particularly high shares of energy consumption expenditures that are well above the other MS and the EU-average. This may be due to high wholesale electricity prices in Greece, which result from the country's heavy reliance on natural gas and coal. For all of the shown MS the share of energy expenditures decreases steadily across the income groups. Overall, the share spent is lower than the EU-average. This is notable especially for Malta, Cyprus, Spain, and Portugal. Energy expenditures in Italy are comparable to the EU-average.

[379] Year of data is as follows: Ireland (2015), the Netherlands (2015), France (2017), Germany (2018), Austria (2020). For all others 2022 data was available.

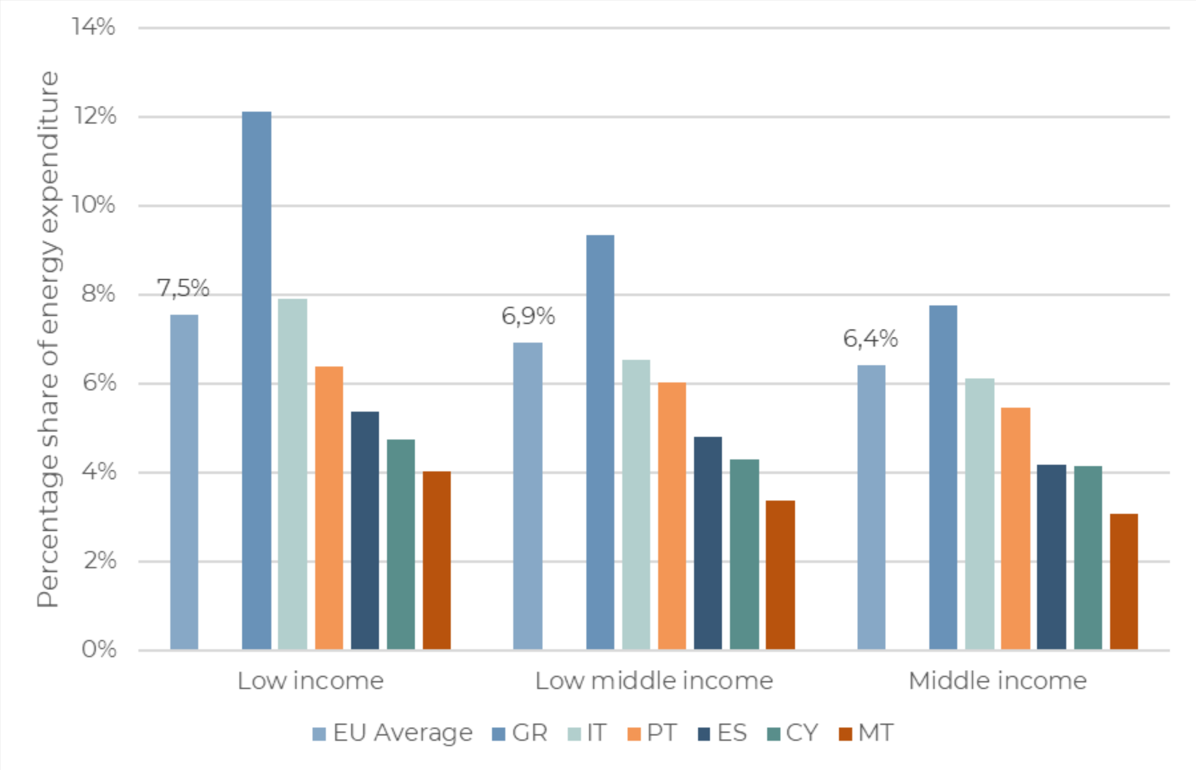

Figure 166: Share of energy expenditure in total expenditure by income groups for Greece, Portugal, Italy, Spain, Cyprus, and Malta[380]

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

The share of energy expenditures in MS in **Central and Eastern European MS** is significantly higher than the EU-average. Slovakia has particularly high shares of energy expenditures across all income groups at 22%, 17%, and 15% for the three income groups respectively. In Czechia the high shares of energy expenditures in Czechia also decrease with an increase in income. This is not the case in Poland where low-income households spend around 11% of their total expenditures on energy and low-middle income and middle-income groups spend 13% and 12% on energy. This may be due to very low consumption patterns by the poorest households that underuse on energy due to other financial constraints. Approximately 1.5 million households in Poland are affected by energy poverty.[381]

[380] Year of data is as follows: Portugal (2015), Malta (2015), Cyprus (2016), Greece (2020), Spain (2021). For all others 2022 data was available.

[381] *Sokolowski (2023). Energy poverty and unfit housing in Poland*

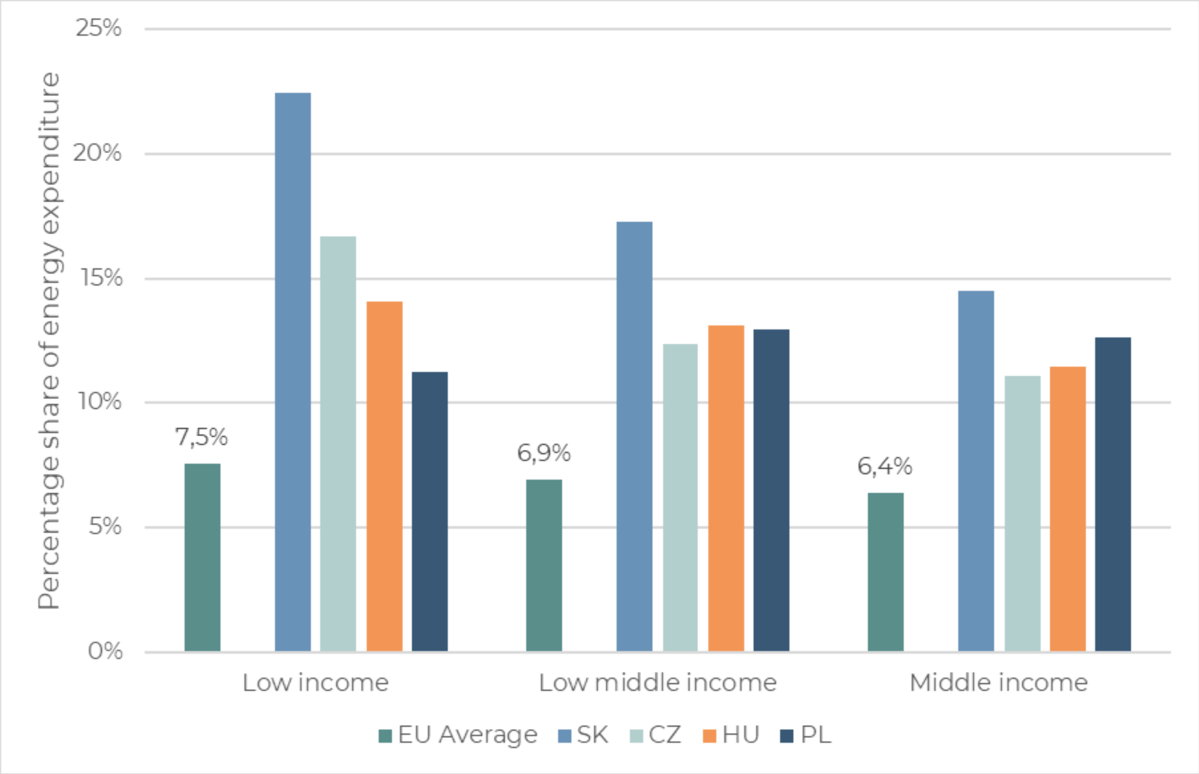

Figure 167: Share of energy expenditure in total expenditure by income groups for Slovakia, Czechia, Hungary, and Poland[382]

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

[382] Year of data is as follows: Slovakia (2019), Czechia (2020), Hungary (2020), Poland (2021)

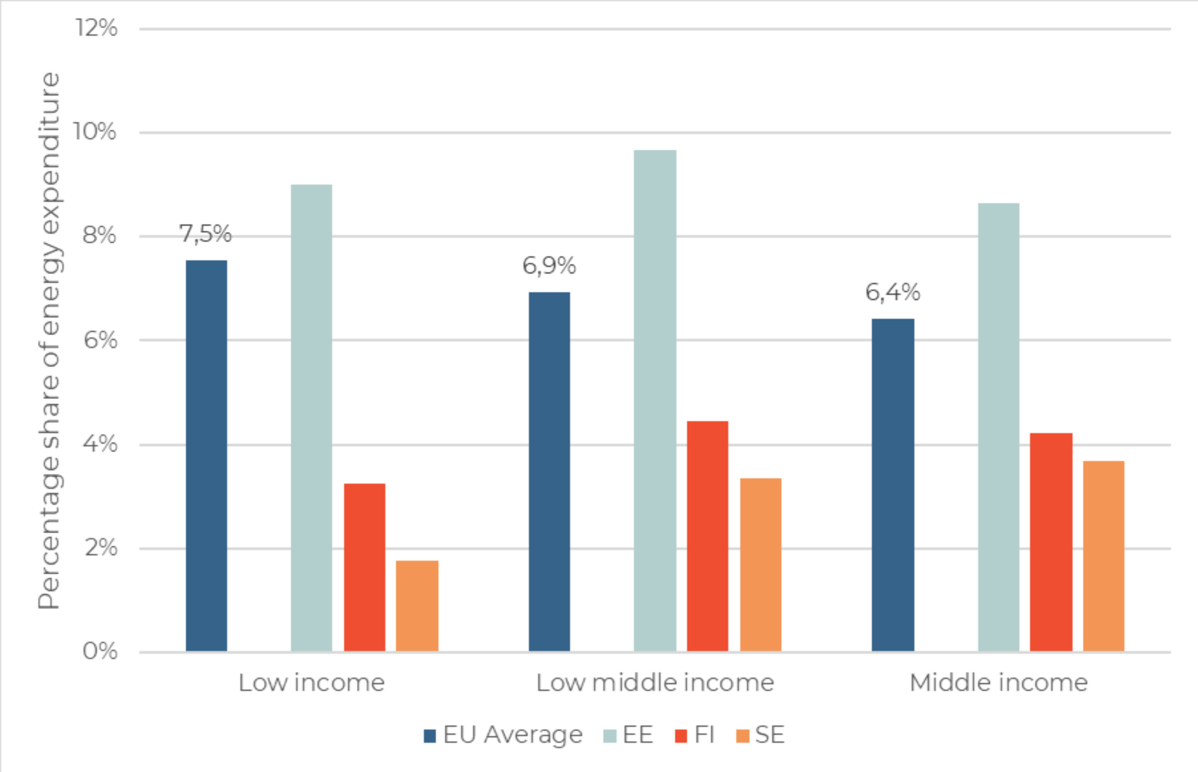

Figure 168: Share of energy expenditure in total expenditure by income groups for Denmark, Finland, and Sweden[383]

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

Households in Finland and Sweden have amongst the lowest energy expenditures. Particularly the low-income households spend only 3% and 2% of their total expenditures on energy. It should be noted that this share increases across the income groups, while still remaining low in comparison to the other MS and the EU-average. In both of these MS, heating costs are often included in rent, which may explain why this share is so low and makes it difficult to assess energy costs accurately. Energy expenditures in Estonia are significantly higher by comparison.

These expenditures are more comparable to those in Latvia, Denmark, and Lithuania. These are higher than the EU-average ranging from 11-14% for low-income households, for example. This may be linked to lower energy efficiency in the residential buildings sector which tends to disproportionately affect low-income groups. On the other hand, low levels of income in Lithuania and Latvia may be driving factors, as well as high energy prices in Denmark.

[383] Year of data is as follows: Estonia (2020), Sweden (2021). For all others 2022 data was available.

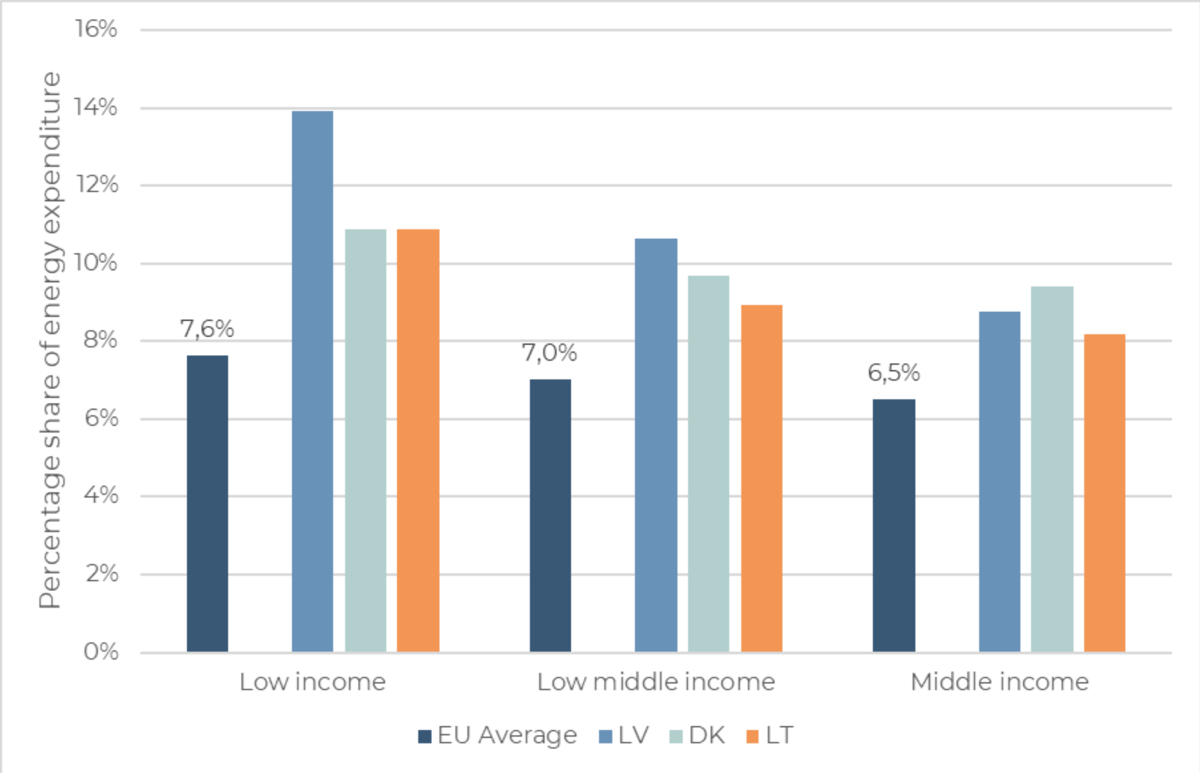

Figure 169: Share of energy expenditure in total expenditure by income groups for Latvia, Estonia, and Lithuania[384]

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

In **South Eastern European MS** the share of energy expenditures are also generally significantly higher than the EU-average. This is particularly the case for low-income households who spend between 12-15% of their total expenditures on energy in these countries. These shares stay high for the middle-income groups in Romania and Bulgaria but decrease significantly in Slovenia and Croatia as income increases. In Romania the share spent on energy does not decrease with an increase in income and remains high even for middle-income groups. This may be related to high levels of energy poverty in Romania which according to the European Parliament amounted to 28% of affected households in 2022.[385] Reasons for that include low energy efficiency in residential buildings and household appliances, unsustainable energy use, limited access to diverse energy sources, rising energy prices, and low incomes. These factors combine to make it difficult for households to afford the energy needed to maintain a comfortable living environment. Again, low energy efficiency and low purchasing powers of these MS play a significant role.

[384] Year of data is as follows: Latvia (2019), Lithuania (2021), For all others 2022 data was available.
[385] European Parliament (2022). Combating energy poverty in Romania

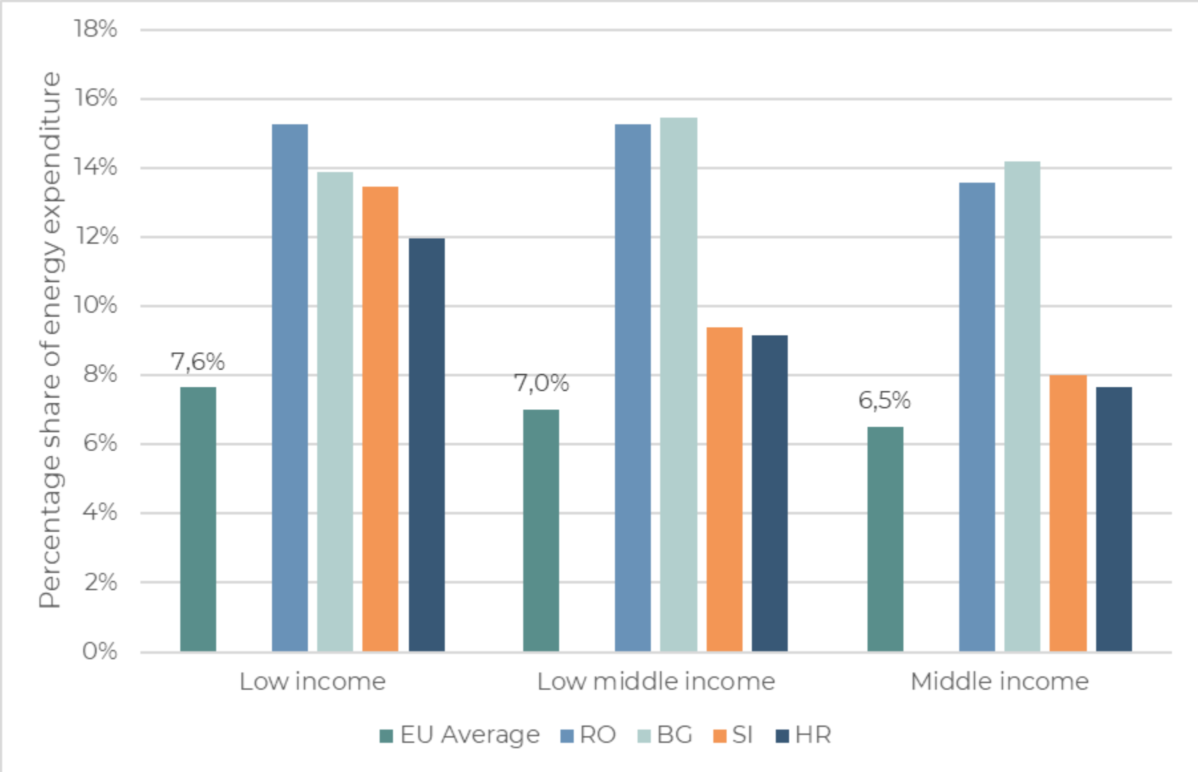

Figure 170: Share of energy expenditure in total expenditure by income groups for Romania, Slovenia, Bulgaria, and Croatia[386]

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

6.4. Household energy expenditures for transport

The previous sections focused exclusively on households' energy expenditures without considering energy expenditures related to transport. In the following sections energy expenditures are shown exclusively for those related to transport. This includes expenditures for transport fuel related costs.

6.4.1. Transport energy expenditure in households with low-income

In 2022, low-income households spend on average EUR 545 on transport fuels which accounts for 3% of their total consumption expenditure. This average is based on the MS who provided data from 2022 and transport-related expenditures vary across MS. Germany does not report any data on transport expenditures. Sweden only reports total consumption expenditures and does not differentiate by fuel types.

Figure 171 shows a clear trend that annual absolute transport expenditures are significantly lower in countries with lower GDP including Romania (EUR 13), Greece (EUR 57), Slovakia (EUR 57), Latvia (EUR 65), and Czechia (EUR 82). This also corresponds to a very low share of consumption expenditures spent on transport fuels with the exception of Latvia where low absolute expenditures still correspond to 3% of consumption expenditures. Low absolute transport fuel expenditures in these MS are likely to correspond to low levels of car ownership in the lowest income deciles.

The highest absolute transport expenditures can be seen in Luxemburg (EUR 1478), Malta (EUR 1053) and Sweden (EUR 828). In Malta this also corresponds to a high share of total consumption expenditures (9%). High shares of expenditures can also be seen in Cyprus (6%), Poland (6%), Estonia (5%), and Portugal (5%). High shares of car ownership in Malta, likely due to a lack of other transport

[386] Year of data is as follows: Slovenia (2018), Romania (2019). For all others 2022 data was available.

infrastructures, contribute to the high costs even for low-income groups. Additionally, in countries with a high share of a rural population shares of transport related expenditures is higher as car-dependencies are more pronounced.

Among the MS costs for petrol plays the most significant role. This is most pronounced in Hungary (88%), Greece (81%), the Netherlands (86%), and Finland (89%). Highest diesel shares can be found in Lithuania (67%), Latvia (58%), France (60%), Luxemburg (65%), and Romania (56%). It should be noted that in Malta the share of "other fuels" is very high at 59%. This may relate to ethanol or to electric-powered vehicles which since 2024 have been subsidized by the government of Malta but may also be a reporting error.

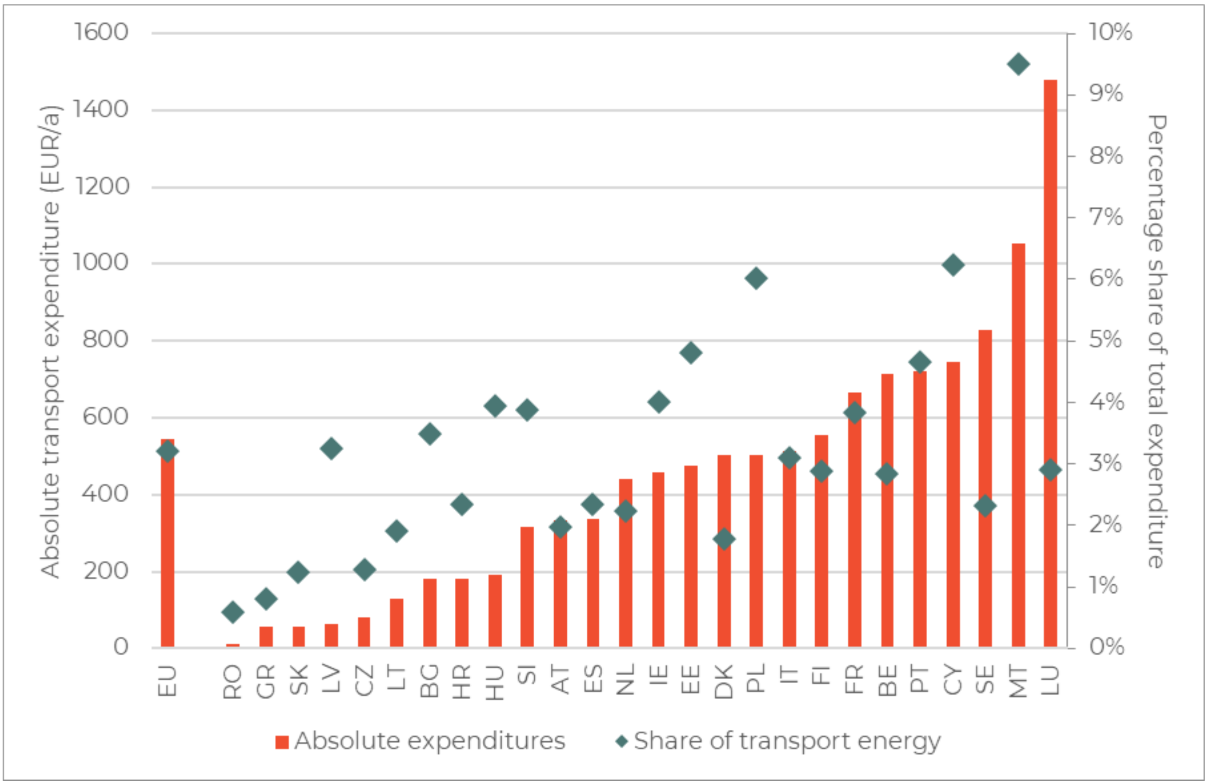

Figure 171: Absolute transport expenditures and share of transport expenditures for low-income households for Member States in the EU27[387]

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

[387] Year of data is as follows: Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Poland (2021). For all others 2022 data was available. Germany and Sweden did not deliver transport data.

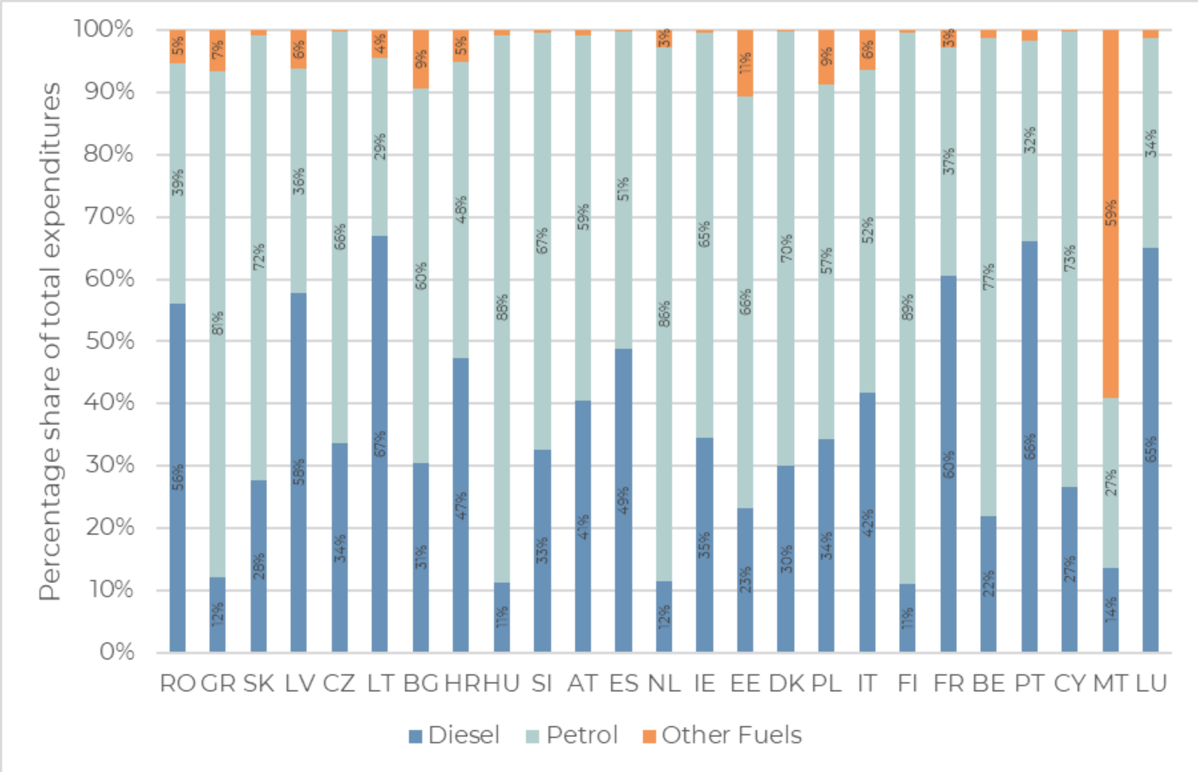

Figure 172: Share of transport fuels in transport expenditures for low-income households of Member States in the EU27[388]

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

6.4.2. Transport energy expenditure in households with middle-income

Middle-income households are more likely to own a car and be able to afford motorized private mobility options. In 2024, on average middle-income households spend EUR 1321 per year on transport fuels. This makes up 4% of their total consumption expenditure.

The distribution of MS ranked by absolute transport-related energy expenditures does not change drastically across income groups. Low absolute expenditures are still seen in Romania, Latvia, and Bulgaria, while the highest absolute expenditures can be seen in Luxemburg, Cyprus, and Malta. The highest shares spent on transport fuels can be seen in Cyprus and Malta, as well as Slovenia, Poland, and Hungary. An increase in the share spent on transport fuels increases by two percentage points in Czechia, Spain, Greece, Hungary, Italy, and Slovakia.

In Malta the opposite is the case and middle-income households spend 7% of their consumption expenditures on transport, while low-income households spend 9%. This may be due to high car ownership rates across income groups (rather than higher shares for higher income groups), meaning that higher incomes will lead to a decrease in the share of transport related expenditures. In Malta there is also a significant shift across the share of fuels with an increase in the share of diesel and petrol and a decrease in the spending of other fuels.

Other notable shifts across the transport fuels with an increase in the share of expenditures on diesel can be seen in Austria, Belgium, Finland, and Slovenia. This generally corresponds to a decrease in

[388] Year of data is as follows: Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Poland (2021). For all others 2022 data was available. Germany and Sweden did not deliver transport data.

The EU 2022 average is based on expenditure data from those Member States that reported for 2022 and where the number of surveyed households were reported. This includes Belgium, Bulgaria, Finland, Denmark, Croatia, Italy, Portugal, and Luxemburg. The average was weighted according to the number of households.

petrol expenditures. This indicates that middle-income groups in these MS may be more likely to drive a diesel car that are vernally more expensive, but also more efficient or economical for longer or more frequent journeys. The opposite trend can be seen in Romania, Luxemburg, and Latvia where the share of petrol expenditures increases for middle-income groups.

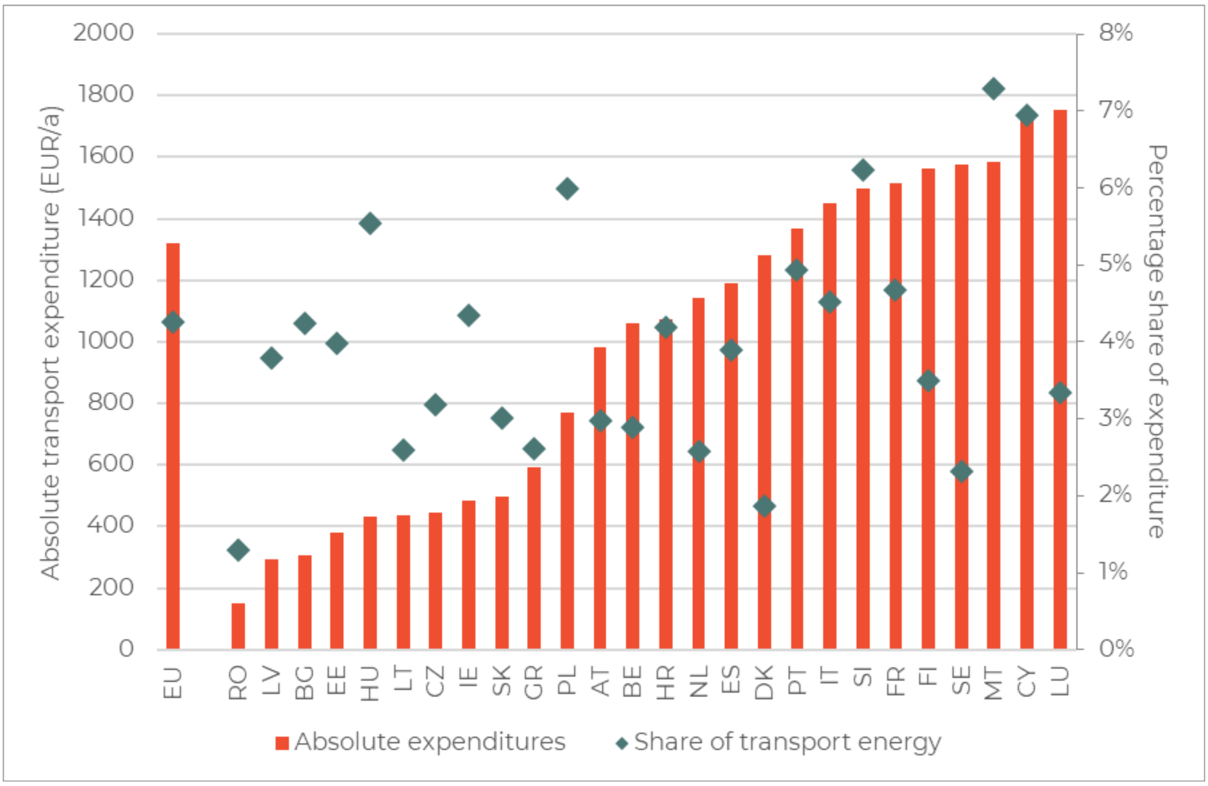

Figure 173: Absolute transport expenditures and share of transport expenditures for middle-income households for Member States in the EU27[389]

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

[389] Year of data is as follows: Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Poland (2021). For all others 2022 data was available. Germany and Sweden did not deliver transport data.

The EU 2022 average is based on expenditure data from those Member States that reported for 2022 and where the number of surveyed households were reported. This includes Belgium, Bulgaria, Finland, Denmark, Croatia, Italy, Portugal, and Luxemburg. The average was weighted according to the number of households.

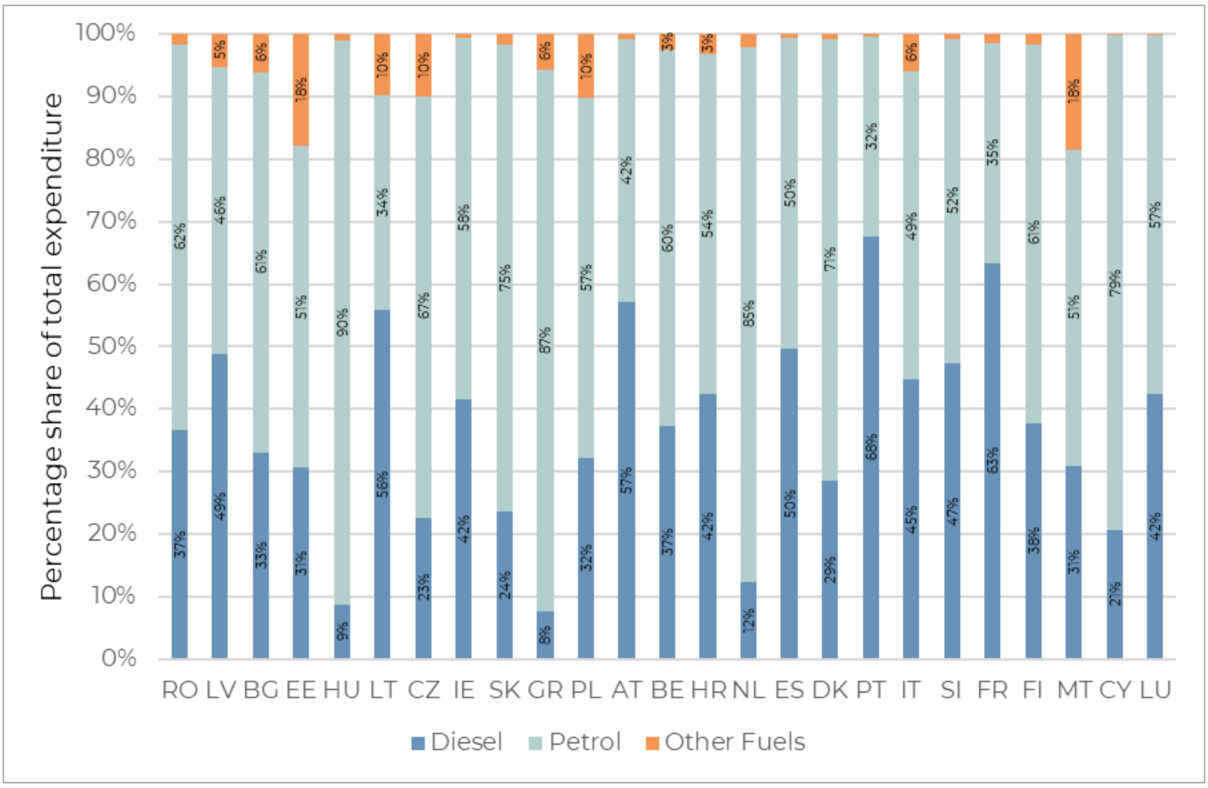

Figure 174: Share of transport fuels in transport expenditures for middle-income households of Member States in the EU27[390]

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

6.5. Changes in energy expenditures in the Member States over time (2010-2022)

Energy and transport related expenditures change over time as there are many aspects that influence these including energy prices, inflation, and other economic and political developments. Figure 175 shown the share of total consumption expenditure spent on energy and transport for the three income groups between 2010 and 2022. These yearly averages are calculated based on the available data for those years and are weighted based on the number of households in those MS. This is therefore only a partial display of energy consumption expenditures over time.

Household energy expenditures excluding transport expenditures are overall higher than those on transport. Generally, low-income households spend the highest share of their expenditures on energy, while spending from low-middle and middle-income households converges around 2018. The inverse relationship can be observed for transport expenditures, where low-income households spend a significantly lower share of their expenditures on transport that higher income groups. Low-middle and middle-income groups also do not differ significantly in their share of spending.

In 2021 there is a notable dip in the share of energy related consumption expenditures, which may be due to short-term relief measures that were implemented in connection to the energy prices crises. This is, however, followed by a notable upward trend in 2022. The share of transport-related expenditures dips slightly in 2020, before continuing in an upward trend which is likely due to the reduced mobility needs during the Covid-19 pandemic.

[390] Year of data is as follows: Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Poland (2021). For all others 2022 data was available. Germany and Sweden did not deliver transport data.

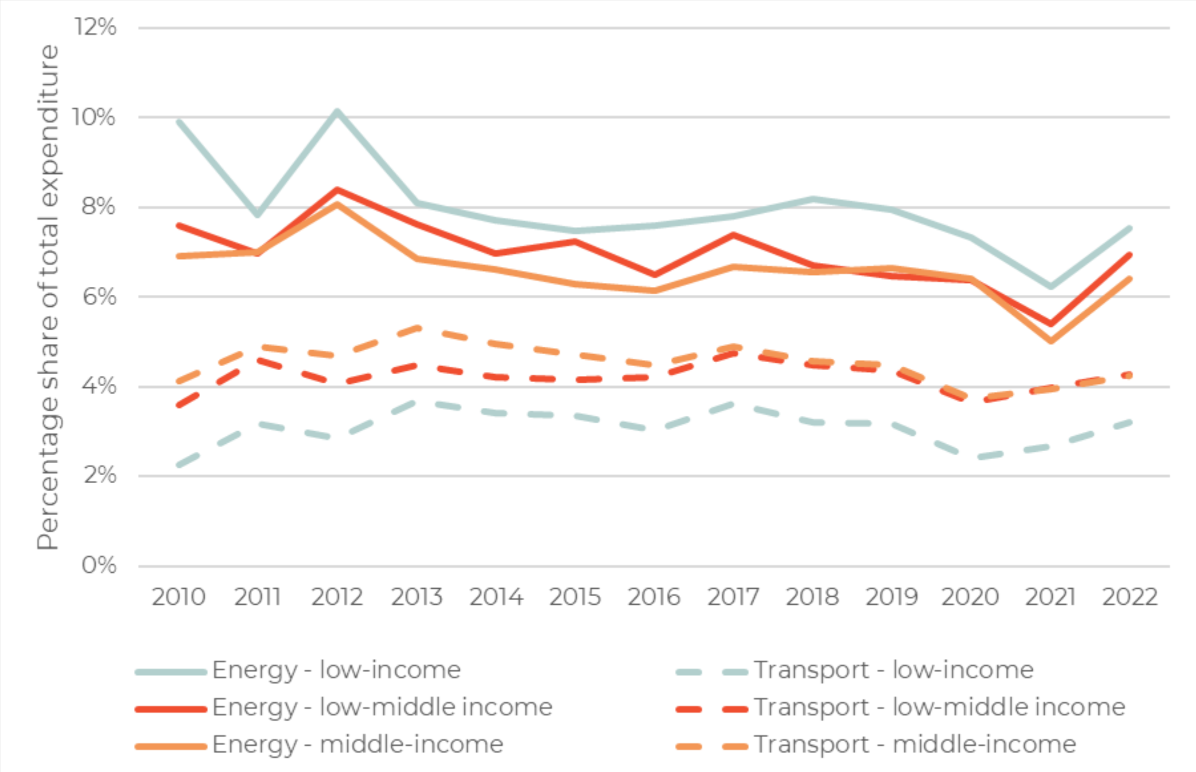

Figure 175: Expenditures on household energy (electricity, gas, heating, etc.) and transport energy (petrol, diesel, etc.) for the poorest, lower middle, and middle-income households by EU Member State 2010-2022[391]

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

Generally, a decrease in the share of expenditures on energy excluding transport can be seen between 2010 and 2022. This is most pronounced for low-income households and related primarily to changes between 2010 and 2015, as between 2015 and 2022 changes are marginal. Between 2020 and 2022 there are also only very marginal changes in the share spent on energy, although the upward trend can be seen clearly for all income groups examined. In relation to transport expenditures there was a jump in expenditures for all income groups between 2020 and 2022, including between 2010-2020 where low-income households experience the highest increase.

Table 32: Changes of share of expenditure on energy across Member States (2010-2022)

	2010	2015	2020	2022	2010-2022	2015-2022
Low-income households	9,9%	7,5%	7,3%	7,6%	-2,3%	0,2%
Low middle-income households	7,6%	7,2%	6,4%	7,0%	-0,6%	-0,2%
Middle-income households	6,9%	6,3%	6,4%	6,5%	-0,4%	0,2%

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

[391] Year of data is as follows: Ireland (2015), Malta (2015), the Netherlands (2015), Cyprus (2016), France (2017), Germany (2018), Slovenia (2018), Latvia (2019), Romania (2019), Slovakia (2019), Estonia (2020), Austria (2020), Czechia (2020), Greece (2020), Hungary (2020), Lithuania (2021), Spain (2021), Sweden (2021), Poland (2021). For all others 2022 data was available.

Table 33: Changes of share of expenditure on transport energy across Member States (2010-2022)

	2010	2015	2020	2022	2010-2022	2015-2022
Low-income households	2,2%	3,4%	2,4%	3,1%	0,8%	-0,3%
Low middle-income households	3,6%	4,2%	3,6%	4,2%	0,6%	0,1%
Middle-income households	4,1%	4,7%	3,8%	4,2%	0,1%	-0,5%

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

6.6. Energy poverty: expenditure indicators and changes over time

Households that cannot meet their energy needs at a reasonable cost are often referred to as energy poor. In the recent Energy Poverty Recommendation (EC 2023)[392] and accompanying Staff Document the following definition is included:

"Energy poverty is a situation in which households are unable to access essential energy services and products, thus affecting health, living standards and the levels of heating, cooling, and lighting of homes. It occurs when a high percentage of consumers' income is spent on energy bills, when the energy efficiency of buildings and appliances is low or when household's energy consumption needs to be reduced to a degree that negatively impacts health and well-being (EC 2023)."[393]

The staff document also includes a range of measures that aim to alleviate energy poverty and some discussion of indicators used to measure energy poverty. A definition for energy poverty is included in Art. 2 No. 52 of the Energy Efficiency Directive (EED)[394]

"'energy poverty' means a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, ***insufficient disposable income, high energy expenditure and poor energy efficiency of homes****;"*

It highlights the main causes of energy poverty which are often referred to as the energy poverty triangle: low (or low medium) income, high energy costs, and low efficiency. The latter addresses the issue that energy needs, and thus cost burden, might be high because of structural factors, such as inefficient buildings or heating technology. All three causes need to be addressed when aiming to alleviate or avoid energy poverty.

Other EU regulations and directives refer to the definition provided in the EED including the Social Climate Fund Regulation[395] and the Energy Performance of Buildings Directive (EPBD)[396].

[392] European Commission (EC) (2023): EU guidance on energy poverty. Commission Recommendation on energy poverty. Staff Working Document. SWD (2023) 647. Online: https://energy.ec.europa.eu/document/download/a17c2aa6-02ca-49b3-8df6-b106ca9f37ed_en?filename=SWD_2023_647_F1_OTHER_STAFF_WORKING_PAPER_EN_V5_P1_3016190.PDF
[393] Ibid.
[394] *European Commission (2023). Directive EU/2023/1791*
[395] *European Commission (2023). Regulation EU/2023/955*
[396] *European Commission (2024). Directive EU/2024/1275*

At the EU level, four indicators are most commonly used to assess levels of energy poverty. These include two expenditure-based indicators and to self-reported indicators:

- 2M – proportion of households whose share of energy expenditure in relation to income is more than twice the national median.
- M/2 – proportion of households whose absolute energy expenditure is less than half of the national median.
- Self-reported: Inability to keep home adequately warm.
- Self-reported: Arrears on utility bills.

The indicators were developed and recommended by the EU Energy Poverty Observatory and are included in the current EU Energy Poverty Advisory Hub dashboard[397]. The expenditure-based indicators, 2M and M/2, are based on Household Budget Survey (HBS)[398] data which is available for 2010 and 2015. Within this study, additional data is available for some countries for the year 2020.

Figure 176 shows the available data for the indicator 2M for the years 2010 (all MS), 2015 (without DK) and 2020 (without CY, CZ, FI, FR, IE, MT, PL, PT, RO, SE). The proportion of households whose share of energy expenditure in relation to income is more than twice the national median is higher than the EU average (around 15% at all points of time) in Sweden (for 2010 and 2015), Denmark and Estonia (in 2020), Finland (in 2015), Lithuania (in 2010) and Malta (in 2015). A few other Member States are also above EU-average: Austria, Germany, Greece, Ireland, Poland, Portugal, Romania, and Slovenia.

The indicator shows households that have high relative energy expenditures, but the indicator is not very price sensitive. When prices increase the median also shifts and thus the share of affected households may not increase significantly even when absolute expenditures and cost-burden rise. The indicator also does not represent those households who are under-consuming (see Gouveia et al., 2022[399]).

[397] Energy Poverty Advisory Hub (2024). National indicators

[398] Eurostat (2020). Household Budget Surveys

[399] Gouveia, P.; Palma, P.; Bessa, S.; Mahoney, K.; Sequeira, M. (2022): Energy Poverty National Indicators. Insights of a more effective measuring. Energy Poverty Advisory Hub. https://energy-poverty.ec.europa.eu/system/files/2024-05/EPAH_Energy%20Poverty%20National%20Indicators%20Report_0.pdf

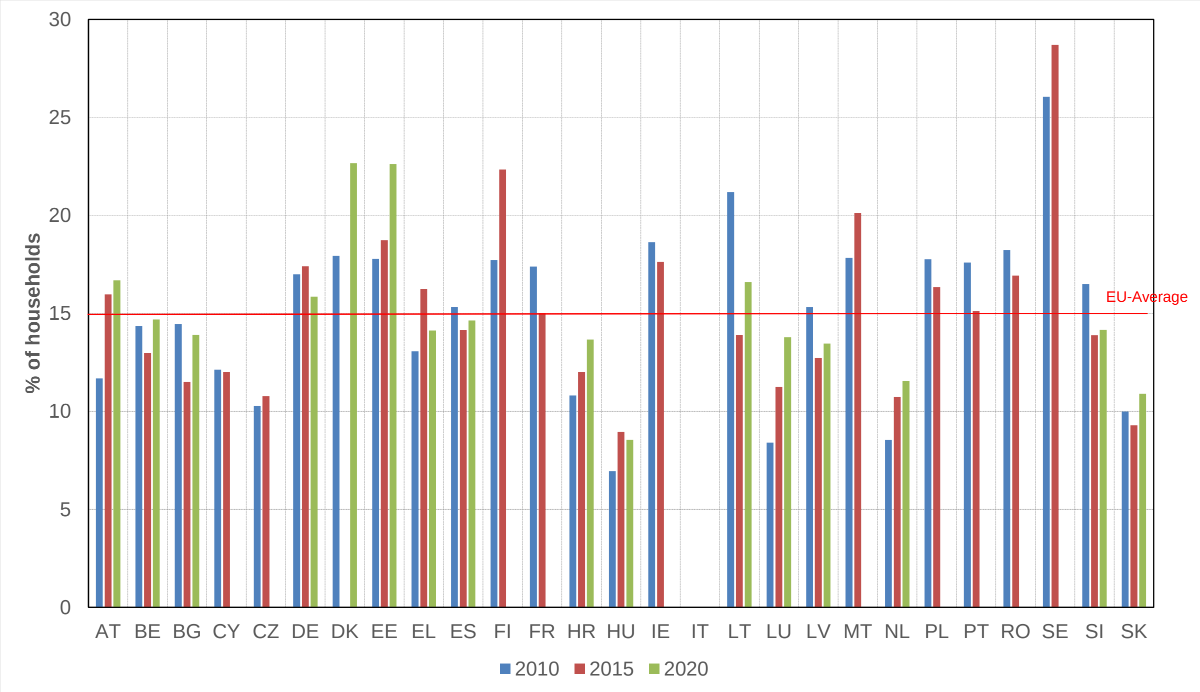

Figure 176: High share of energy expenditure in income (2M) between 2010 and 2020

Source: EPAH (2024)[400]

Due to these limitations, not only high energy cost burden in relation to income (2M) should be analysed but also households whose absolute energy expenditure is below half the median (M/2), or "abnormally low" (Gouveia et al. 2022). M/2 thus reflects on hidden energy poverty, i.e. households that do not meet their energy needs because they cannot afford it. Figure 177 shows the proportion of households whose absolute energy expenditure is less than half of the national median. The EU average for M/2 was about 14% in 2010 and decreased to 12% in 2020. Significantly above EU average at least for some years are Czechia, Estonia, Finland, France, Lithuania, Malta, Poland, Romania and Sweden.

This indicator along with the 2M indicator, however, only focus on the economic dimension of energy poverty. Gouveia et al. (2022) recommend using the indicator in combination with an income threshold that excludes high income households (see chapter 3.7) or further indicators which represent disparities and inequality. For example, living in a plus-energy house and driving a battery-powered car can result in zero (or even negative) energy expenditure. However, households need a fairly high income to be able to afford this.

[400] Energy Poverty Advisory Hub (2024). National indicators

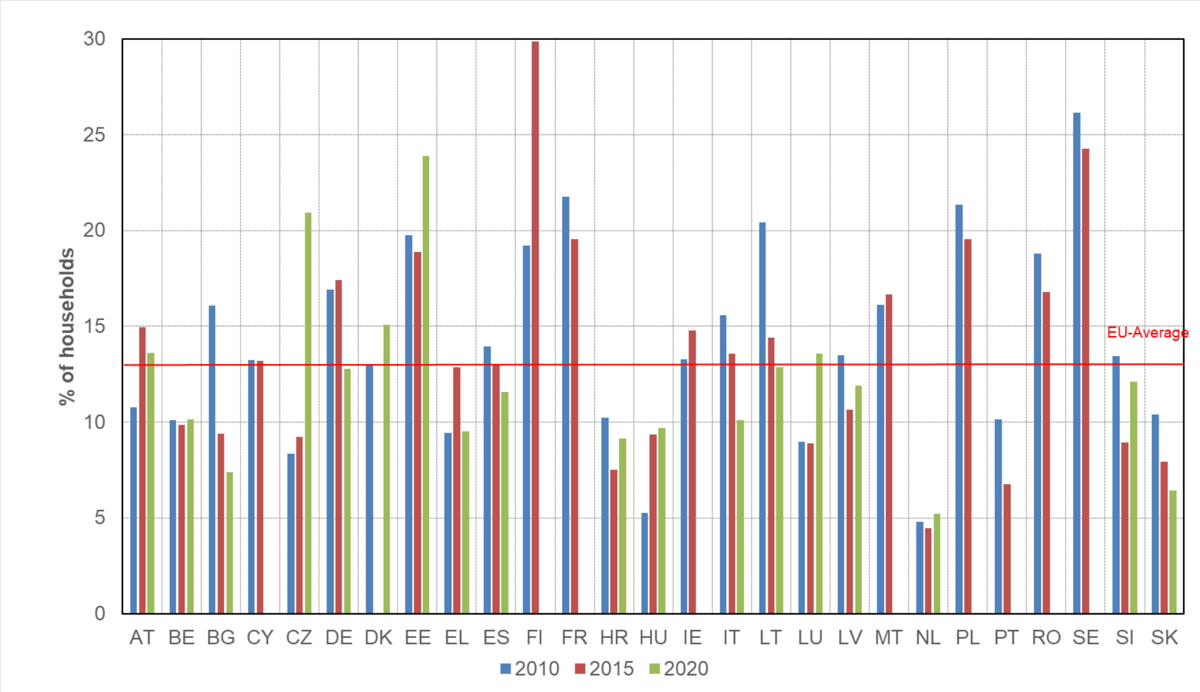

Figure 177: Low absolute energy expenditure (M/2) 2010, 2015and 2020

Source: EPAH (2024)[401]

Data for these two expenditure indicators can also be differentiated by income deciles. Figure 178 below shows the proportion of households whose energy expenditure as a percentage of income is more than twice the national median for the years 2015 and 2020 in the first and tenth income decile (including net income). The burden of high energy bills is significantly higher for the first decile, averaging 41%. In contrast, the average burden for the 10th decile is around 4%. The relation between energy expenditure and disposable income shows the relation on the macro level.

Finland and Luxemburg are the only two Member States (in 2015 and 2020) where the median equalized income is higher than the 2M indicator value. This means that the burden of high energy bills is made more affordable. Member States like Estonia, Greece, Croatia, Hungary, Latvia, and Slovakia show the highest burden, as 2M is more than four times higher than net income. The picture is similar in 2020. Despite energy price increases, there is no significant change in the burden on households' energy expenditures in relation to income that was not already visible in 2015. Rising incomes between 2015 and 2020 do not help alleviate the burden.

[401] Energy Poverty Advisory Hub (2024). National indicators

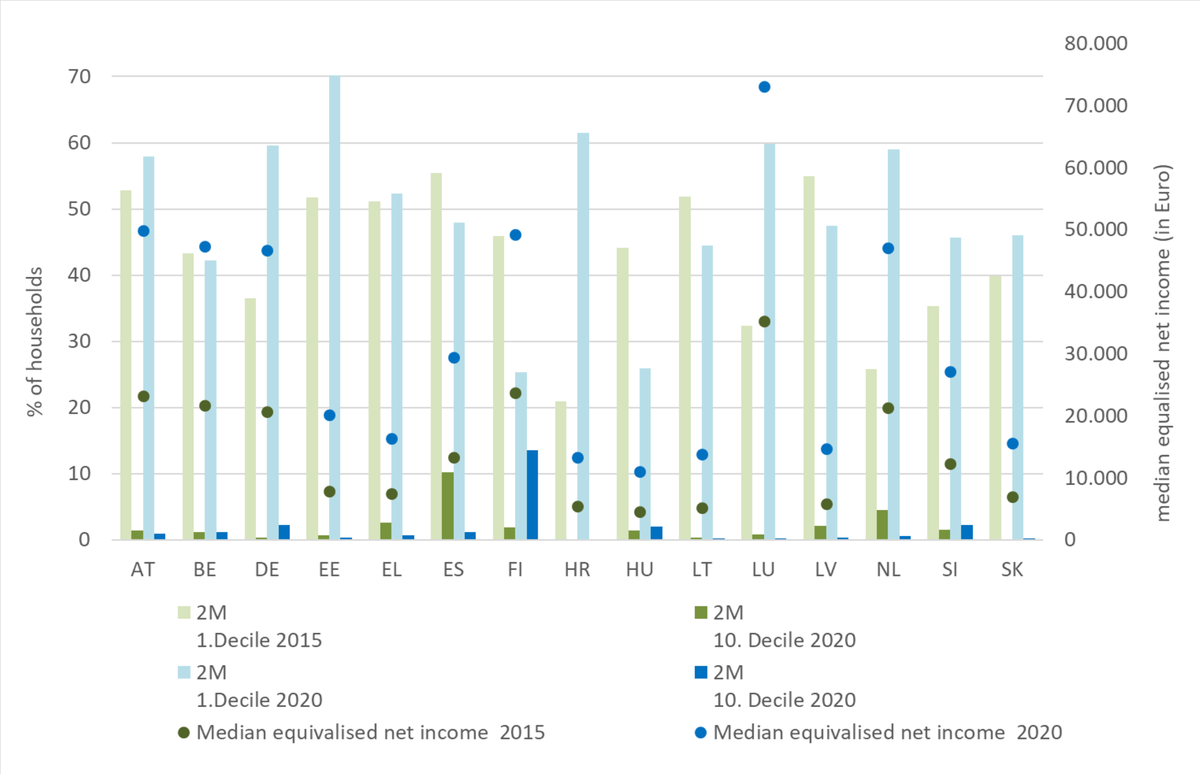

Figure 178: 2M Decile 1 and 10 in comparison with median equalised net income (2015 and 2020)

Source – EPAH (2024)[402], Member States missing do not have data for 2015 and/or 2020

Figure 179 shows the M/2 indicator and considers households whose energy expenditure is less than half the national median to be energy poor by income decile. The difference between the first and tenth deciles in 2015 and 2020 seems less pronounced than for the 2M indicator. The burden of high energy bills is higher for the first decile, averaging 26%. Rising incomes between 2015 and 2020 do not help alleviate the burden. By contrast, the average burden for the 10th decile is around 8%. However, relatively low energy expenditure can be the result of high energy efficiency. Therefore, households in the tenth decile can be classified as energy poor according to the M/2 indicator even if they live in highly efficient dwellings.

[402] Energy Poverty Advisory Hub (2024). National indicators

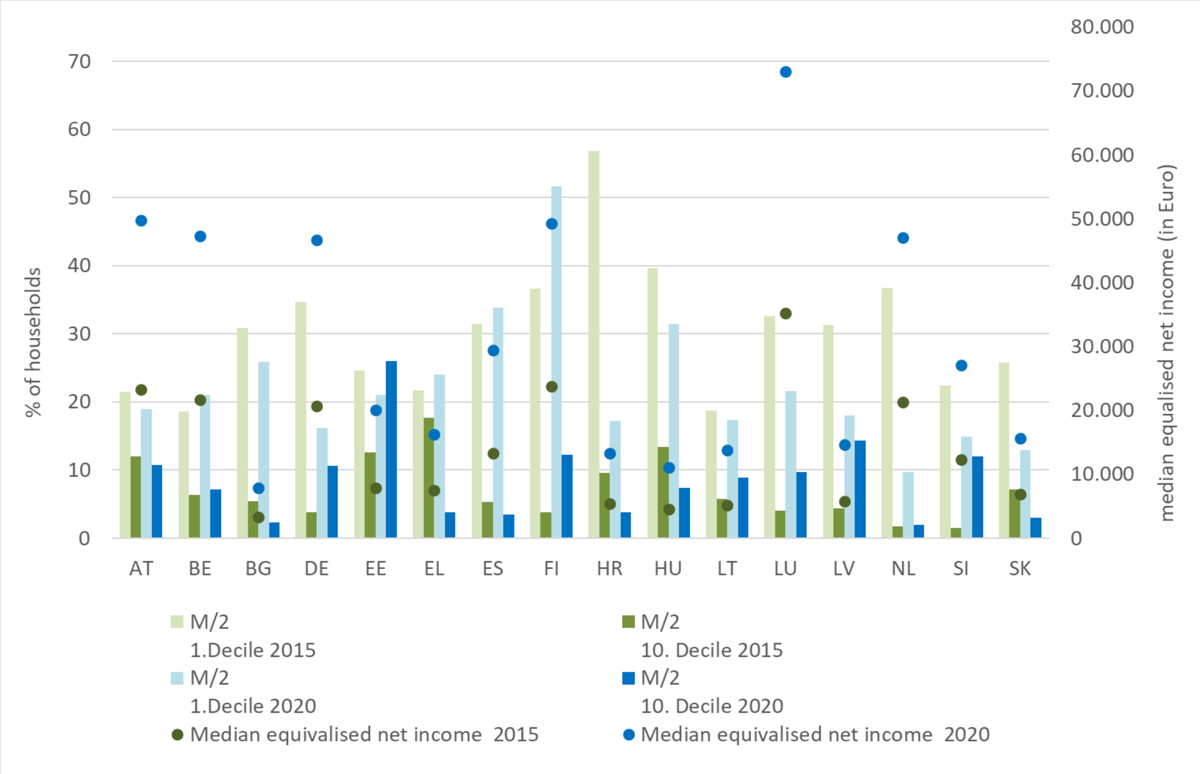

Figure 179: M/2 Decile 1 and 10 in comparison with median equalised net income (2015 and 2020)

Source: EPAH (2024)[403], Member States missing do not have data for 2015 or/and 2020

Expenditure-based indicators can be helpful to get a first impression on energy poverty issues. However, to address the three underlying causes of energy poverty as described in the triangle it is important to differentiate by income and focus on those households that have low income and high energy cost burden or low absolute energy expenditure. It is important to analyse in more depth country-specific conditions and combinations of indicators to understand causes of over- or under-consumption and distributional impacts. Additional indicators are needed to capture energy efficiency issues, social issues, climate issues etc.

As outlined above, energy poverty is a phenomenon that cannot only be understood and tackled by addressing expenditure and income issues alone. For the indicators "inability to keep home adequately warm" and "arrears on utility bills" data are currently available until 2023. It also allows a comparison of self-reported and expenditure-based indicators.

The percentage of households that report to be unable to keep their homes adequately warm is shown in Figure 180, whereas Figure 181 shows the share of households that has experienced arrears on utility bills. One might expect that countries in colder climates would be more susceptible to low levels of home heating security. But this is not the case. Bulgaria, Cyprus, Greece, Spain, Lithuania and Portugal show the highest percentages of households affected by indicator "inability to keep home warm". The highest rates of excess winter deaths are found in the warmest countries, where people are more likely to live in inadequate buildings or lack access to heating that would support thermal comfort (EPAH 2024)[404].

The share has been increasing since 2018 in some Member States, with a significant increase in the energy crisis year 2023 in Germany and the Netherlands where the share has nearly doubled. Austria, Czechia, Denmark, Spain, France, and Sweden also show an increase by around 30-50%. The increase

[403] Energy Poverty Advisory Hub (2024). National indicators
[404] Energy Poverty Advisory Hub (2024). National indicators Indicator: excess winter mortality/deaths

is due to methodological changes in the database in the year 2019 but also due to the energy price increase following the Russian invasion in the Ukraine.

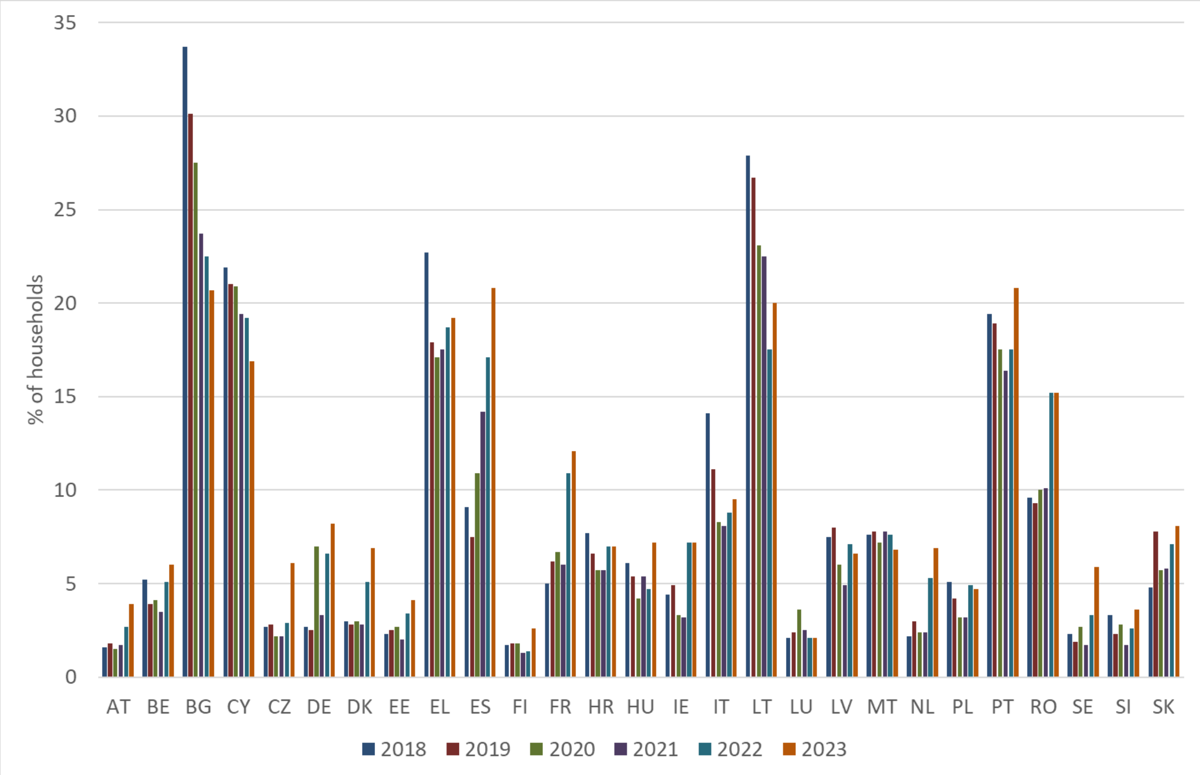

Figure 180: Percentage of households affected by inability to keep home warm between 2018 and 2023

Source: EPAH (2024)[405]

Figure 181 provides the share of households affected by arrears on utility bills. The change over time varies from country to country. It declined in some countries, e.g. Bulgaria, and increased in others, e.g. Germany and Austria.

[405] Energy Poverty Advisory Hub (2024). National indicators

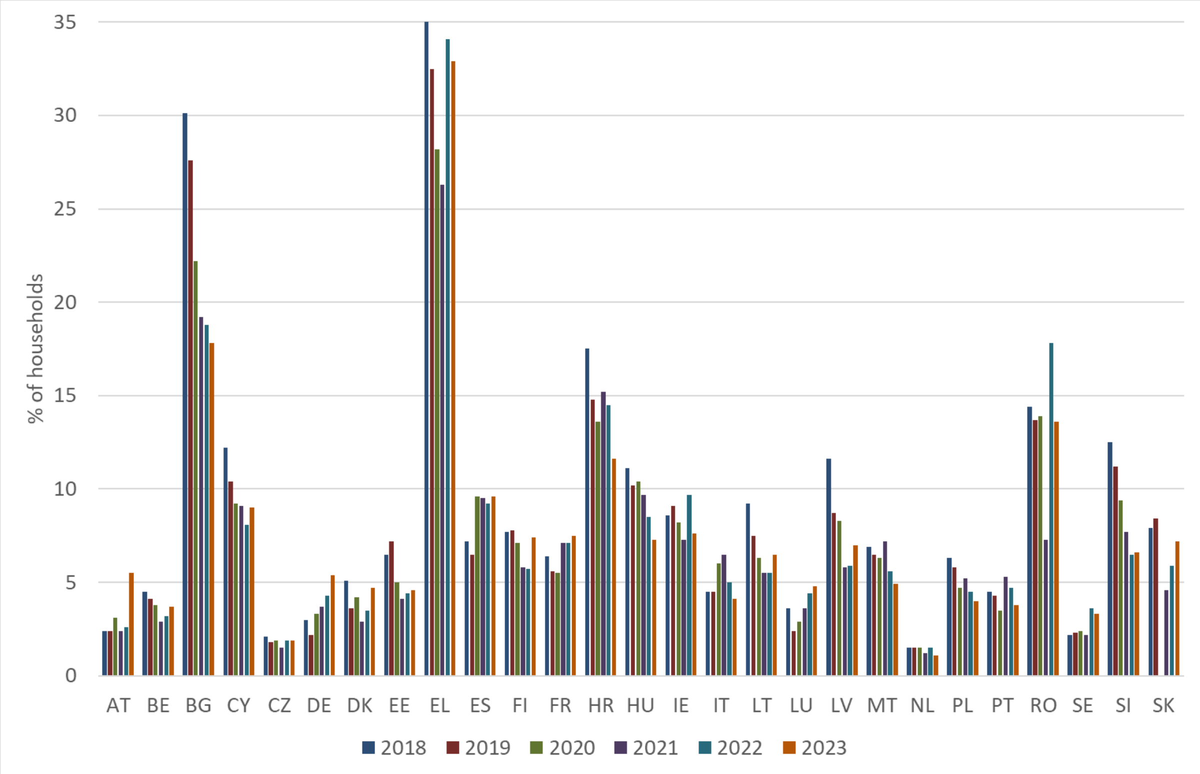

Figure 181: Percentage of households affected by arrears on utility bills between 2018 and 2023

Source: EPAH (2024)[406]

Countries who are significantly affected by the "inability to keep home warm" indicator tend to also be significantly affected by the "arrears on utility bills"-indicator, see Figure 182. This applies particularly to Bulgaria, Greece, and Romania. Lithuania and Portugal show a higher share of households for the "inability to keep home warm" indicator.

[406] Energy Poverty Advisory Hub (2024). National indicators

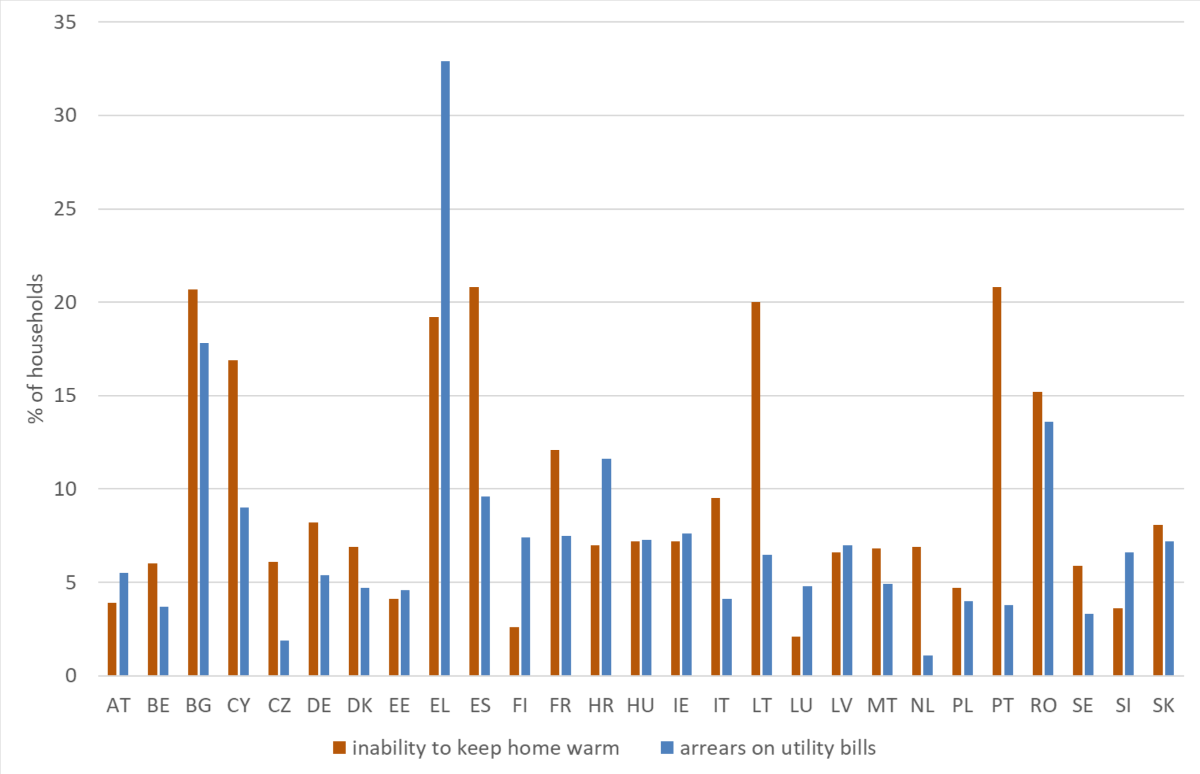

Figure 182: Percentage of households affected by inability to keep home warm und arrears on utiliy bills 2023

Source: EPAH (2024)[407] Data on the indicator "inability to keep home warm" for Romania and Croatia from 2022

6.7. Sensitivity analysis: the effects of high energy prices on energy poverty

To account for more recent changes in energy and consumer prices, a sensitivity analysis was conducted. The sensitivity analysis uses data for the most recent year for household energy expenditureas a starting point.[408]

If we assume that consumption patterns remain unchanged since the last available data points, an increase or decrease of expenditures for energy (including and excluding transport) as well as total consumption expenditure can be estimated using the harmonized index of consumer prices (HICP; see Table 34) for energy and for total consumption (all items) and inflating previous values to the year 2024. It is more likely, however, that energy and overall consumption changes over time especially in response to price changes. In this case the price and consumption effect would need to be disentangled. Unfortunately, no data is available to allow for such a decomposition, especially by income group.

Therefore, for the purposes of this analysis, we proceed as follows.

- If data on energy and consumption expenditures through the ad-hoc working group data collection (see chapter 6.2.1.) is available for the year 2022 or 2023, adjustments in energy

[407] See: https://indicator.energypoverty.eu/

[408] 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 Ireland, Netherlands and Malta data was only available for the year 2015 respectively. Most recent data is as follows: Austria (2020), Belgium (2022), Bulgaria (2023), Cyprus (2016), Czech Republic (2020), Germany (2018), Denmark (2023), Estonia (2020), Spain (2023), Finland (2022), France (2017), Greece (2020), Croatia (2022), Hungary (2020), Italy (2023), Lithuania (2023, Luxembourg (2023), Latvia (2019), Poland (2021), Portugal (2022), Romania (2019), Sweden (2023), Slovenia (2018), Slovakia (2019).

demand in response to the energy crisis are likely to at least partially be already accounted for and extrapolation to the year 2024 can be done including the demand adjustment.

- If data is only available for pre-crisis years (i.e. pre 2022), adjustments in energy consumption will not be covered in the data. We extrapolate to the year 2024 assuming that higher prices lead to increased expenditure and lower prices to decreased expenditure without a change in consumption since the latest year data is available for. This presents a limitation to the approach as the interrelation of energy quantity restrictions, price change, and consumption reduction cannot be reflected.

In the following analysis, we thus distinguish countries by the year most recent data is available for to account for the different quality of extrapolation.

Table 34: Harmonized index of consumer prices (HICP) - Classification of individual consumption by energy expenditures (COICOP) May 2024 compared to May 2020 (i.e. 05/2020 = 100)

	Electricity	Natural Gas	Liquid fuels and fuels for transport	Solid fuels[409]	District heating	Transport	All-items HICP
Austria	118,0	259,91	200,13	151,18	176,38	129,78	124,66
Belgium	127,8	203,68	246,40	154,55	no data	127,48	121,37
Bulgaria	115,8	160,07	no data	168,14	184,01	133,95	129,47
Croatia	113,3	124,95	265,15	134,85	93,11	131,75	128,01
Cyprus	166,2	160,59	174,02	124,00	no data	130,96	117,91
Czechia	175,2	195,18	145,16	177,44	172,46	136,54	136,81
Denmark	119,7	169,51	180,84	152,33	124,47	119,44	115,80
Estonia	366,5	130,86	170,78	162,56	160,81	142,49	142,10
Finland	128,5	no data	207,51	no data!	123,73	119,42	115,60
France	146,0	175,60	179,23	128,16	178,47	122,83	117,16
Germany	126,5	188,42	166,48	147,63	174,39	127,34	121,56
Greece	116,8	138,59	179,43	136,15	no data	118,47	116,31
Hungary*	123,8	144,42	no data	170,08	100,00	157,83	147,89
Ireland	164,6	193,68	240,09	151,07	no data	127,72	118,50
Italy	163,0	168,00	149,42	120,18	no data	122,59	118,21
Latvia	140,8	201,68	no data	158,21	158,12	137,33	134,55
Lithuania	115,0	164,07	253,33	231,06	168,76	139,82	136,95
Luxembourg	102,6	177,88	237,14	121,64	184,87	137,23	119,49
Malta	100,0	100,00	no data	no data	no data	109,80	115,28
Netherlands	155,9	151,42	no data	no data	167,02	126,43	123,29
Poland	139,0	163,45	212,38	193,78	171,39	139,51	136,46
Portugal	113,9	135,57	169,36	126,03	no data	119,01	118,84
Romania	135,2	163,62	137,24	141,03	153,16	136,49	134,53
Slovakia	109,6	120,79	no data	154,96	135,13	136,40	131,44
Slovenia	153,6	139,45	169,71	139,49	181,55	126,85	123,11
Spain	132,1	105,74	213,16	no data	no data	124,47	118,71
Sweden	119,6	137,05	no data	175,95	110,83	125,94	120,30
EU27 average	144,1	162,60	186,67	166,45	157,80	127,11	122,51

Source: Eurostat (2024), HICP - monthly data (index) [PRC_HICP_MIDX__custom_3462527];
Notes: In blue = Maximum per Member State and consumption purpose

[409] This refers only to coal. Wood is not included.

Because of very different data availability, we group Member States according to the latest year data is available. Table 35 provides an overview. Eleven countries have reported data for the year 2022/2023, the peak of the energy price spike. For sixteen countries, we only have pre-crisis data. As outlined above, we inflate all values to 2024 using the harmonized consumer price index (all items) and compare the change to the most recent year data is provided for.

Table 35: Country groups with recent and older data on energy and consumption expenditures

2023	2022	2021/2020	2019/2018	2017 and older
Bulgaria	Belgium	Austria	Germany	Cyprus
Denmark	Finland	Estonia	Latvia	Czechia
Spain	Croatia	Greece	Romania	France
Italy	Portugal	Hungary	Slovenia	Ireland
Lithuania		Poland	Slovakia	Malta
Luxemburg				Netherlands
Sweden				

Source: own presentation

The impact of price increases on the shares of energy expenditure in total household expenditure is shown in Figure 183 to Figure 187 excluding transport fuels and in Figure 188 to Figure 192 including transport fuels. The figures show expenditure shares for each Member State by income quintile for the latest year that data is available and for the most current situation in 2024.

6.7.1. Impact of price increases on energy expenditure excluding transport fuels

The energy price spike during the energy crisis has had significant effects on households' energy expenditure. Compared to pre-crisis years (pre-2022) the share of energy expenditure is still substantially higher. The effect is most pronounced for low income households and highlighting the negative distributional (i.e. regressive) effect of rising energy prices. Compared to the years 2022/2023, energy prices have decreased again.

A change in the share of energy expenditure is a combination of a change in prices for energy carriers and a change in the consumption of these energy carriers. Keeping in mind the share of final energy use as shown in Figure 155, we found combinations of high shares of fossil energy use and high price increases compared to pre-crisis levels 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.

Results for countries with recent data (year 2022/2023)

The impact of price changes on energy expenditure **excluding transport fuels** since 2022/2023 is shown in Figure 183 and Figure 184 for eleven Member States that report data for these years. It can be seen that the energy cost burden, expressed as energy expenditure in comparison to total consumption expenditure, has decreased again and in most countries is now again at the same level or even below the pre-crisis share.

The share of energy expenditure in these countries compared to pre-crisis levels is driven by at least the following factors: i) demand adjustment which might have happened in response to rising energy prices, ii) the inflation rate with its effects on overall consumption expenditure (see chapter 6.7.3.), iii) the share of fossil fuels, in particular natural gas, in energy consumption which experienced the highest price increase.

According to Table 33 the price increase of energy carriers is higher than overall inflation which would result in a higher share of energy expenditure if demand remained constant. Realizing, however, that the share of energy expenditure has not increased this points towards a decrease in the use of energy.

Comparing different income quintiles as shown in the figures, we still see a much higher burden for low income than for high income households. In many countries the burden is twice as high high for low income households. Low income households are thus substantially more affected by energy expenditure than high income households, indicating a regressive effects of energy costs. The gap particularly high in Bulgaria, Lithuania and Croatia, amounting to up to five percentage points. Only Finnland and Sweden show a positive pattern for vulnerable groups. The energy expenditure burden for low income households in these two countries is lower than for medium and high income households.

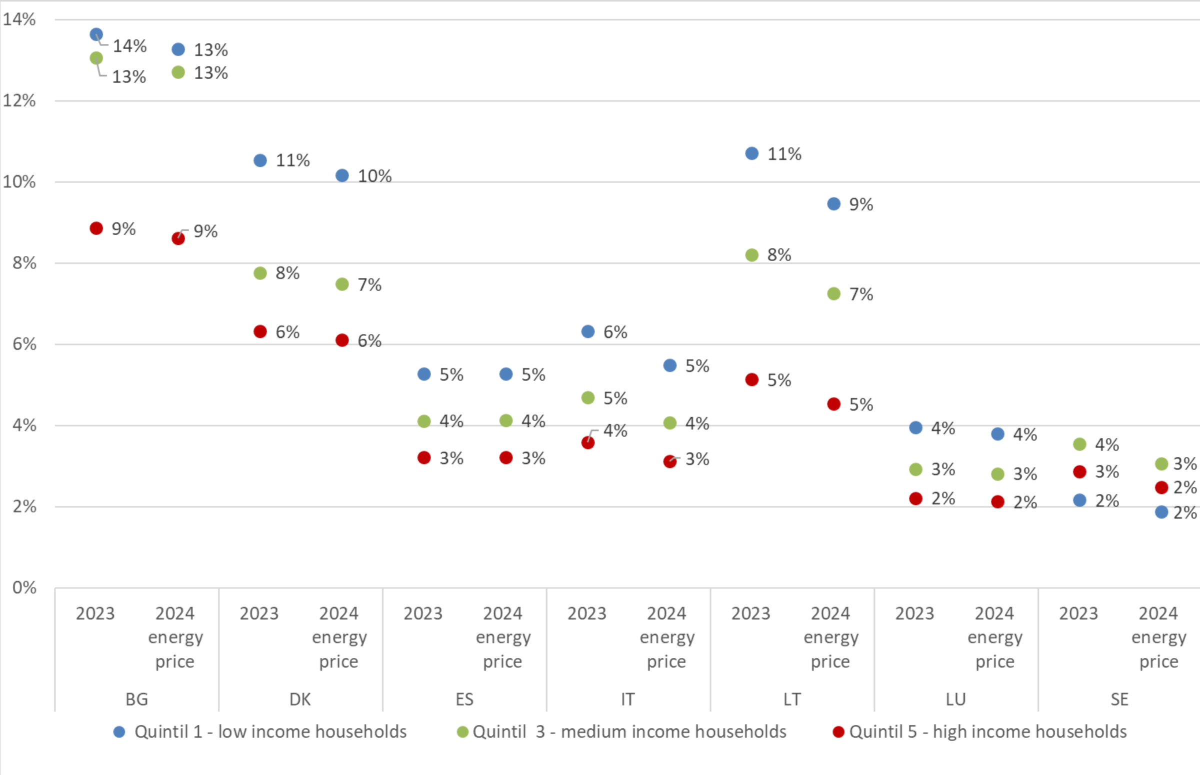

Figure 183: Share of energy expenditures (excluding transport fuels) in total consumption expenditure – 2023 and 2024 price levels – Group 2023: Bulgaria, Denmark, Spain, Italy, Lithuania, Luxemburg, Sweden

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

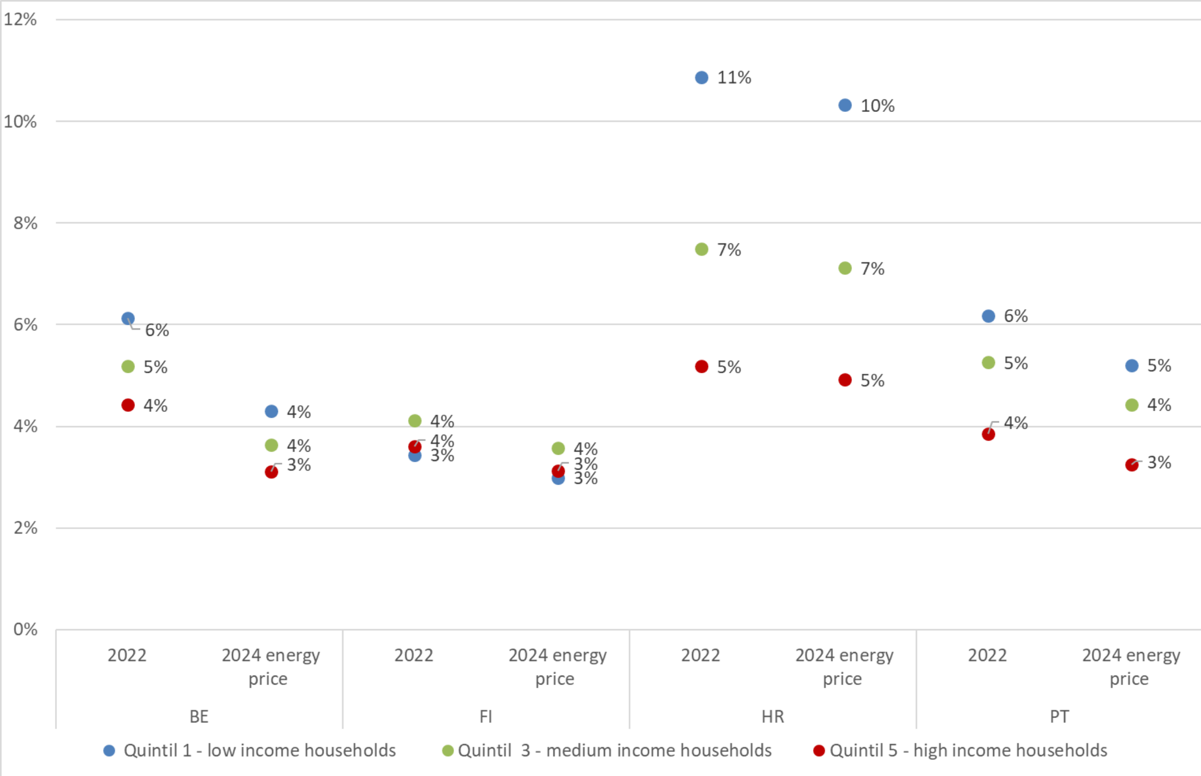

Figure 184: Share of energy expenditures (excluding transport fuels) in total consumption expenditure – 2022 and 2024 price levels – Group 2022: Belgium, Finland, Croatia, Portugal

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

<u>Results for countries with pre-crisis data (year 2015 to 2020)</u>

For those Member States that report data for pre-crisis years only, we group countries according to the last year that data is available for. Figure 185 shows countries that report data for 2020/2021, Figure 186 for countries that report data for 2018/2019 and Figure 187 for countries with data 2017 and older. We inflate energy expenditure and total expenditure to May 2024 values to show the change in energy expenditure burden. This approach does not include any demand changes that might have happened since the last year that data has been reported. We thus call it a hypothetical increase in expenditure burden.

It can be seen that the hypothetical energy cost burden in 2024 is substantially higher in 13 Member states, in particular compared to pre-crisis years 2020/2021 (compare Figure 185). Only a few countries show an energy burden that is the same or even lower in 2024 than in the pre-crisis year that data is available for, e.g. Belgium, Italy, Lithuania, Portugal, Sweden and Slovakia. Some governments have adjusted taxes to keep energy prices lower and protect consumers, compare chapter X.

The gap in the burden between low and high income households is quite pronounced in many countries, up to 11 percentage points in Slovakia. In many countries, the burden for low income households is twice as high as in high income households. Poland is an exception where the burden for low income households is still higher than for high income houselds, but lower than for medium income households.

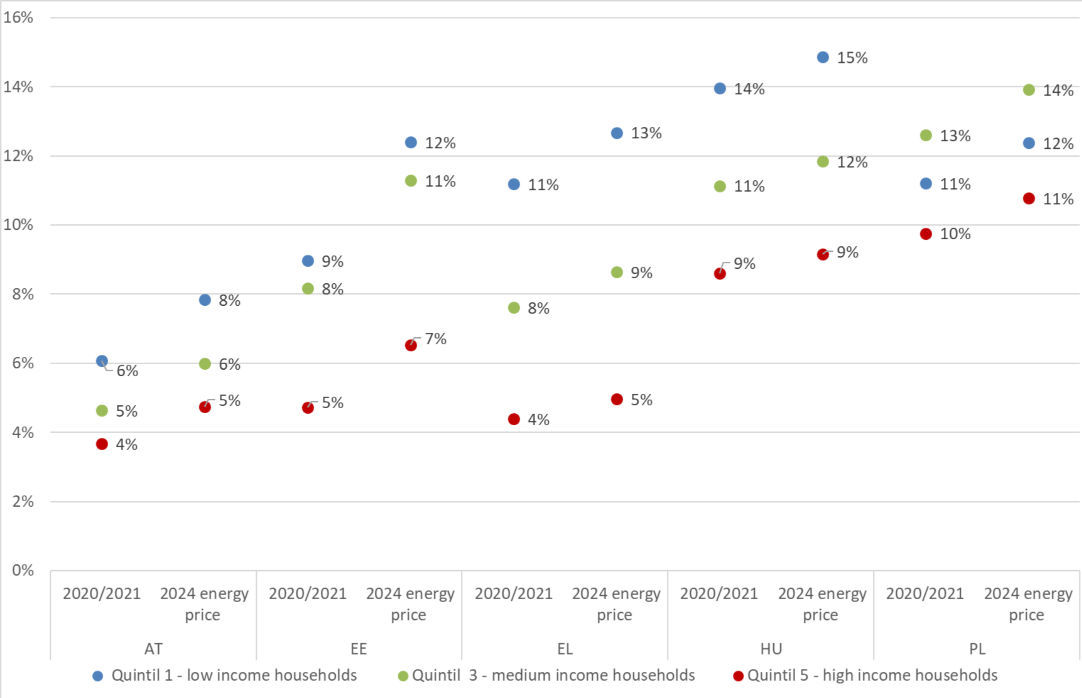

Figure 185: Share of energy expenditures (excluding transport fuels) in total consumption expenditure – pre-crisis and 2024 price levels – Group 2020/2021: Austria, Estonia, Greece, Hungary, Poland

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

Figure 186: Share of energy expenditures (excluding transport fuels) in total consumption expenditure – pre-crisis and 2024 price levels – Group 2018/2019: Germany, Latvia, Romania, Slovenia, Slovakia

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

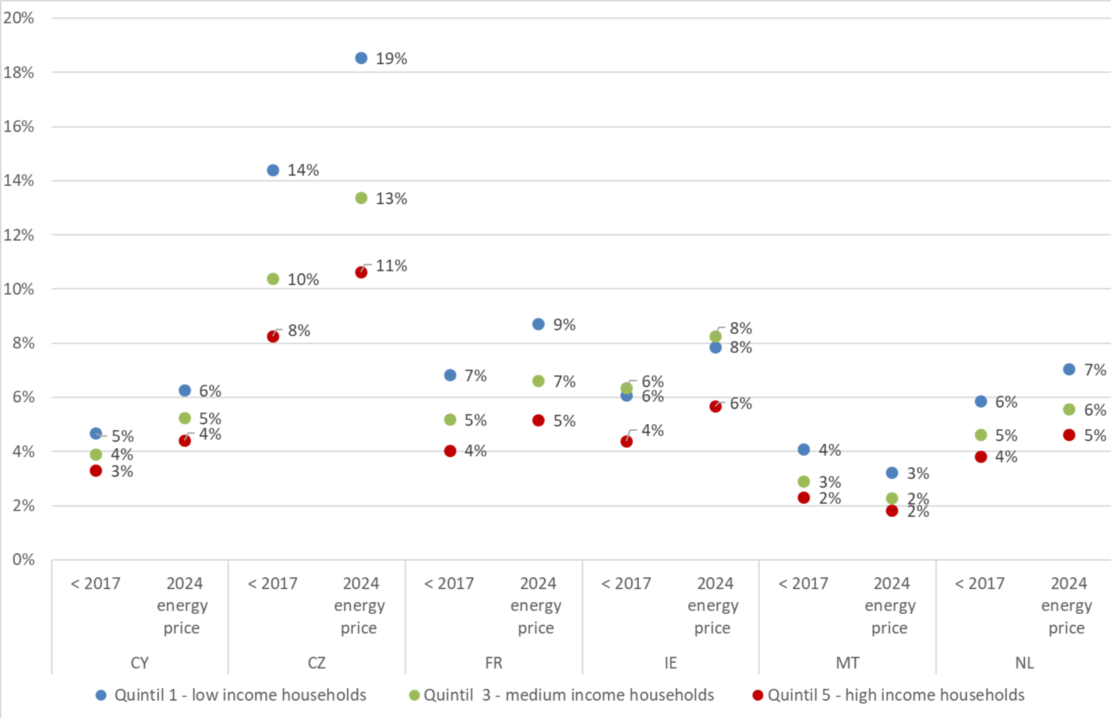

Figure 187: Share of energy expenditures (excluding transport fuels) in total consumption expenditure – pre-crisis and 2024 price levels – Group < 2017: Cyprus, Czechia, France, Ireland, Malta, Netherlands

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

6.7.2. Impact of price increases on energy expenditure including transport fuels

Results differ slightly when transport fuels are included. Low-income households are less likely to own or drive a car and thus generally have a lower share of transport fuel related costs. For high income households, on the other hand, transport fuels represent a significant expenditure share. On average across EU Member States, low-income households spend about 47% of their energy expenditure on transport fuels (ranging from 11% in Finland to 25% in Slovakia), medium income households spent about 63% of their energy expenditure on transport fuels (ranging from 14% in Greece, to 31% in Slovenia) and high income households about 74% (ranging from 15% in Italy and Spain to 31% in Slovenia).

<u>Results for countries with recent data (year 2022/2023)</u>

The energy expenditure shares **including transport fuels** in 2022/2023 and 2024 are shown in Figure 188 and Figure 189 for eleven Member States that report data for 2022/23. Expenditure shares have decreased since the crisis and are now about the same as before the crisis (2020). Given the fact that transport fuel prices have substantially increased compared to the year 2020 and also more than overall inflation (see Table 33), this points towards demand adjustment and lower use of fossil fuels.

For most countries, the expenditure share including transport fuels is highest for high income households, some countries, however, show the highest burden for middle income households, e.g. Bulgaria, Luxembourg, Sweden, Portugal. Low income households have the lowest expenditure share when including transport fuels. It should be noted that this effect arises from lower transport fuel use because of lower car ownership and kilometers driven in case of car ownership. The numbers do not include expenditure for public transport or information on transport deprivation or transport poverty. Households might have had to reduce car usage because they could no longer afford fuel costs.

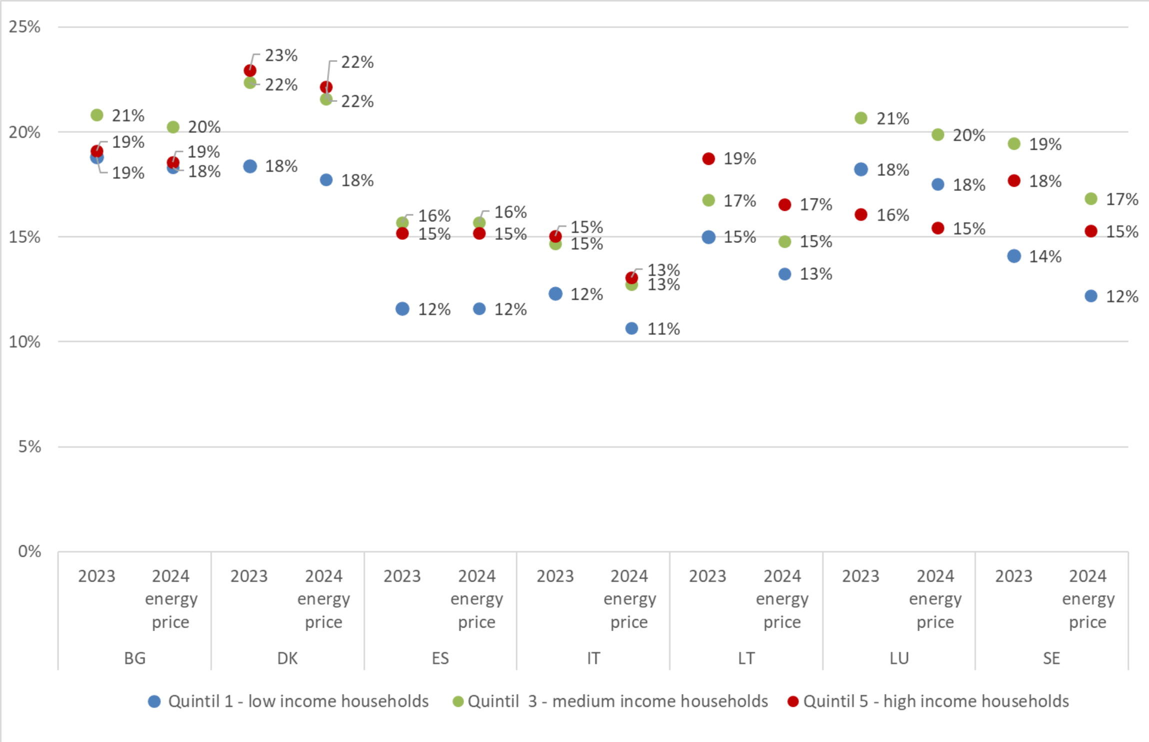

Figure 188: Share of energy expenditures (inluding transport fuels) in total consumption expenditure – 2023 and 2024 price levels – Group 2023: Bulgaria, Denmark, Spain, Italy, Lithuania, Luxemburg, Sweden

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

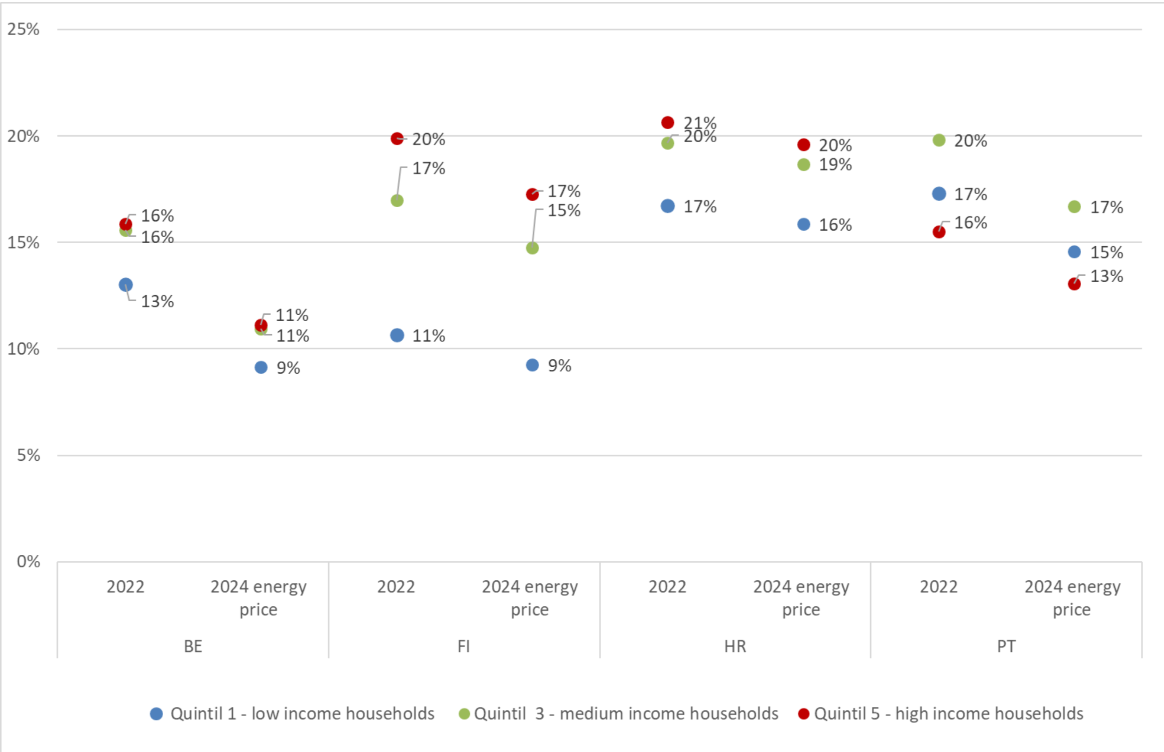

Figure 189: Share of energy expenditures (including transport fuels) in total consumption expenditure – 2022 and 2024 price levels – Group 2022: Belgium, Finland, Croatia, Portugal

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

<u>Results for countries with pre-crisis data (year 2015 to 2020)</u>

For those Member States that report data for pre-crisis years only, as in the case excluding transport fuels, we group countries according to the last year that data is available. Figure 190 shows countries that report data for 2020/2021, Figure 191 for countries that report data for 2018/2019 and Figure 192 for countries with data 2017 and older. We inflate energy expenditure and total expenditure to May 2024 to show the change in energy expenditure burden. This approach does not include any demand changes that might have happened since the last year that data has been reported. We thus call it a hypothetical increase in expenditure burden.

It can be seen that the hypothetical energy cost burden including transport fuels in 2024 is substantially higher in almost all countries. Only Malta and Slovakia show an energy burden that is lower in 2024 than in the pre-crisis years that data is available for. Governments might have taken action to keep prices lower in order to protect consumers. In particular in Malta prices did not increase much (compare Table 33 and Chapter 4.

The gap in the burden between low and high income households is quite pronounced in many countries, up to 11 percentage points in Austria, France and Netherlands, followed by Estonia and Germany with 10 percentage points.. In many countries, the burden for low income households is twice as high as in high income households. Poland is an exception where the burden for low income households is still higher than for high income houselds but lower than for medium income households.

Including transport fuels, we see energy expenditure shares of 19% before the price increase and hypothetical expenditure shares of up to 20%. The combination of a high share of liquid fuel use and a high increase in the price for liquid fuels can increase energy expenditure shares if no demand adjustment takes place. The share is lower for low income households. Thus transport costs present a large part of the expenditure burden even for low income households that less often own a car or drive less.

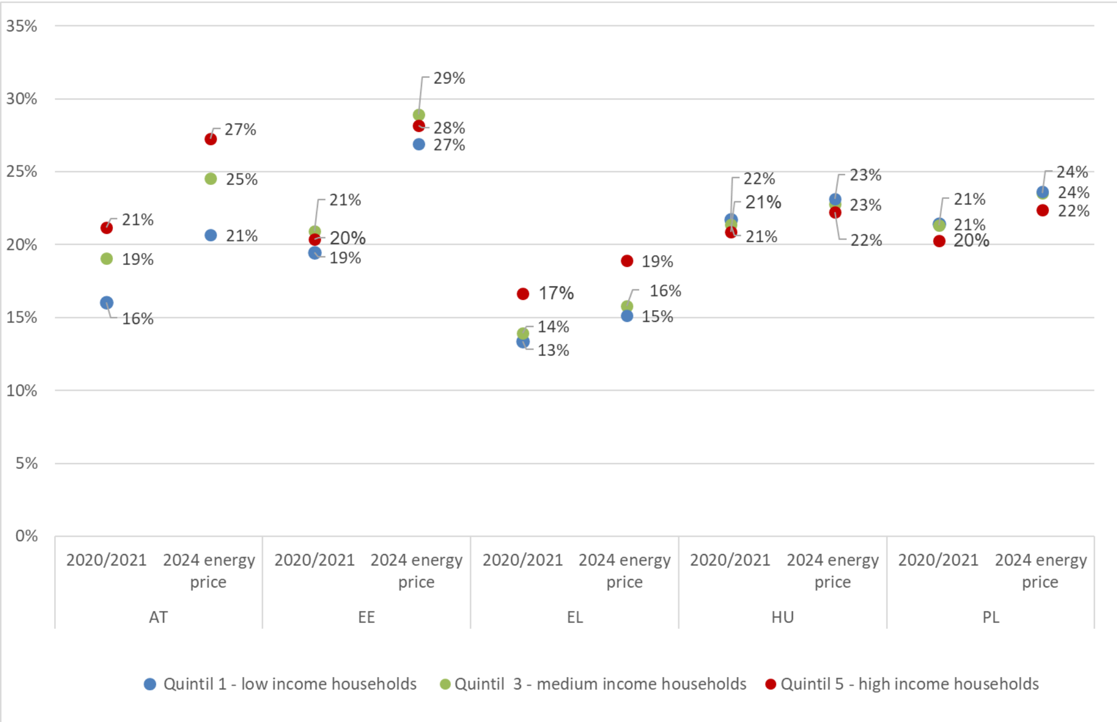

Figure 190: Share of energy expenditures (including transport fuels) in total consumption expenditure – pre-crisis and 2024 price levels – Group 2020/2021: Austria, Estonia, Greece, Hungary, Poland

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

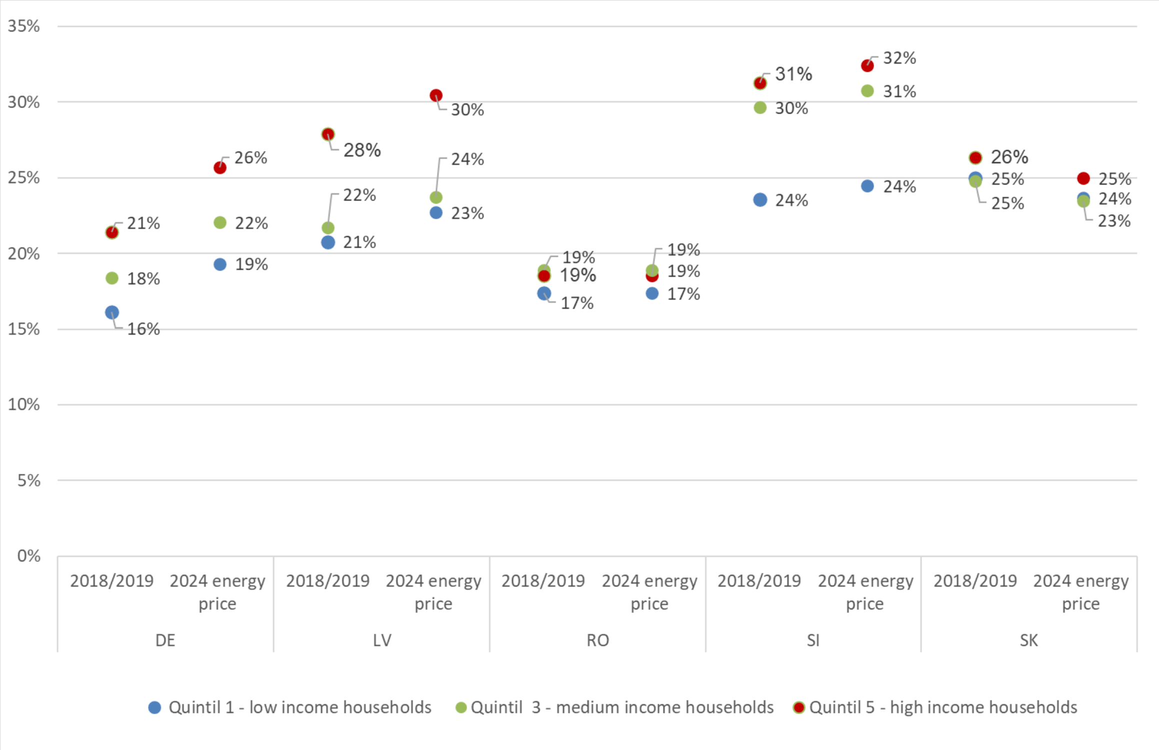

Figure 191: Share of energy expenditures (including transport fuels) in total consumption expenditure – pre-crisis and 2024 price levels – Group 2018/2019: Germany, Latvia, Romania, Slovenia, Slovakia

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

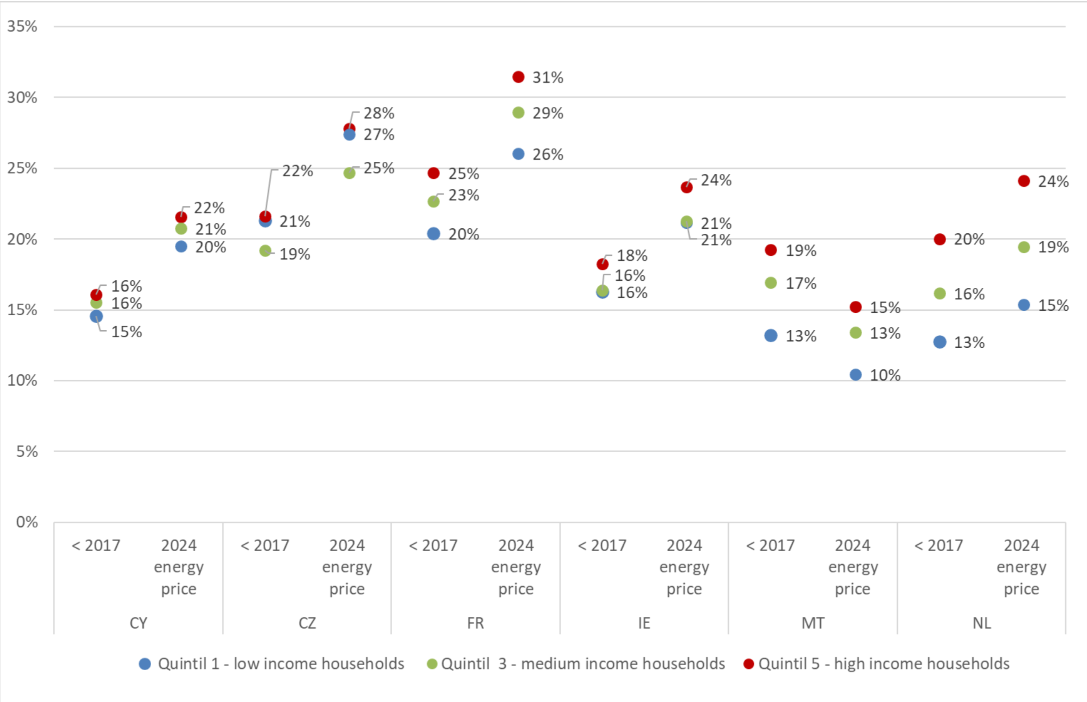

Figure 192: Share of energy expenditures (including transport fuels) in total consumption expenditure – pre-crisis and 2024 price levels – Group < 2017: Cyprus, Czechia, France, Ireland, Malta, Netherlands

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

Box F: **Demand adjustment across income groups and distributional effects**

Higher energy prices have led to demand adjustments including fuel switches, efficiency improvementes or demand reductions. This lowers cost burdens and helps households be more resilient towards rising energy prices. However, the ability to adjust differs by income group. High income groups are better equipped to reduce their energy consumption, for example by purchasing EVs or heat pumps, and thus reduce energy expenditure. Low income groups, however, likely do not have the additional funds to adjust and invest in low energy or low carbon technology. Thus, they continue to have high energy expenditures, which they cannot easily reduce.

To show these effects a scenario with differentiated elasticities by income group would need to be conducted. As such differentiated elasticities are not available from the literature, we take an ad-hoc simplified approach for illustrative purposes. Specifically, we assume as an example that high income groups reduce their energy consumption by 50% and low and medium income groups remain with their current consumption levels. The illustration is done to provide insights into the possible extent of the effects on the gap between income groups.

The following figure shows the share of expenditure including transport fuels for a number of countries when an adjustment in energy consumption of 50% has been taken by high income households.

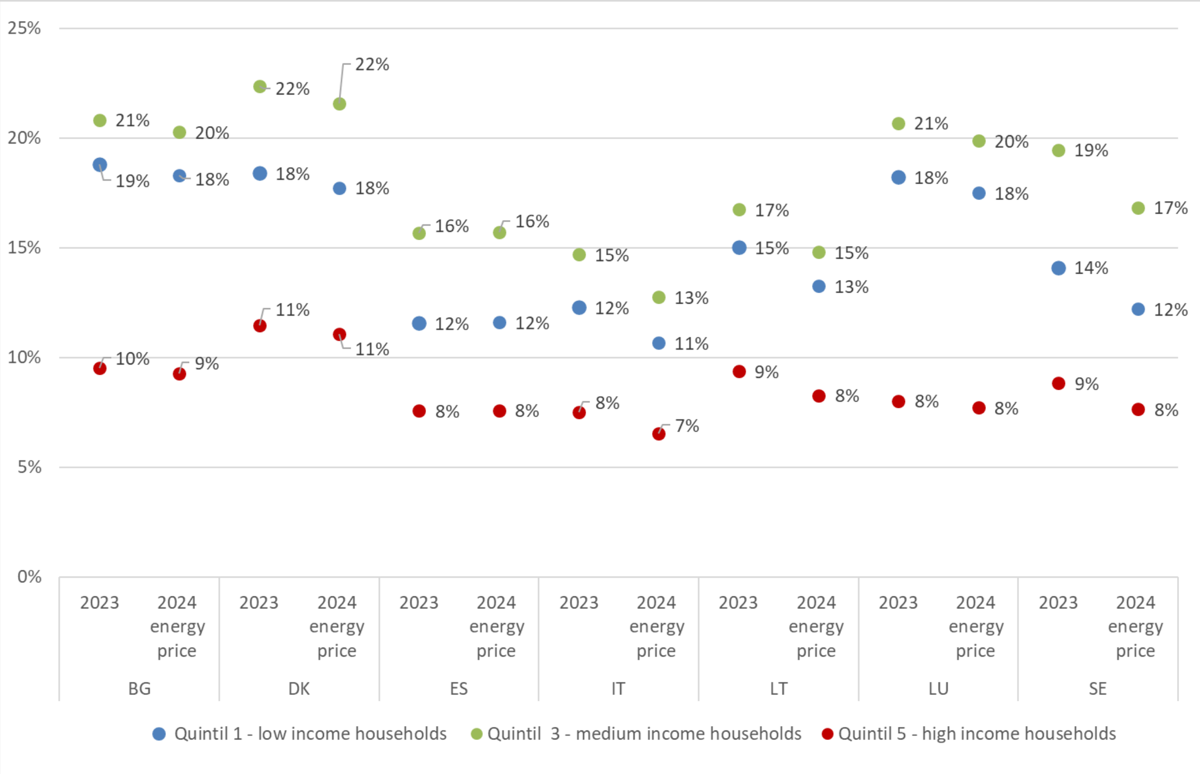

Figure 193: Consumption adjustment - Share of energy expenditures (including transport fuels) in total consumption expenditure– pre-crisis and 2024 price levels – Group of Member States that report 2023 data.

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

Compared to Figure 188, we see a reversed pattern between low and high income households. High income households who had the highest energy expenditure share before adjustment now have the lowest after adjustment even though they continue to more often own a car and drive more often. Lower, and also medium, income households remain burdened by high cost shares. In times of rising energy prices such a carbon-lock-in for low income households would make the distribution of the energy cost burden increasingly more uneven. To allow for a just and fair transition it is thus important to enable and support all households to reduce energy use through investment in energy efficiency and low carbon technology.

6.7.3. Role of inflation

The volatility of the markets and the crisis and market-related energy price increases between 2020 and 2023 show more than ever that climate policy reforms are necessary to ensure the security of supply for end consumers, but also to cushion the economic burden of vulnerable groups.

Russia's invasion of Ukraine on 24 February 2022 not only had direct consequences for the Ukrainian population, but also lead to repercussions for other countries (Zika et al. 2022[410]). The economic sanctions introduced only a short time later showed what the dependence on fossil fuels means, in this case also and in particular on Russian gas supplies. As early as March 2022, we experienced a massive increase in energy prices at an unprecedented scale. In most European countries, short-term measures were taken to reduce energy consumption, ensure security of supply and, above all, limit the impact of rising energy costs on (vulnerable) households.

Not only the energy price dynamics of the recent years, but also the effects of the pandemic or rising food prices all over the EU show the risks for crises in the future. This requires political action to strengthen society's resilience by investing in sustainability. The increase of inflation in the European Union since mid-2021 makes it particularly important to investigate the extent to which inflation is impacting different groups of the population differently, due to different effects on lower or higher income households.

The income development over time is shown in Figure 194 with Luxemburg having the highest net income and Romania having the lowest. The income (in nominal terms) slightly increased in the EU, except Luxemburg with a sharper increase since 2020.

[410] Zika, G.; Schneemann, C.; Weber, E.; Zenk, J.; Kalinowski, M.; Maier, T.; Wolter, M.I. (2022): Die Folgen des Kriegs in der Ukraine und der Energiekrise für Wirtschaft und Arbeitsmarkt in Deutschland. Institut für Arbeitsmarkt und Berufsforschung. IAB-Forschungsbericht 11/2022. https://downloads.gws-os.com/fb1122.pdf

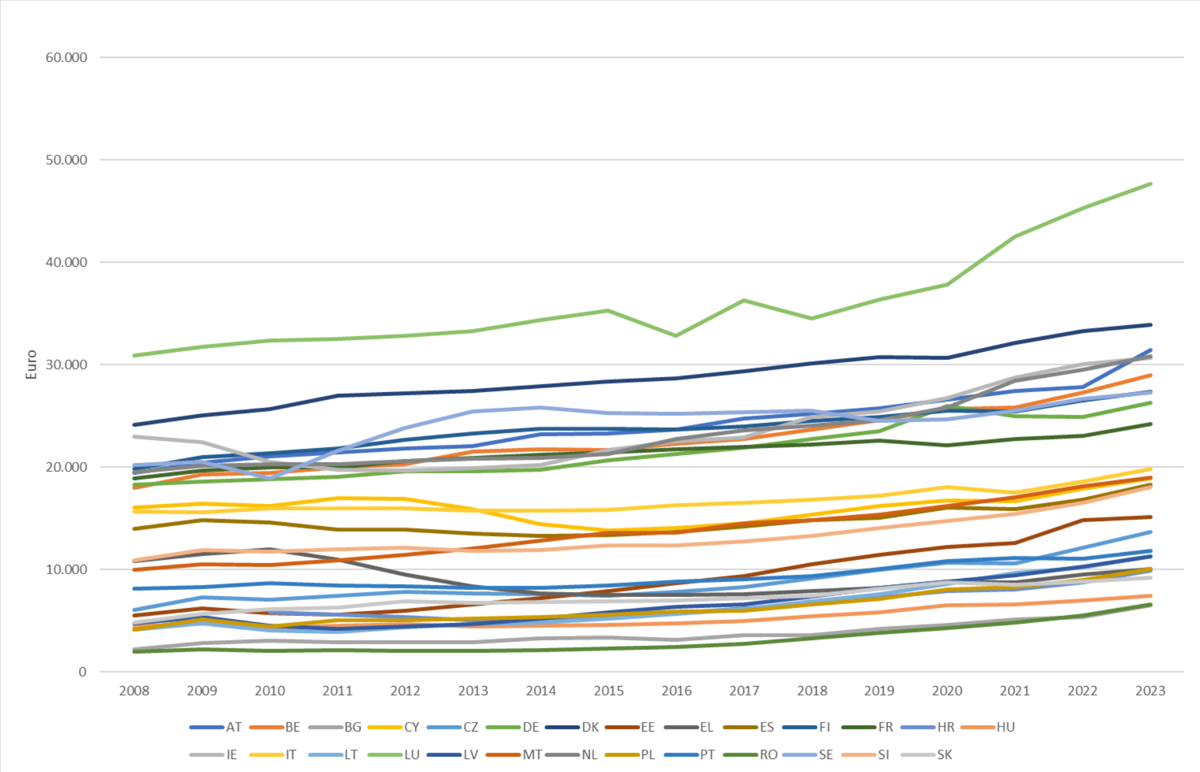

Figure 194: Median equalized net annual income between 2008 and 2023

Source: Claeys et al. (2024)[411]

Median equalized incomes in nominal terms increased by 11% in the period from 2020 to 2023. Consumer expenditures increased by 12% in the same period (relative change, see Figure 195).

[411] Claeys, G.; Guetta-Jeanrenaud, L.; McCaffrey, C.; Welslau, L. (2024): Inflation inequality in the European Union and its drivers. Dataset. Online: https://www.bruegel.org/dataset/inflation-inequality-european-union-and-its-drivers

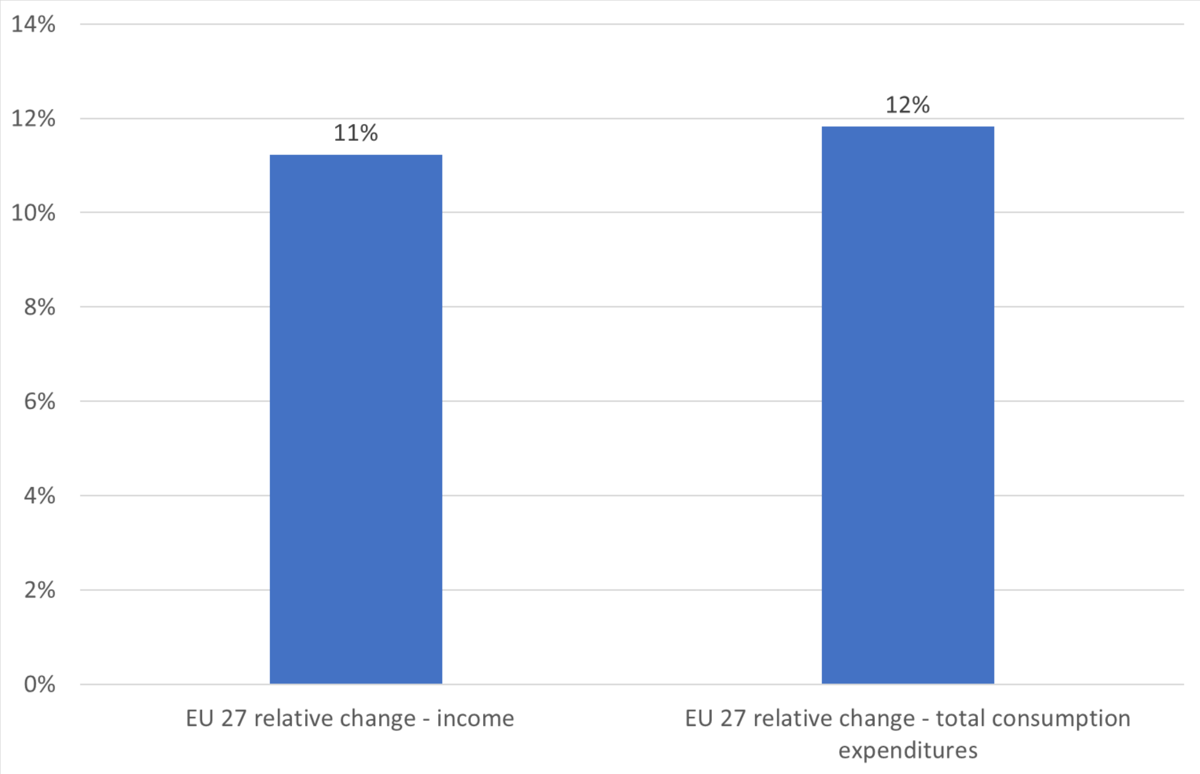

Figure 195: Relative Change of median equalized income vs. total consumption expenditures 2020 or last available year to 2023

Source: own calculation based on ad hoc data collection on household consumption expenditures, based on last available year per Member State[412] and Eurostat (2024) EU-SILC and ECHP survey, [ilc_di03__custom_11947872]

Households face different inflation rates because their spending patterns are different. Charalampakis et al. (2022)[413] see "t**he difference between the effective inflation rate in the lowest and highest income quintiles currently at its greatest".** Decomposing the inflation gap, "electricity, gas and other fuels" and, increasingly food prices are the main drivers of the higher inflation faced by lower-income households.

Figure 196 shows the income-specific consumption baskets calculated by income quintile. As we have seen in previous chapters, households with lower income spend a higher share of their total consumption expenditures on electricity, gas and heating and a lower share on transport. Nevertheless, a comparison between inflation rate and spending patterns shows that the ability to buffer cost of living increases through savings or borrowing is more difficult for household with lower income due to higher liquidity-constraints than high-income households. Therefore, they have less opportunities to absorp sharp increases in their cost of living through savings.

[412] Austria (2020), Belgium (2022), Bulgaria (2023), Cyprus (2016), Czech Republic (2020), Germany (2018), Denmark (2023), Estonia (2020), Spain (2023), Finland (2022), France (2017), Greece (2020), Croatia (2022), Hungary (2020), Italy (2023), Lithuania (2023, Luxembourg (2023), Latvia (2019), Poland (2021), Portugal (2022), Romania (2019), Sweden (2023), Slovenia (2018), Slovakia (2019).

[413] Charalampakis, E.; Fagandini, B.; Henkel, L.; Osbat, C. (2022): The impact of the recent rise in inflation on low-income households. In: ECB Economic Bulletin, Issue 7/2022. Online: https://www.ecb.europa.eu/press/economic-bulletin/focus/2022/html/ecb.ebbox202207_04~a89ec1a6fe.en.html

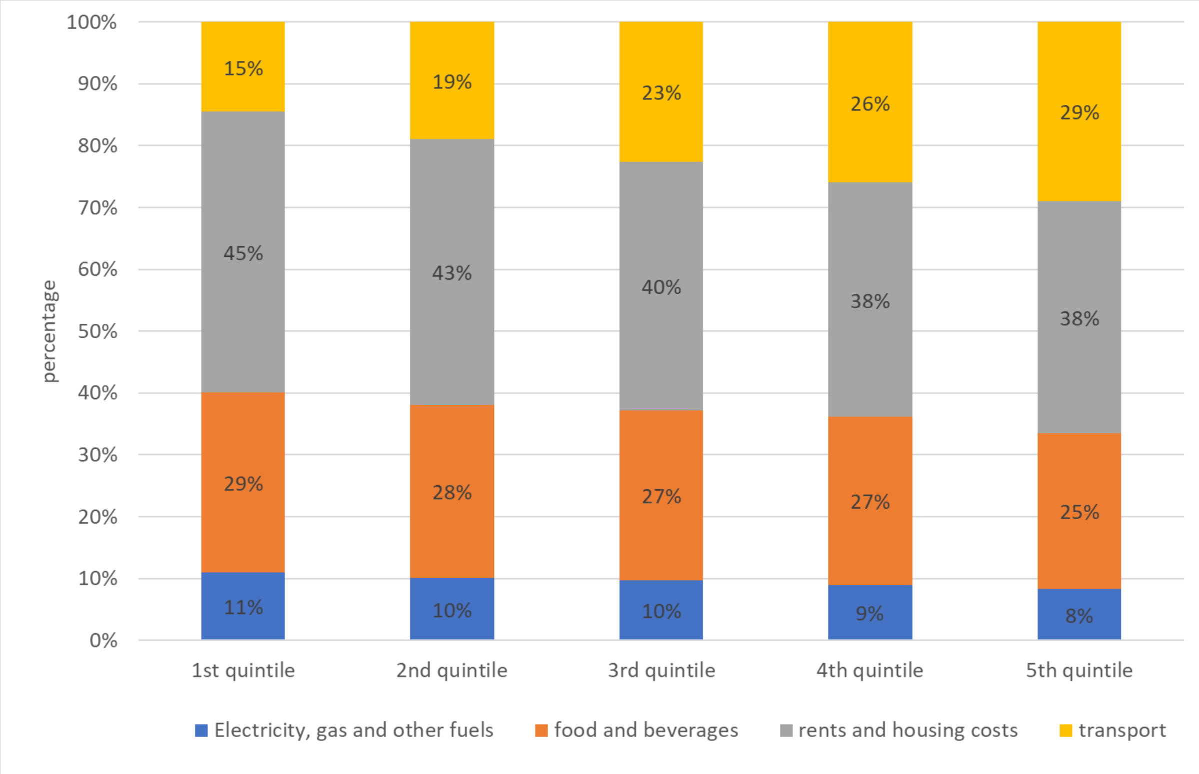

Figure 196: EU average consumption basket by income quintile (last available year)

Source: own calculation based on ad hoc data collection on household consumption expenditures, based on last available year per Member State[414]

Figure 197 shows the categories that drive inflation. Bulgaria, Estonia, Croatia, Hungary, Lithuania, and Latvia have the highest inflation on food and beverages, other Member States are also affected. Estonia, Greece, and Latvia show the highest inflation in the category "water, electricity, gas and other fuels". Transport was not an inflation driver in 2022. This may be due to reduced mobility (needs) during the pandemic. Charalampakis et al. (2024) assume that households with higher income have a tendency to consumer more expensive varieties of items within the same category. This also means that they can reduce spending, but substituting for cheaper alternatives, which low-income households will likely already have as their default choice and thus are less able to adjust to inflation through substitution.

[414] *Austria (2020), Belgium (2022), Bulgaria (2023), Cyprus (2016), Czech Republic (2020), Germany (2018), Denmark (2023), Estonia (2020), Spain (2023), Finland (2022), France (2017), Greece (2020), Croatia (2022), Hungary (2020), Italy (2023), Lithuania (2023, Luxembourg (2023), Latvia (2019), Poland (2021), Portugal (2022), Romania (2019), Sweden (2023), Slovenia (2018), Slovakia (2019).*

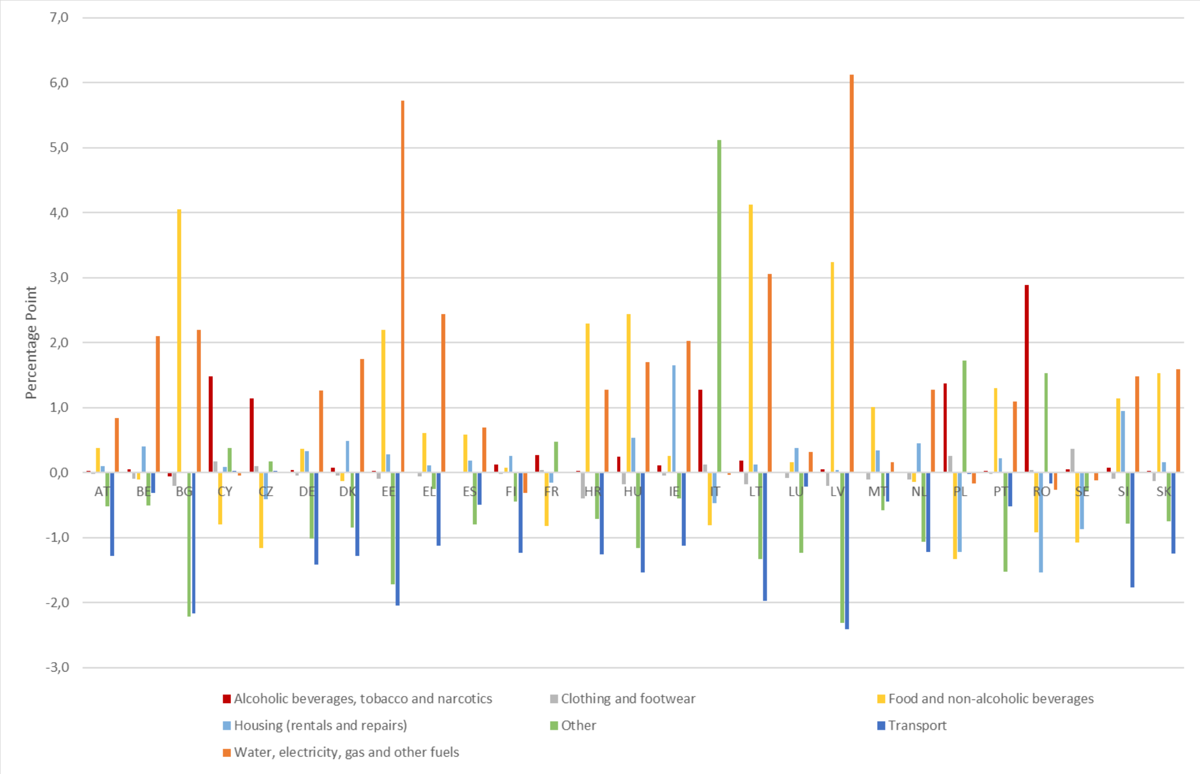

Figure 197: Expenditure categories driving inflation inequality within Member States (2022)

Source: Claeys et al. (2024)415

For instance, while a sharp rise in the cost of fuel increases overall inflation, a household with no car will be less affected than one with a car (Claeys et al. 2024). Figure 198 shows the inflation differences between lower and higher income. A positive value means that price changes contribute to the difference in inflation rates faced by low- and high-income households. These increases could be due to the higher share that this category represents for low-income consumption baskets (ibid.).

The analysis shows that the drivers of inflation matter and need to be taken into account regarding the design, implementation, and improvement of policy instruments and measures. Households of different income levels consume different baskets of goods and services, and therefore are affected differently by price increases. Low-income households will see a more considerable impact on their staple foods and services (Hernandez de Cos 2023[416]).

[415] Claeys, G.; Guetta-Jeanrenaud, L.; McCaffrey, C.; Welslau, L. (2024): Inflation inequality in the European Union and its drivers. Dataset. Online: https://www.bruegel.org/dataset/inflation-inequality-european-union-and-its-drivers

[416] Hernandez de Cos, P. (2023) Inflation and household income distribution. Annual Congress of the European Economic Association (EEA). Online: https://www.bde.es/f/webbe/GAP/Secciones/SalaPrensa/NotasInformativas/23/IIPP-2023-08-30-hdc-en.pdf

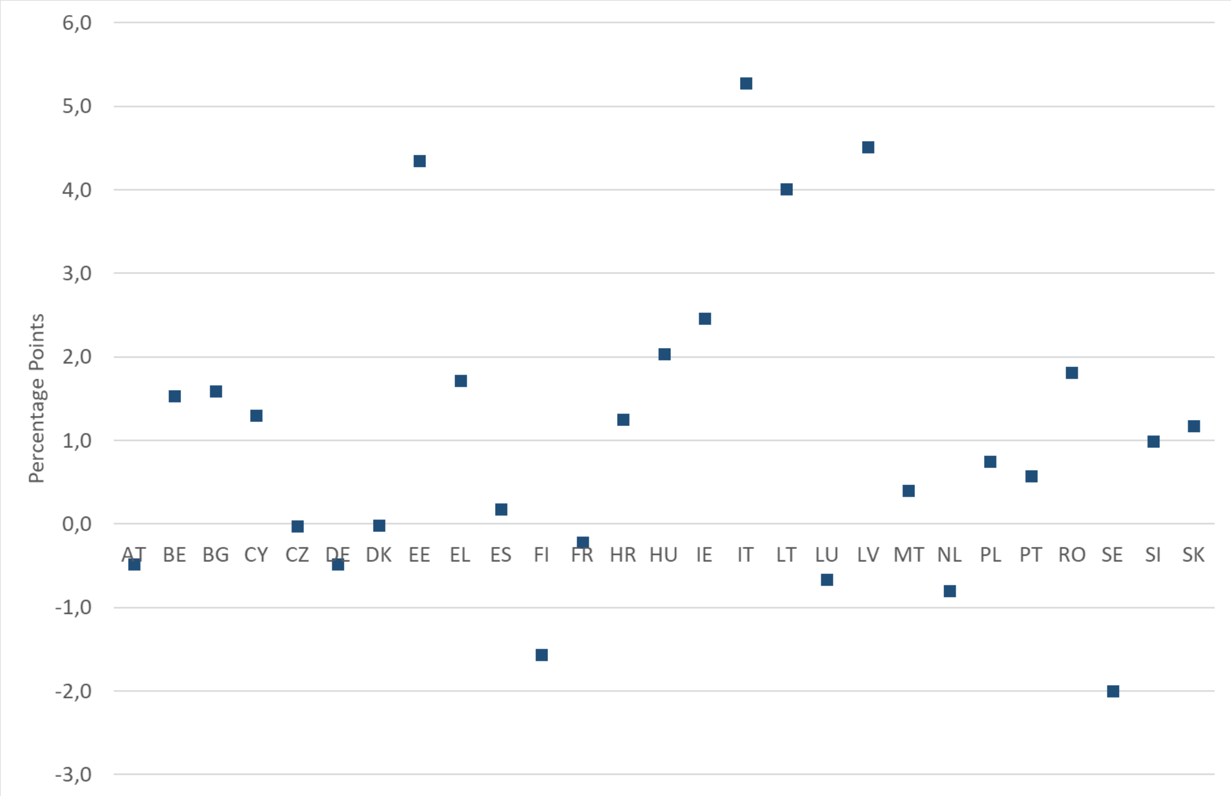

Figure 198: Inflation differences between the lowest and highest income households for transport[417] and energy expensed

Source: Claeys et al. (2024)418

[417] "Transport" contains "Purchase of vehicles", "Operation of personal transport equipment", "Transport services" (COICOP)

[418] Claeys, G.; Guetta-Jeanrenaud, L.; McCaffrey, C.; Welslau, L. (2024): Inflation inequality in the European Union and its drivers. Dataset. Online: https://www.bruegel.org/dataset/inflation-inequality-european-union-and-its-drivers

7. EU energy import bill

The EU is a net importer of energy: the import dependency (the share of energy imported over total energy consumed,) has a clear upward trend over the 1990-2019 period going from 50.7% in 1990 to 59.7% in 2019, despite plateauing between 2008 and 2016. It decreased slightly to 53.8% in 2021 as a result of the decrease of energy consumption related to the COVID-19 pandemic. In 2022 it rebounded sharply to reach a maximum at 62.6%.

This means that the EU needs to import over half of the energy it consumes. Oil import dependency has been consistently over 90% since 1990 with the notable exception of 2021. Natural gas import dependency has a clear upward trend since 1990, it has specifically two increasing phase, a steady one from 1993 to 2006 going from 50% to 70% and a sharper one between 2015 and 2019 going from 70% to 90%. All fuels import dependency decreased during the Covid pandemic years (2020, 2021).

In 2022 the import dependency of nearly all fuels reached a new maximum due to a combination of post pandemic rebound and a response to the Russian invasion of Ukraine. Specifically for oil and hard coal it is driven by increased imports (13% and 22% respectively compared to 2021), returning to their pre-pandemic levels. For natural gas it is driven by decreasing demand (-13%).

In 2022 the gas import dependency exceeded 100%, due to increased storage levels in response to Russia's invasion of Ukraine.

Estimated values for 2023 import dependencies show a decrease from 2022, in part due to reduction in gross demand. Import dependencies of 2023 are in line with the pre-pandemic trend.

[419]

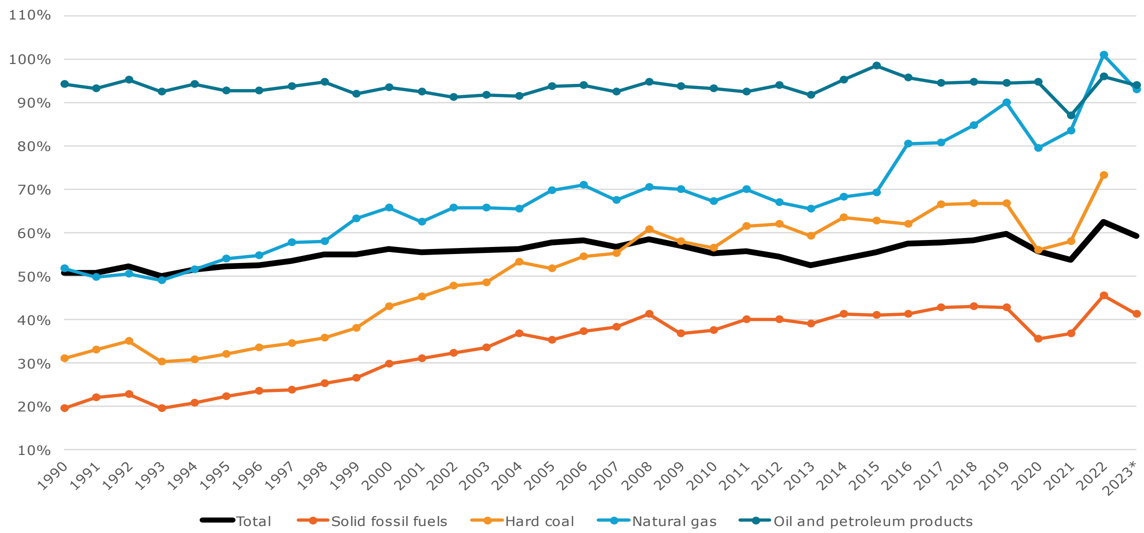

Figure 199: EU import dependency by fuel (Eurostat, *Estimates for 2023)[1]

The term "energy import bill" refers to the total cost incurred by a country or region for importing energy commodities, such as oil, gas, coal, and electricity. It represents a significant part of a nation's trade balance and can be influenced by various factors, including global energy prices, exchange rates, and the volume of imports.

[419] *Solid fossil fuels include various forms of coal and peat that are used as energy source. Hard Coal includes coals with a gross calorific value that is not less than 24 MJ/kg. Effectively, hard coal is comprised of anthracite and bituminous coals.*

7.1. Methodology

7.1.1. Scope

In the analysis hereafter, the EU is treated as a whole. Therefore, only extra-EU net imports are considered in the EU import bill calculation. However, when the import bill of an individual Member State is examined, it is of course reasonable to account for all imports, including those from other Member States. For instance, an oil import by an EU Member State A stemming from another EU Member State B does not constitute an import at the EU level. However, for the purposes of Member State A's import bill assessment, it is considered an import and an export for Member State B.

The analysis covers the main fossil fuels: crude oil, natural gas and hard coal. These fuels still account for two thirds of the EU's gross inland energy consumption and the overwhelming majority (over 98% in 2022) of net energy imports. Crude oil alone accounts for 56% (5697 TWh) of the EU's net energy imports, while gas accounts for 34% (Figure 200).

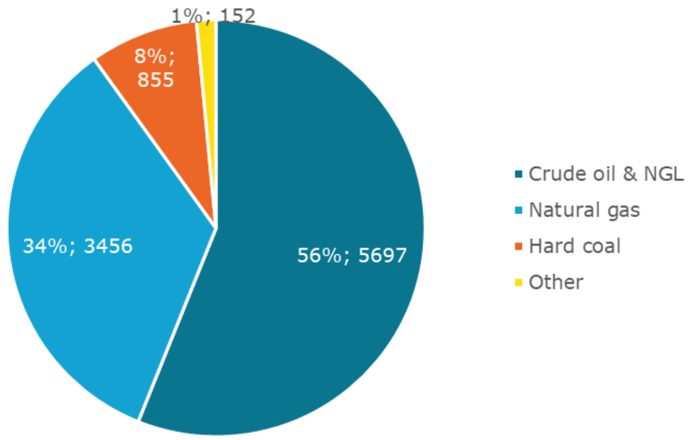

Figure 200: EU net imports of energy in 2022 (% of total, TWh; source: Eurostat)

In addition to crude oil, the EU is also an importer of petroleum products. In 2022 the EU petroleum products imports and exports amounted to 1667.6 TWh and 1627.3 TWh respectively, net imports of petroleum products accounted for 0.7% of the total oil and petroleum products. Considering the practical difficulties in finding reliable volume and price data for a multitude of products with different specifications and 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), 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 limited to hard coal.

7.1.2. 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 terawatt hours (TWh), 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[420], 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 to the energy balances figures to obtain harmonised energy data for extra-EU imports and exports (in TWh)[421].

7.1.3. Calculation of energy import bills

Regarding the calculation of energy import 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[422] of imported crude oil[423]. 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. 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[424]. 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.

The following should be noted:

- Since 2015 Czechia has not reported these figures. In 2014, Czechia's imports represented about 1.5% of total EU imports, implying an estimated annual import bill of EUR2-4 billion.
- 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, not prices, are reported for Bulgaria, Lithuania and Hungary from January 2020 and Belgium from September 2022 onwards.

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 EU 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 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 done on the monthly bills.

Natural gas

For natural gas, in agreement with DG ENER, we have favoured the use of Comext data for gas import values. The Comext database, managed by Eurostat, is a statistical resource that provides comprehensive access to recent and detailed historical data on international trade in goods (ITG). It provides data for monthly values of trade in Euros. For extra-EU trade, those data come mainly from

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[420] *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.*

[421] *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.*

[422] *The CIF price includes the FOB (Free On Board) price (the price actually invoiced at the port of loading), the cost of transport, insurance and certain charges related to transfer operations.*

[423] *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.*

[424] *European Central Bank (2022). Euro foreign exchange rates.*

customs administrations of EU Member States. Trade within the EU is provided directly by trade operators.

However, import volumes from the Comext dataset are significantly smaller than import volumes from Eurostat and Entsog datasets, the monthly import volumes of the European Network of Transmission System Operators for Gas (ENTSO-G) transparency platform[425]. The latter are used here, 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. Volumes are calculated by adding the gas flows at the relevant entry points of the EU gas network, while in 2020 LNG imports were coming from 12 supplying countries to 24 terminals in 12 Member States. As the reexports (Balkans, Kaliningrad, etc.) are removed, these volumes can be considered as net imports.

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[426] 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.

At the date of writing, data from Eurostat are only available until 2022. Import volumes for 2023 and the first quarter of 2024 are estimated by applying the variations in extra-EU imports from the Eurostat nrg_cb_sffm dataset to the 2022 data. The CIF ARA spot price is available for the whole period.

7.1.4. Calculation of the market concentration index

The Eurostat import by partner countries datasets[427] are used to calculate a market concentration index inspired by the Herfindahl-Hirschman Index (HHI): $H = \sum_{i=1}^{n} s_i^2$ where H is the concentration index, n the number of supplying countries and s their market share.

Table 36: Interpretation of the HHI range.

concentration index	interpretation
Below 0.01	Highly competitive; no anti-competitive effects.
Below 0.15	Unconcentrated; unlikely to have anti-competitive effects.
0.15 to 0.25	Moderate concentration; may raise anti-competitive concerns.
Above 0.25	High concentration; considered anti-competitive.

7.1.5. Weekly proxies

We looked at the feasibility of constructing weekly proxies for the EU energy bill. Data on a weekly timestep are non-existent for key components of the energy bill (i.e. oil imports). Therefore, we consider the calculation of such proxies to be unrealistic.

7.2. Drivers of the energy import bill

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.

[425] Entsog (n.d.). Transparency platform.
[426] The CIF ARA spot price refers to the price of coal delivered on a Cost, Insurance, and Freight (CIF) basis to the Amsterdam-Rotterdam-Antwerp (ARA) region.
[427] Eurostat tables: nrg_ti_sff, nrg_te_sff, nrg_ti_gas

7.2.1. Volumes

Import volumes depend mainly on the level of consumption. In addition, the evolution of domestic production (a decrease in which leads to an increased dependency on imports, even if consumption remains unchanged) and, to a lesser extent, stock changes also affect import volumes. Exports also influence import volumes, as an increase in exports is generally balanced by an increase in imports.

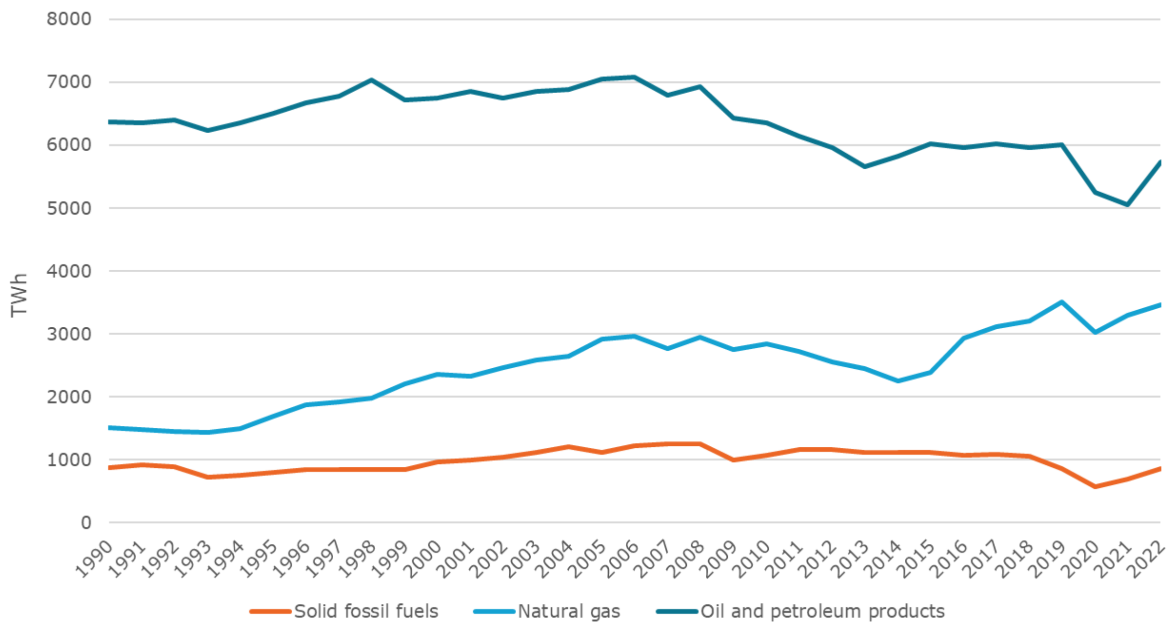

Figure 201: EU net imports from 1990 to 2022 (TWh, Source: Eurostat)

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 (Figure 201).

Oil imports declined from 2008 onwards but rebounded in 2015 as the sharp fall in oil prices triggered an increase in fuel demand. As a result, they rose slightly until 2019. In 2020, oil imports plummeted due to the COVID-19 pandemic which drastically reduced demand and international trade. A further decrease in 2021 is followed by a sharp rebound in 2022.

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 with gas for industrial and power generation needs. In 2020, gas imports plummeted due to the COVID-19. In 2021 and 2022 gas imports rose again to get back to their pre-pandemic level.

Hard coal imports increased in 2010 and 2011, helped by low prices (cheap shale gas squeezed out the fuel from 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 to 2020. In 2021 and 2022 coal imports rebounded to reach its 2019 level. Preliminary data for 2023 and Q1 2024 show a strong decrease; -24.5% in 2023 compared to 2022 and coal imports in 2024 could be as small as 60 TWh, half that of 2022.

7.2.2. Prices

International commodity prices decreased in spring 2020 in response to the reduced demand due to the COVID pandemic. In 2021 there was an unprecedented surge in gas and coal prices. In 2022 the invasion of Ukraine by Russia triggered a further surge, with gas prices reaching 230 EUR/MWh in July 2022 and coal price reaching 308 EUR/t, both all-time highs. In early 2023, prices dropped to pre-war levels (Figure 202).

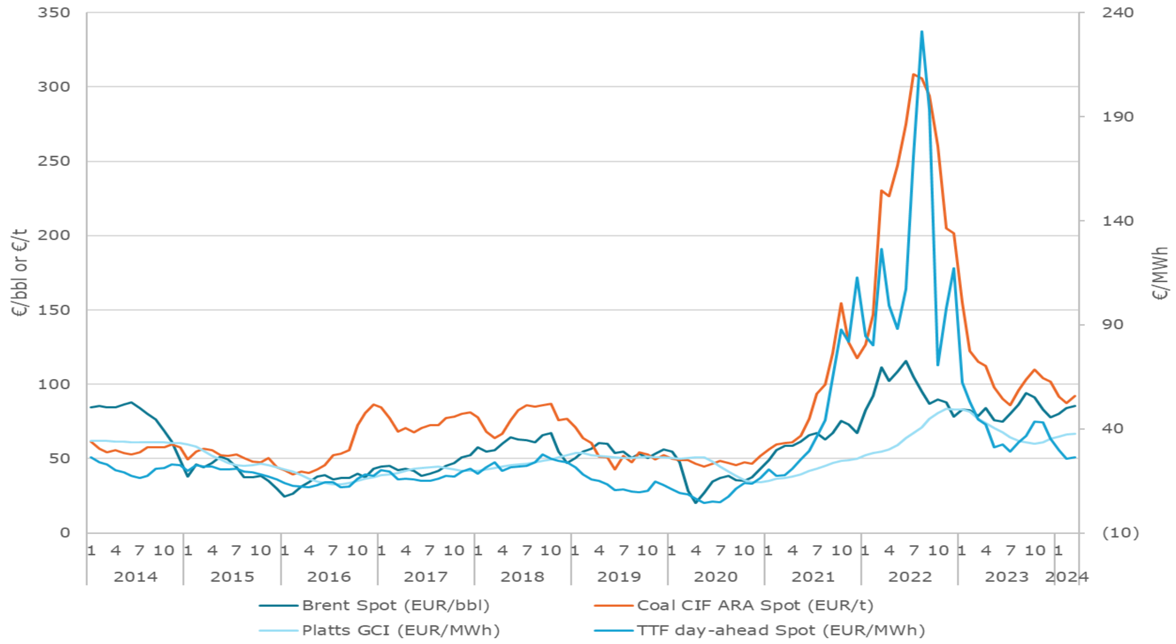

Figure 202: Monthly prices per energy (in EUR)

Platts' GCI is the North-West Europe Gas Contract Indicator, a theoretical index showing what a gas price linked 100% to oil would be.

7.2.3. Exchange rate

Most energy products are traded in US dollars. Therefore, fluctuations in the USD/EUR exchange rate (Figure 203) directly affect prices and the import bill when measured in euros.

In recent years, the USD/EUR exchange rate fluctuated 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 0.95 in late September 2022. Since 2023 the USD/EUR exchange rate stabilized around USD 1.08 per EUR (Figure 203).

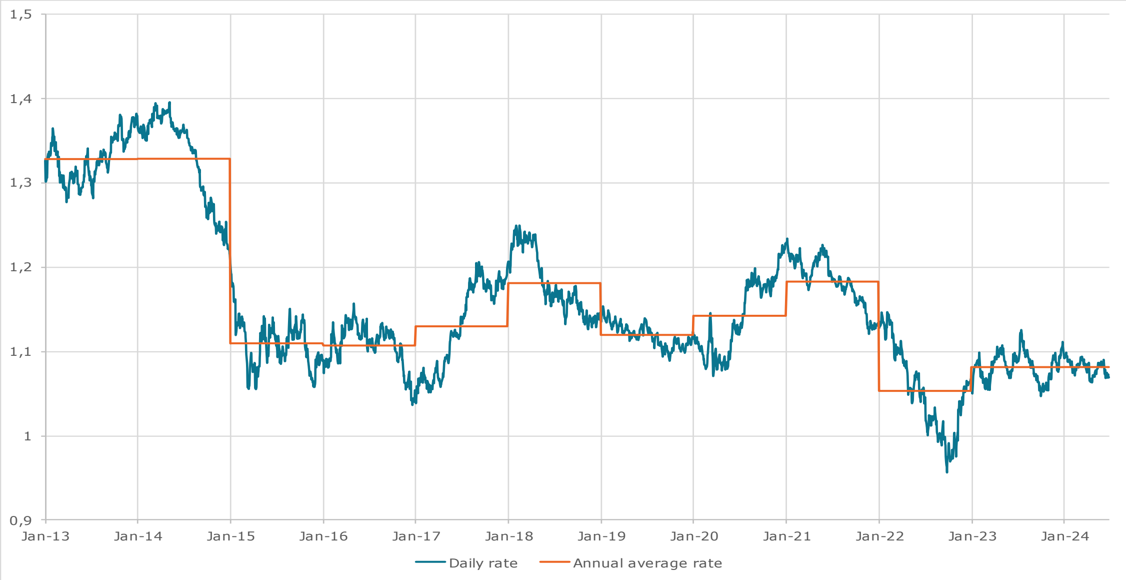

Figure 203: The USD/EUR exchange rate since 2013

7.3. Import bill calculation

7.3.1. Data sources

The table below provides an overview of relevant sources per energy and timestep.

Table 37 Overview of relevant sources per energy and timestep

		Source (volume)	Source(prices)
Annual	Coal	Eurostat	
Annual	Oil	Eurostat	
Annual	Gas	Eurostat	
Monthly	Coal	Eurostat	Thermal Coal 6000 kcal/kg NAR CIF ARA
Monthly	Oil	Eurostat	Eurostat
Monthly	Gas	Eurostat, ENTSO-G, Comext	Comext (traded values)

7.3.2. Oil

Oil imports volumes into the EU are very stable over the 2014-2023 period, remaining between 3500 Mbbl and 3735 Mbbl, with the notable exception of 2020 and 2021 when travel restrictions led to a reduction in demand. Therefore, the main driving factors of the oil import bill are prices and to a lesser extent the USD/EUR exchange rate.

Table 38: EU import bill for crude oil up to Q1 2024

	Unit	2019	2020	2021	2022	2023	Q1 2024	Source
Imports (extra-EU)	Mbbl	3659	3150	3204	3519	3735	919	Eurostat
Average CIF price	USD/bbl	64,1	40,1	65,9	90,2	72,1	73.8	Eurostat
USD/EUR exchange rate	USD/EUR	1,12	1,14	1,18	1,05	1,08	1,08	ECB
Import bill	bn EUR	209	112	180	301	249	62	Calculated

In 2023 the volume of crude oil imports has reached its maximum in 10 years. The crude oil import bill shows a 17% decrease despite a 6% increase of net total crude oil imports based on declining prices.

In 2022 a combination of increased price (+36.9%), volume (+10%) and decreased USD/EUR exchange rate (-11%) led to a 67% increase in the EU crude oil import bill, reaching a 10 year maximum.

7.3.3. Gas

Natural gas is the second biggest contributor to the EU energy bill. Gas imports have been an increasing part of the EU energy imports since 1993 (). Yearly averages prices have been oscillating between 7.6 EUR/MWh and 13 EUR/MWh over the 2014-2019 period. The COVID pandemic in 2020 led to a decrease in both import prices and volumes. In 2021 a rebound in both price and demand led to 175% increase of the gas bill. in 2022 a surge in both price and volumes led to a 260% surge of the gas bill.

Table 39: EU import bill for gas up to 2023

	Unit	2019	2020	2021	2022	2023	Q1 2024	Source
Net imports (extra-EU)	TWh	3966	3555	3689	3505	2858	686	EntsoG
Average import price	EUR/MWh	8,9	6,2	16,4	62,8	41,4	26,1	Calculated
Import bill	bn EUR	35,3	22,0	60,5	220,1	118,2	17,9	Comext

In 2022 the gas import bill was driven by surging gas prices that increased 283% over 2021. Prices went up as a response to the Russia-Ukraine conflict.

In 2023 a milder winter and high gas prices led to a reduce demand in natural gas across the EU, yielding a 18% decrease of gas import compared to 2022.

Data for the first quarter of 2024, when extrapolated to the full year, would yield a 39% decrease in import value, driven by a 4% decrease in volumes, therefore implying a 37% decrease in prices.

In order to account for seasonality of gas demand we can compare Q1 2024 to Q1 2023, this shows a 2% decrease in volume and a 55% decrease in the gas import value, his approach doesn't account for the decreasing trend of gas prices over 2023.

7.3.4. Coal

Coal is the third biggest contributor to the EU energy bill. It amounted to 5% of the total in 2022 and 2.5% in 2023. Only hard coal is accounted for in the calculation as brown coal is not typically traded internationally.

Table 40: EU import bill for coal up to Q1 2024

	Unit	2019	2020	2021	2022	2023	Q1 2024	Source
Net imports (extra-EU)	Mt	115,3	77,5	92	116	88	15	Eurostat
Coal CIF ARA Spot	EUR/t	54,1	47,7	91	236	108	90	Platts
Import bill	Bn EUR	6,2	3,7	8	27	9	1	Calculated

In 2022 coal import volumes and prices have reached a 5-years maximum. This is likely a response to the pressure on gas imports resulting from the Russia-Ukraine conflict.

In 2023 coal import bill has been divided by 3 due to a decrease in both volume and price (-24% and -54% compared to 2022, respectively).

Extrapolated data of the first quarter 2024 would yield a 41% decrease in 2024 over 2023; driven by a 29% decrease in volume and a 16% decrease in price.

7.3.5. Total import bill

The total energy import bill of the EU is calculated by summing its 3 most significant components, crude oil, natural gas and coal. It is also expressed as its part in the EU GDP.

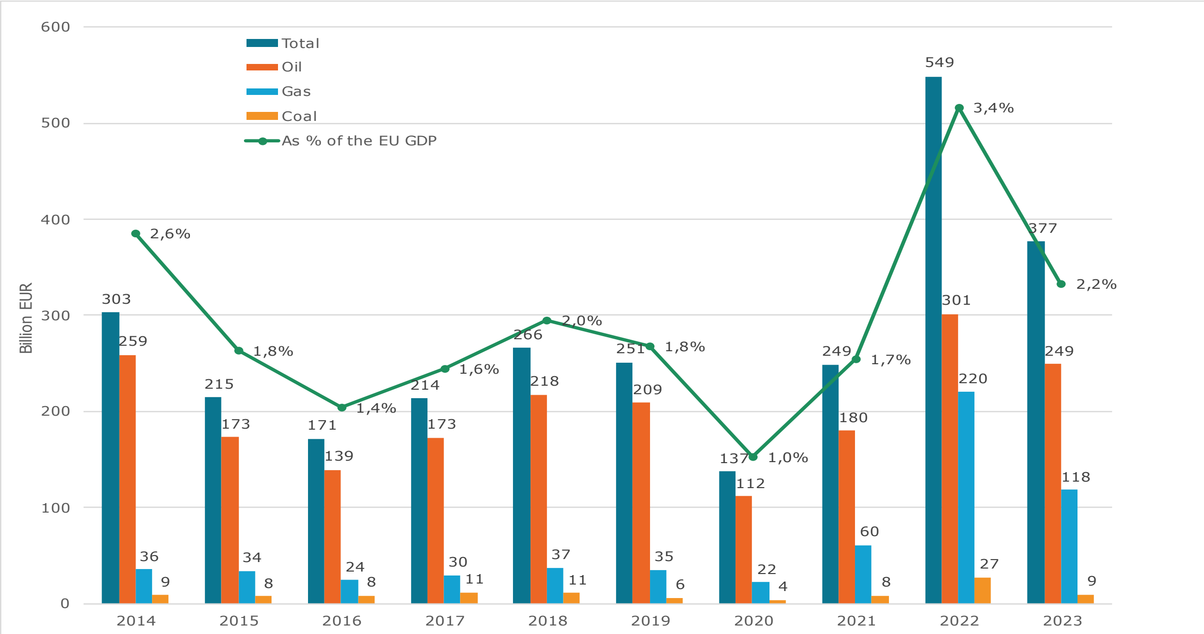

Figure 204: EU import bill up to 2023. Source: COMEXT

Oil remains the main component of the EU energy bill. It represented over 80% of the total energy bill from 2014 to 2020. Oil bill variations were the main driver of the total energy bill before 2021.

The natural gas import bill remained stable between 2014 and 2019 and surged in 2021 and 2022.

It has varied between 10% and 16% of the total import bill from 2014 to 2020. The share of natural gas in the total energy import bill became much more significant with the surge of prices in 2021 (24% of total) and 2022 (40% of total).

Despite a sharp decrease compared to 2022, the energy import bill in 2023 is 44% higher than the 2014-2022 average. This decrease was driven by significant reductions in every import bill driving factors, except for oil import volume. Between 2022 and 2023 import prices of oil, gas and coal decreased by 20%, 34% and 54% respectively. Import volumes of gas and coal decreased by 18% and 24% respectively. Crude oil import volumes went up 6%.

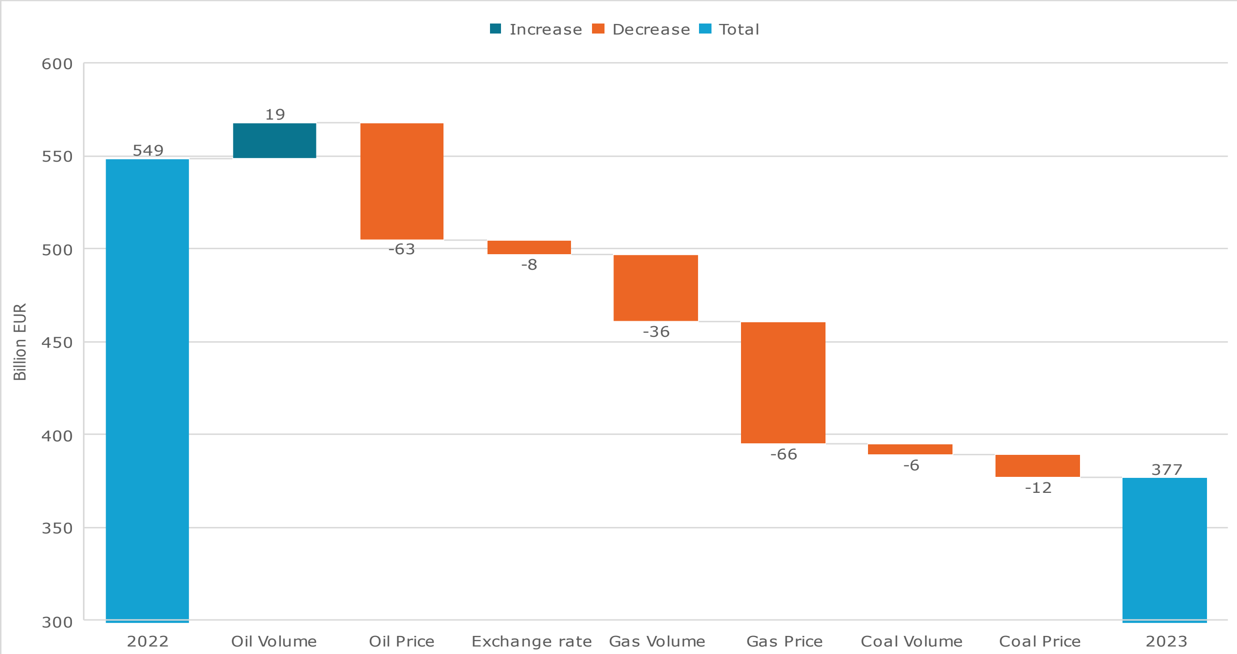

Figure 205: Breakdown of the 2023/2022 change of the total import bill

7.4. Comparison with trading partners

The energy markets are global (with some limitations for natural gas). To provide better insights into the EU energy import bill, it is interesting to compare it with that of its main trading partners.

As shown in Table 41, a list of five relevant trading partners was established, because their energy market resembles that of the EU (i.e. Japan, South Korea, heavily relying on energy imports), or because of their significance in the global energy market (USA, China) or because of its proximity with the EU energy market (UK).

The import bill of the EU's relevant trading partners was calculated using annual data from trade and custom agencies and based on net imports of the same fossil fuels as for the EU (i.e. crude oil, natural gas and hard coal).

All the import bills are expressed in US dollars (USD). the EU imports was converted to USD using the yearly average exchange rate of the ECB.

In some instances (UK, USA), countries can be net energy exporters and therefore their energy bills can be negative for certain years.

Table 41: List of five relevant tranding partners

	Source (volumes & prices)
China	*General Administration of Customs People's Republic of China*
Japan	*Trade Statistics of Japan*
South Korea	*Korea International Trade Association*
United Kingdom	*HM revenue and Customs*
United States	*U.S. International Tarde Administration*

Table 42: total import bill of EU and trading partners in billion USD

Import bill	2018	2019	2020	2021	2022	2023	Unit
China	284	282	215	330	444	431	bn USD
Japan	175	156	105	155	256	194	bn USD
South Korea	99	85	61	98	155	118	bn USD
United Kingdom	11	1	-2	19	56	34	bn USD
United States	44	9	-21	-15	-55	-50	bn USD
European Union	408	355	198	447	750	407	bn USD

The United States is a net exporter of energy (in value) since 2020, mainly due to increasing exports of natural gas (shale gas). In 2014 the USA energy import bill was USD 44 bn (1% of GDP), in 2023 the USA had USD 50 bn of revenues from net energy export (0.2% of GDP).

China has available trade data from 2018 onward. Its import bill represents around 2% of its GDP and consist for two third of Oil.

Japan imports the totality of its fossil energy and is highly dependent on oil prices. Japan' energy import bill amounted to 5% of its GDP in 2014. It reached a 2.1% 10 minimum in 2020 and a 6.1% 10 maximum in 2022.

South Korea relies heavily on import for its energy. Its energy import bill to GDP ratio is the highest of the considered countries. It was between 3.7% and 9.3% of GDP over the 2014-2023 period.

The UK was a net exporter of gas until 2020. Its energy import bill is driven by its oil imports and only amounted to less then 1% of its GDP until 2021.

Most notably, all relevant partners' import bills, with the exception of the US, showed a decrease in 2020 due to the COVID-19 pandemic and a subsequent surge in 2022 following the Russian invasion of Ukraine. The variations of the energy import bill in the EU are more pronounced than those of other trading partners, suggesting a greater dependence on Russian gas and a challenging search for suitable substitutes.. In 2021 China's energy import bill was similar to that of the EU. In 2022 it went up by 34% in China mostly due to increased prices (Oil +42%, Gas +39%, Coal +31%). The EU was more affected by increased prices (Oil +67%, Gas +200%, Coal +158%) driving a steeper increase of the energy bill resulting in the EU's import bill to be 52% higher than China's in 2022. The EU's import bill surge in 2022 is amplified by the low USD/EUR exchange rate in 2022.

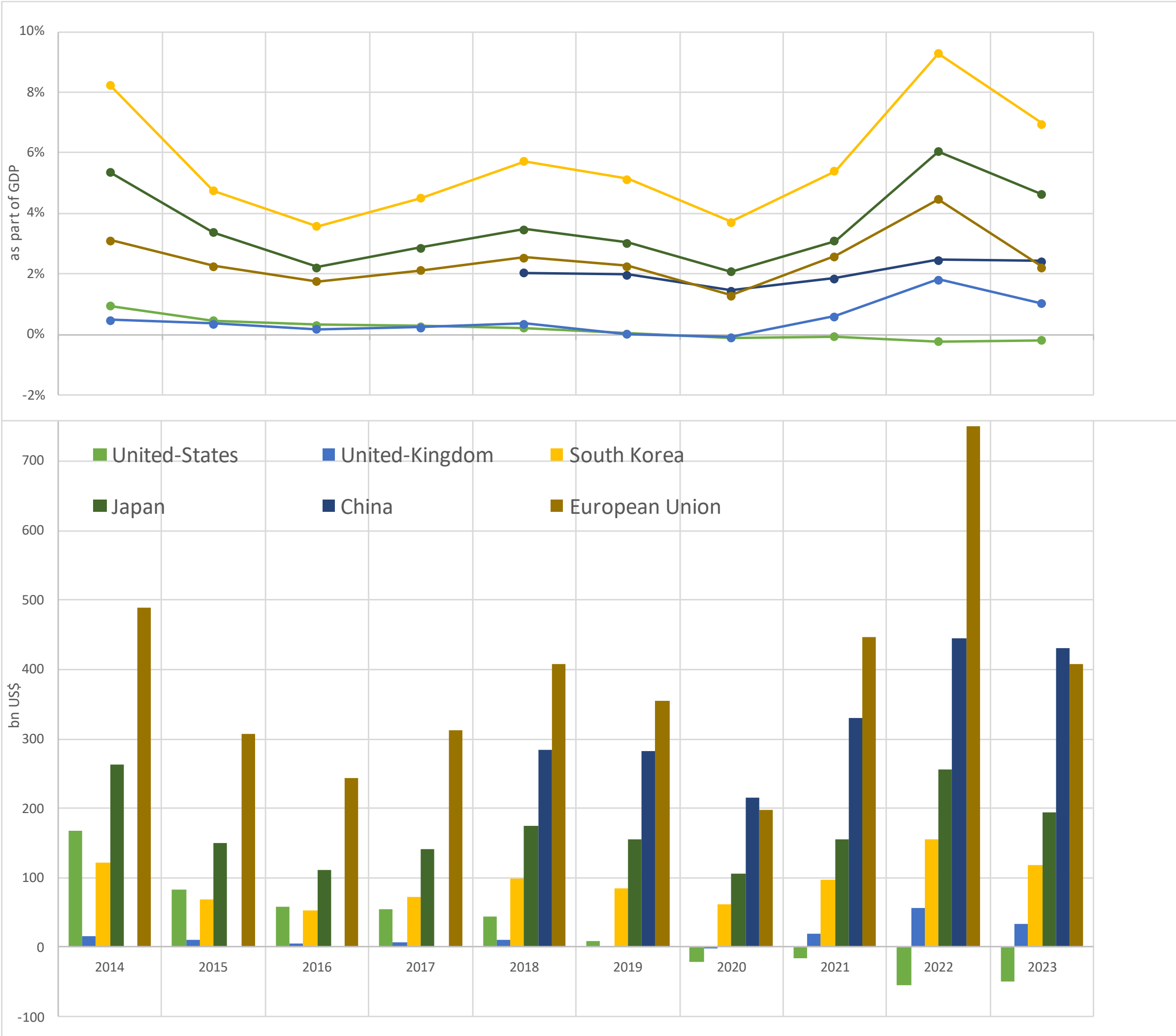

Figure 206: Comparison of the EU import bill with that of its main trading partners.

7.5. Market concentration index

The market concentration index, as described in the methodology section 7.1. ,**Error! Reference source not found.** is calculated using Eurostat annual import dataset. Values above 0.15 represent moderate to high concentration and raise concern, whilst value above 0.25 represent a highly concentrated market and is considered anti-competitive.

It is a simple and efficient way to quantify market concentration, but several caveats apply. It does not account for elasticity of demand (i.e. how prices affect demand and supply), nor for competition of other markets (e.g. non-EU energy market or competition between energy).

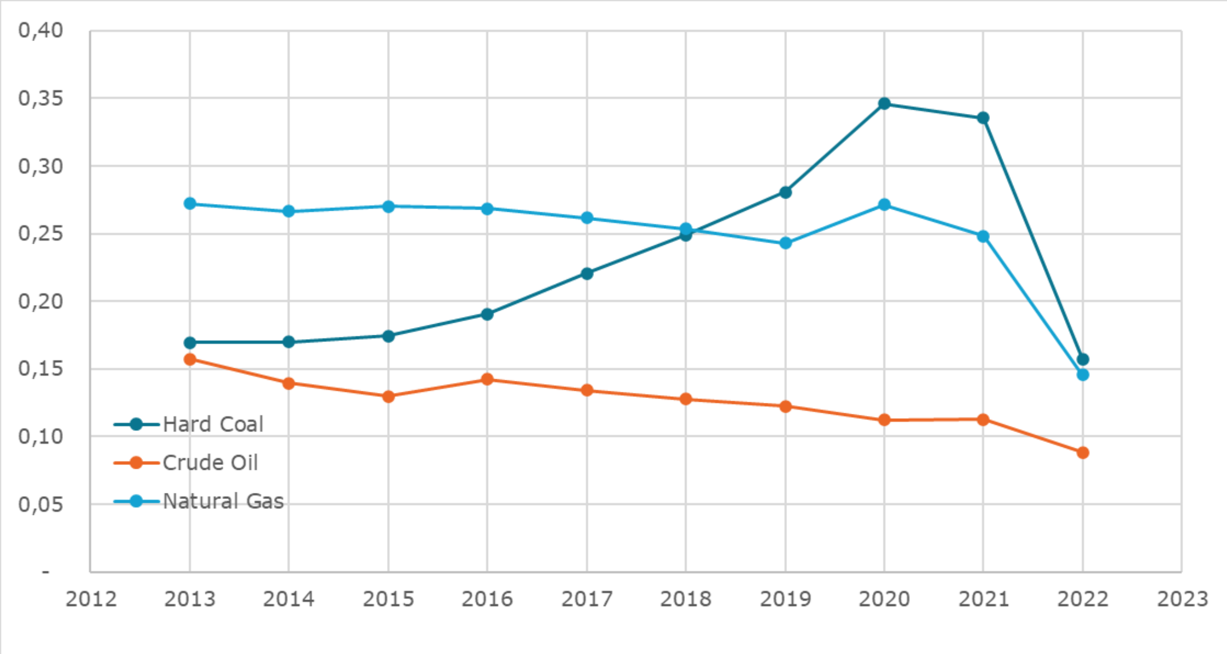

Figure 207: Market concentration index of EU energy imports

Natural Gas' overall concentration index trend is slightly downward before 2019, in 2020 and 2021 the reduced demand, related to the COVID pandemic, yields a temporary market concentration. In 2022 the invasion of Ukraine and its impact on energy import from Russia led to a strong diversification of the gas market.

The Crude Oil import market follows a slow dispersion trend from 2013 to 2022. It remained nearly untouched by global events such as the COVID pandemic in 2020 or the Russian invasion of Ukraine. Crude oil is an unconcentrated market with concentration index values consistently below 0.15 since 2013. This index does not account for the capacity of OPEC to influence supply as it has in the past 2 years.

Unlike natural gas and oil, hard coal imports have a concentrating trend up to the 2020, which was mainly due to the increasing share of Russian coal in EU imports (growing from 27% in 2013 to 54% in 2020). In 2022, Russia only represented 23% of total hard coal imports and the concentration index dropped back to its 2013 level.

Box G Hydrogen imports[428]

As of 2024 there aren't any hydrogen imports into the EU. Hydrogen imports into the EU are developed by repurposing current gas pipeline infrastructure, e.g. through the south2 corridor, or by shipping. Shipping hydrogen is initially planned to be done by shipping ammonia, as there is currently no existing tanker capable of carrying liquified hydrogen, although ships are in development and several liquid hydrogen tanker ship designs have already received approval in principle from classification societies. The hydrogen infrastructure within the EU is in its conception phase. Import infrastructure is expected to start operation around 2030.

7.6. Russian focus

Comext data are used to analyse the energy imports from Russia.

[428] *The European Clean Hydrogen Alliance published in November 2023 an extensive study on* LEARNBOOK: HYDROGEN IMPORTS TO THE EU MARKET (entsog.eu)

Russia has been the main provider of energy products to the EU. In 2014 imports from Russia represented 42% of the total value of energy imported. Imports consist primarily of natural gas and crude oil. From 2014 to 2021, approximately two-fifths of the gas consumed in the EU and over a quarter of the EU's imported crude oil originates from Russia.

Table 43: Net energy import bill of the EU for Russia

		2019	2020	2021	2022	2023	Source
Russia	bn EUR	96	57	98	143	28	Comext
Total	bn EUR	251	137	249	549	377	Calculated
Russia/Total	%	38%	41%	39%	26%	8%	Calculated

In 2019, the EU imported energy products worth 96 billion euros from Russia, 38% of the total energy bill. In 2020, with the COVID-19 pandemic, energy imports from Russia decreased in similar proportion to the total imports to the EU. In 2021 it got back to its pre-pandemic level.

In spring 2022 the EU took sanctions on Russian energy products imports, consequently the share of Russia in the EU import bill dropped to 26%, mostly due to reduce import volume of natural gas (-44% compared to 2021, source: Eurostat). Hard coal and crude oil imports have decreased by 45% and 22% respectively. Despite reduced imported volume, the value of energy imports from Russia reached its maximum since 2013 because of sharp increase of prices.

In 2023 the continuing reduction of imported volumes along with decreasing prices lead to energy import from Russia worth 28 bn EUR, its lowest since 2000. Russia only accounted for 8% of the total energy bill of the EU.

Eurostat trade data show that the total import of natural gas into the EU increased by 7% (+280 TWh) while import from Russia decreased by 44% (-734 TWh). The decreasing energy imports from Russia have created opportunities for other providers (e.g. the USA (+342 TWh) and Norway (+83 TWh)). It is worth noting that imports from "non-specified" providers increased by 142% (+390 TWh) over 2021 reaching its 2019 level.

8. Role of energy for government revenues; taxes and levies on energy products

8.1. Summary of main findings

On the EU-27 scale:

- Despite a rise in final energy prices in the EU-27 since 2020, the proportion of taxes and levies in these prices decreased across all energies and end users. These shares were offset by higher raw energy costs and the adoption of national measures set to contain prices.
- In 2022, energy taxes collected in the EU-27 amounted to EUR_{2022} 248bn (i.e. 1.6% of EU GDP, or 3.8% of total revenues from taxes). Revenues decreased since 2019 (-12%), due to the COVID-19 pandemic & energy prices increase.
- The main contributor to energy tax revenues in 2022 were households; they paid 39% of total energy taxes (a decrease compared to 50% in 2008).

On the MSs scale:

- The role of energy taxes in government revenues varies between MSs in 2022: in Bulgaria, energy taxes accounted for 14.4% of total revenues from taxes & social contribution while it represented 2.4% in Ireland. On EU27 average they accounted for 3.8% of MSs revenues from taxes & social contributions.
- In 2021, 76% of revenues from energy taxes and levies in the EU-27 came from excise taxes, and 21% from mechanisms implemented to support the development of renewables.
- Substantial profits (windfall profits) emerged from high energy prices since 2021 in the energy sector. As a response to those, both at the EU and Member States levels, taxes on those profits were introduced to ease the effects of high energy prices.
- MSs estimated tax windfall profits taxes for 2022 reached EUR 17,574 million (as of Sept. 2023).

Excise duties

- Excise duties revenues reached EUR_{2022} 230 billion in 2021 and reduced by 8% in 2022 to EUR_{2022} 211 billion as countries reduced rates to compensate end-users for high energy prices.
- On EU27 average in 2022, 91% of excise taxes and similar charges revenues came from mineral oils, followed by electricity (6%), and natural gas (3%).
- 18 countries reduced their excise tax rate on gasoline, gasoil, electricity and/or natural gas between 2022-2023. Most countries prioritised on the reduction of excise taxes on gasoil (18 countries) and gasoline (14), followed by electricity (9) and natural gas (8).
- 18 countries reduced their excise duty rates on gasoil in 2021-2023, reducing EU average by 7.6%. Those countries were: BE, CY, CZ, DE, EE, FI, HR, HU, IE, IT, LT, MT, NL PL, PT, RO, SE, SI.
- 9 EU countries (AT, BE, CY, DK, ES, HU, NL, PL and SI) reduced excise duty rates on electricity between 2021-2023, and drastically dropped their rates (average EU rates dropped by -32%).
- Excise duty rates are starting to rebound since July 2023-January 2024 for all energies.

VAT rates

- 5 countries took measures to reduce VAT rates to fight rising energy prices (regardless of the energy). Those countries were: BE, IE, LU, NL and PL.
- Most measures were taken on electricity and natural gas. The electricity VAT average reduced by 3.4% (5 countries reduced rates), gas average dropped by 3.3% (4 countries reduced rates).
- Various countries started to increase their VAT rates in January 2024 back to 2022 levels eg. NL, LU, IE (expected in October 2024) for electricity & LU for natural gas.

Impacts on inflation

HOUSEHOLDS

- In 2021, household energy inflation prices (HICP[429]) rose exponentially in the EU, as energy consumption returned to pre-COVID-19 levels, driven primarily by an increase in oil prices and natural gas. In 2022, annual energy-products HICP increased by 35%, the highest level recorded since 2008.
- Compared to the impact of changes in oil prices, taxes and government measures introduced since 2021 have played only a very limited role in developments in HICP energy inflation.
- Between May 2023 and February 2024, energy was the only category for which HICP started its decrease thanks to lower wholesale costs for gas and electricity. Conversely, services, food, alcohol and tobacco's prices continued to increase since May 2023.
- In 2023, when comparing energy price inflation across Member States, electricity prices showed the highest level of variability among all energy types.

INDUSTRY

- From 2020 to 2022, the spike in industrial price inflation was driven by rising prices of natural gas extraction in the context of the war in Ukraine and European sanctions against Russia, and to some extents by rising costs for manufacturing petroleum and electricity.
- In 2023, industrial producer prices on energy products decreased by 14%, mainly driven by a decrease in natural gas producer prices, but remained two times higher than in 2020.
- In 2023, energy industrial producer prices varied significantly among Member States, with increases ranging from 1.5 to 3.3 times.

Comparing Household and Industry

- From 2008 to 2019, energy price inflation evolved quite similarly for households and industrials. In 2022 the gap between household energy price inflation (HICP) and industrial producer prices (IPP) widened. Industrial producer prices rose much more sharply than household energy prices, partly due to national fiscal measures implemented to shield households from energy price hikes.

International comparisons

- EU MSs are more dependent on energy tax revenues to balance their budgets compared to picked international trading partners.
- International VAT rates on electricity and natural gas are quite heterogeneous, but in the same range as the different EU-27 countries.
- European countries tend to tax petroleum fuels at the highest level globally. Excise taxes are approximately 5 times higher in Europe than the US for gasoline and 4 times higher for gasoil.

Link with subsidies

- Between 2015 and 2021, we estimate that energy-related revenues have fallen by EUR 12.6 bn in the EU-27, while in the meantime energy-related subsidies increased by EUR 32.1 bn.
- A decoupling is observed between evolutions of energy-related revenues amount and energy-related subsidies amount.
- Historically, the amount of revenues is stable (except a 48% fall in 2020) while the amount of subsidies is slowly increasing (except a sharp rise in 2022 and 2023).
- While all economic sectors contribute to tax revenues, 3 economic sectors benefit the most from energy subsidies: Electricity, gas, steam and air conditioning supply sector (nearly 50%), Manufacturing (20%) and Households (12%).

[429] *The HICP indicator measures changes in the prices of goods and services that households purchase for consumption. It is "harmonised" as each EU Member State follows the same methodology, allowing comparisons[429]. The HICP indicator provides the official measure of consumer inflation in the Euro area and the EU.*

8.2. Introduction and definitions

Introduction

The objective of this chapter is to analyse energy-related government revenues from taxes and levies on energy products (electricity, gas, oil, gasoline, diesel, heating oil, and coal where relevant) within an EU-27 scope and its main trading partners, and their evolution since 2008.

By adjusting tax rates or levies, governments can influence consumer behaviour and market functioning, or even encourage adoption of cleaner energy alternatives. Since the war in Ukraine and post COVID-19 growth, taxes and levies on energy products were largely used as a mean to address energy prices increase. Consequently, energy-related government revenues fluctuated a lot.

In a nutshell, this chapter will try to answer the questions: *How have energy taxes and levies evolved since 2008 in the EU-27? How have they evolved in a context of rising prices?*

This chapter will also try to answer to the question: How did the evolution of subsidies (including tax rebates, lower tax rates) have impacted the energy transition?

Definitions

1) Energy taxes

The term "energy taxes" is classified by Eurostat (common definition by the OECD) under the umbrella of environmental taxes[430], and defined as follows: "A tax covers any compulsory, unrequited payment to general government levied on tax bases deemed to be of particular relevance. Taxes are unrequited in the sense that benefits provided by government to taxpayers are not normally in proportion to their payments"[431].

Within its "energy taxes" definition, Eurostat includes:

- taxes on energy production and on consumption of energy products used for both transport and stationary purposes
- taxes on the stocks of energy and infrastructures of the energy system.
- revenues from the auctioning of emissions allowances of the EU ETS.

However, Eurostat excludes:

- taxes on oil and gas extraction to facilitate benchmarking across countries and prevent high volatility effect.
- "fees and charges or obligatory contributions to finance renewable energy which are not taxes". (i.e. revenues from mechanisms such as Feed-in-Tariffs are not considered as taxes, thus excluded)
- revenues from VAT on the consumption of energy products.

As a result, revenues from energy taxes reported by Eurostat are yielded by taxes on the consumption of energy, stocks of energy, taxes on infrastructures, as well as auctions of emission allowances of the EU ETS.

2) Energy taxes and levies

The three terms, "taxes, charges and fees" are generally considered forms of levies, which allow "partly to avoid the bad publicity and hence the resistance associated with the word tax"[432]. As mentioned previously, the energy taxes definition by Eurostat excludes compulsory and requited payments to government, or public bodies, i.e. charges and fees.

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[430] *Eurostat (2024). Environmental taxes - A statistical guide - 2024 edition.*
[431] *Eurostat, A statistical guide - Environmental taxes, 2013. Available at: https://ec.europa.eu/eurostat/web/products-manuals-andguidelines/-/KS-GQ-13-005*
[432] *EEA, Environmental taxation and EU environmental policies, 2016. Available at: https://www.eea.europa.eu/publications/environmental-taxation-and-eu-environmental-policies*

The word "duty" is also commonly used in the literature, but it embodies a broader concept than taxes, charges and fees as it encompasses every legal obligation toward government. To facilitate understanding, the word duty will not be used in this report; rather, the words taxes and levies will be used as a generic term to cover levies, charges, fees and duties.

To capture information on "energy taxes and levies", Eurostat's NTL database[433] was used and adjusted:

- by adding Renewable Energy System (RES) charges revenues,
- by excluding revenues from the auctioning of emissions allowances of the EU ETS (which are not considered as taxes in this study).

The RES charges data come from the "Study on energy subsidies and other government interventions in the European Union (2023 edition)"[434] . This study provides an inventory of measures which allowed to identify RES support measures along with their amounts and to retrieve RES charges data until 2021. RES charges (imposed by governments to final customers or other economic actors) are justified by the need to support the development of renewable energy. The amounts collected are typically used to finance price support mechanisms such as Feed-in-Tariff (FiT), Feed-in-Premium (FiP) or Contracts for Difference (CfD).

[433] *Eurostat (2023). National_tax_lists_2022_2023*

[434] *Enerdata and Trinomics (2023). Study on energy subsidies and other government interventions in the European Union*

8.3. Energy taxes and levies

8.3.1. Analysis on an EU-level of energy taxes and levies

The share of taxes and levies on final energy prices

Final energy prices vary depending on: 1) time (*prices fluctuate in time due to changes in the market or economic policies*), 2) the energy product analysed, 3) the end user (e.g. *the price is different for households and industry*). In addition, end users' total prices are made up of 3 components: energy and supply costs (i.e. raw energy costs), network costs, and taxes & levies.

As of 2017, taxes & levies represented 40% of electricity prices for households and 46% for industry in the EU-27 and remained quite stable until 2020. These shares decreased to 37% and 43% (-3%), respectively, in 2021 (cf. Table 44) and dropped to their lowest levels in 2022 at 20% and 25%, respectively, because of rising raw energy prices since 2021[435]. In 2022, as raw energy prices skyrocketed (+123% for industry and +70% for households), MSs cut taxes to partially contain growing electricity prices for final consumers, meaning that taxes level adjustment were used as a regulation tool to a certain extent.

About gas, between 2017 and 2021, taxes and levies accounted for around 1/3rd of gas prices for households and industry in the EU-27 on average. These shares decreased to 22% and 23% (-10%), respectively, for households and industry in 2022 as MSs cut taxes to contain prices[436].

Table 44: *Energy prices and share of taxes & levies since 2020 (EU-27 average)*

		2020	2021	2022	2020-2022
Electricity	Households	*Total price:* 0.21 EUR /kWh *Taxes & levies %:* 40%	0.23 EUR /kWh 37%	0.26 EUR /kWh 20%	EUR /kWh ↗ % ↘
	Industry	0.15 EUR /kWh 46%	0.17 EUR /kWh 43%	0.23 EUR /kWh 25%	EUR /kWh ↗ % ↘
Gas	Households	18.25 EUR /GJ 33%	19 EUR /GJ 34%	26.32 EUR /GJ 22%	EUR /GJ ↗ % ↘
	Industry	9.81 EUR /GJ 31%	11.77 EUR /GJ 30%	23 EUR /GJ 23%	EUR /GJ ↗ % ↘
Gasoline	Retail price	*1.28* EUR / l 65%	*1.5* EUR / l 58%	*1.82* EUR / l 50%	EUR / l ↗ % ↘
Gasoil	Retail price	1.16 EUR / l 59 %	*1.36* EUR / l 53 %	*1.75* EUR / l 43 %	EUR / l ↗ % ↘
Heating oil	Retail price	0.65 EUR / l 37 %	*0.87* EUR / l 34 %	*1.33* EUR / l 29 %	EUR / l ↗ % ↘

Source: Eurostat (data series nrg_pc_204_c)

Energy tax revenues in the EU-27

In this first sub-part of the study energy tax (excluding levies) revenues' evolution in the EU-27 since 2008 was analysed using Eurostat's definition, see Part 8.2. revenues from the auctioning of emissions allowances of the EU ETS

[435] *The decreasing share of taxes and levies in total power prices (for industries and households) since 2020 because of increasing raw energy price was registered in nearly all Member States. (i.e. the EU-27 average was not pulled-up by leading countries).*
[436] *The decreasing share of taxes and levies in total gas prices (for industries and households) since 2020 because of increasing raw energy price was registered in nearly all Member States (i.e. the EU-27 average was not pulled-up by leading countries).*

Taxes imposed on energy products are a significant source of government revenue in EU Member States. In 2022, energy taxes[437] (According to the definition by Eurostat -cf. Part 8.2. -) collected by EU MSs amounted to EUR_{2022} 243 billion (cf. Figure 208). This was equivalent to 1.56% of the EU-27 GDP, or 3.8% of total revenues from taxes (including social security contributions[438]). Energy tax revenues increased by 20% between 2009 and 2019 (on average by +1.8%/year). On the other hand, the share of energy tax revenues in average EU-27 GDP and its share in total (energy and non-energy-related) tax revenues remained relatively stable during this period.

In 2020, energy tax revenues dropped by 11% compared to 2019 in nominal value due to the economic recession in the EU. The main cause for this drop was the reduced consumption of transport fuel due to the 2020 pandemic.

In 2021, energy tax revenues increased again to EUR_{2022} 271 billion (+9%, but remained at a lower level than before the pandemic) before dropping again in 2022 to EUR_{2022} 243 billion. Revenues dropped in 2022 due to high price inflation on raw energy products[439] which forced MSs to reduce taxes to contain final energy prices for consumers.

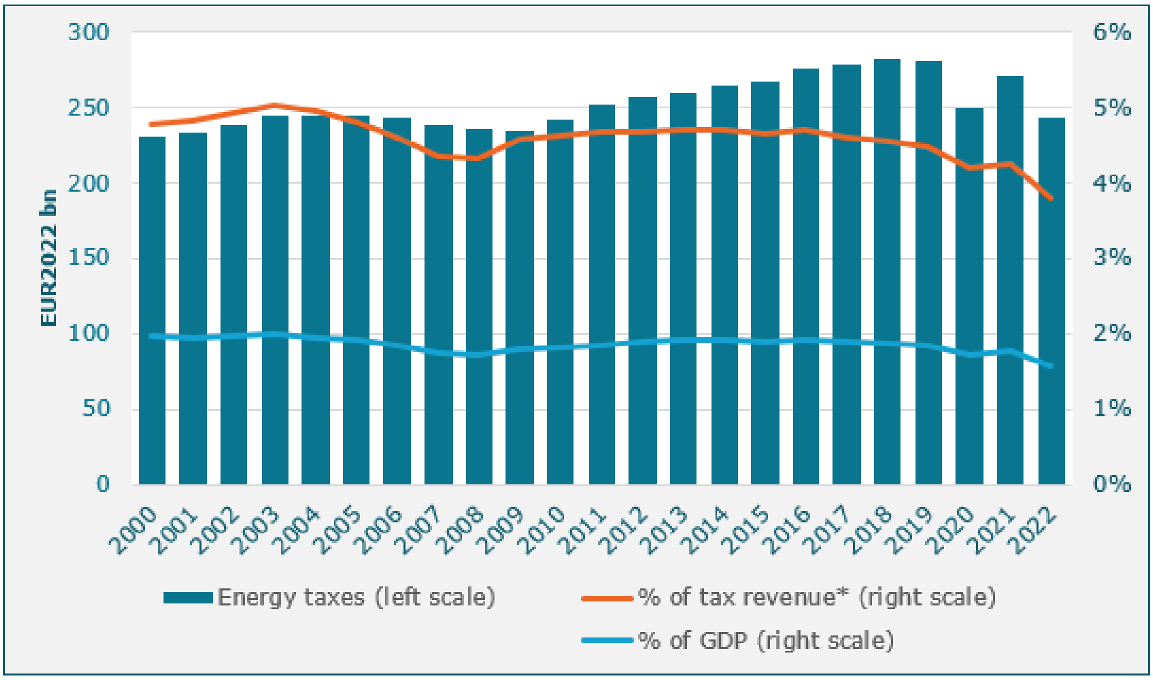


Figure 208: *Energy tax revenues in the EU-27*

Source: Eurostat (data series env_ac_tax)[440]

Households[441] are the main contributor to energy tax revenues: in 2022 they paid 39% of total energy taxes (cf. Figure 209). This represents a decrease compared to 2008 when this share was 50% (at the expense of electricity, gas, steam and air conditioning supply).

[437] Energy-related environmental taxes as defined in "Environmental taxes – A statistical guide – 2024 edition" (https://ec.europa.eu/eurostat/en/web/products-manuals-and-guidelines/w/ks-gq-23-016); this category includes taxes imposed on energy production and on energy products used for both transport and stationary purposes, as well as on greenhouse gases but does not include VAT imposed on energy products.

[438] *Social security contributions are compulsory payments paid to general government that confer entitlement to receive a (contingent) future social benefit.*

439 Induced by various factors since 2020, including: the post COVID-19 recovery, heat waves in Europe during the summer 2020 which resulted in more energy demand, the Russian invasion of Ukraine, etc.

[440] *Percentage of total revenues from taxes and social contributions (including imputed social contributions)*

[441] *Households here do not include transport. Source: Eurostat "Environmental taxes by economic activity (NACE Rev. 2)"*

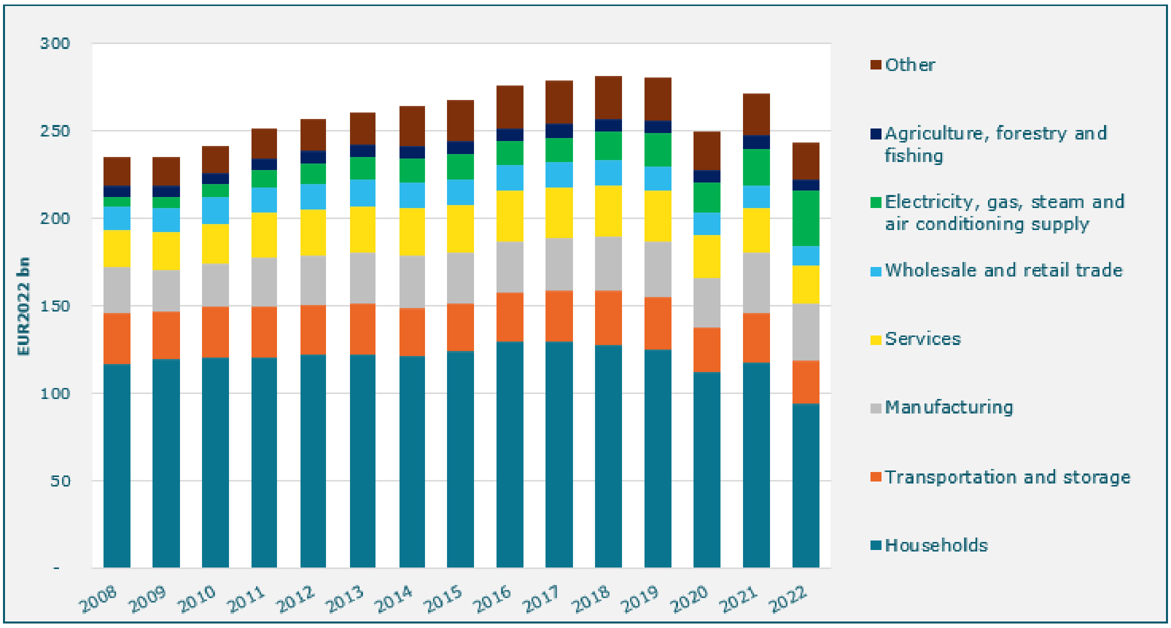


Figure 209: Energy tax revenues by economic sector in the EU-27

Source: Eurostat (data series env_ac_taxind2)

The underlying base of energy taxes declined in the last decade: the EU's gross inland energy consumption decreased by 6.5% between 2010 and 2019 (cf. Figure 210). This decrease reached -14.1% in 2020 compared to 2010 which is mainly due to the COVID-19 crisis and the related mobility restrictions. In 2021, it rebounded by +6.1% (compared to 2020) with the end of the mobility restrictions in the EU. In addition, the increase in energy prices starting in 2021 limited this rebound and caused a new drop in 2022 (-4.8%). Regarding average energy tax rates in EUR/toe, it remained at around 16.5 EUR_{2022}/MWh since 2016 and decreased to 15.4EUR_{2022}/MWh in 2022 (-6% compared to 2021).

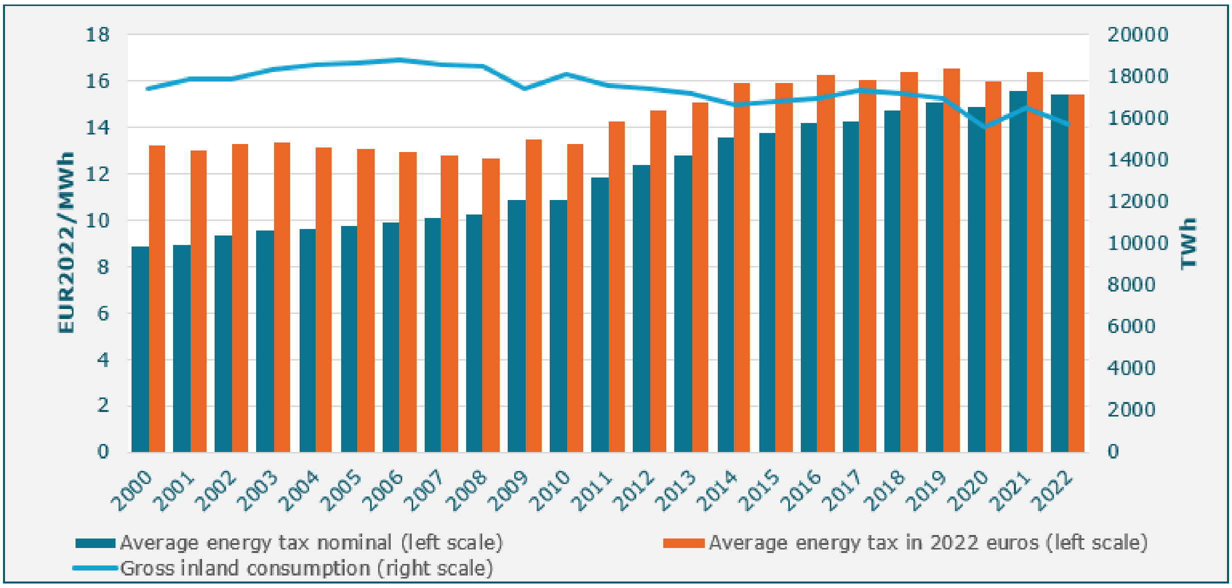


Figure 210: Average energy tax for 1 MWh of gross inland energy consumption in EU-27

Source: DG Energy calculation based on Eurostat data (env_ac_tax, nrg_100a and prc_hicp_aind)

8.3.2. Analysis at Member State level of taxes and levies

The weight of energy taxes (including EU ETS and excluding levies) in government revenues varies between MSs. In 2022, they represented 14.4% of total revenues from taxes and social contributions in Bulgaria (including imputed social contributions) while this share was only 2.4% in Ireland (cf. Figure 211).

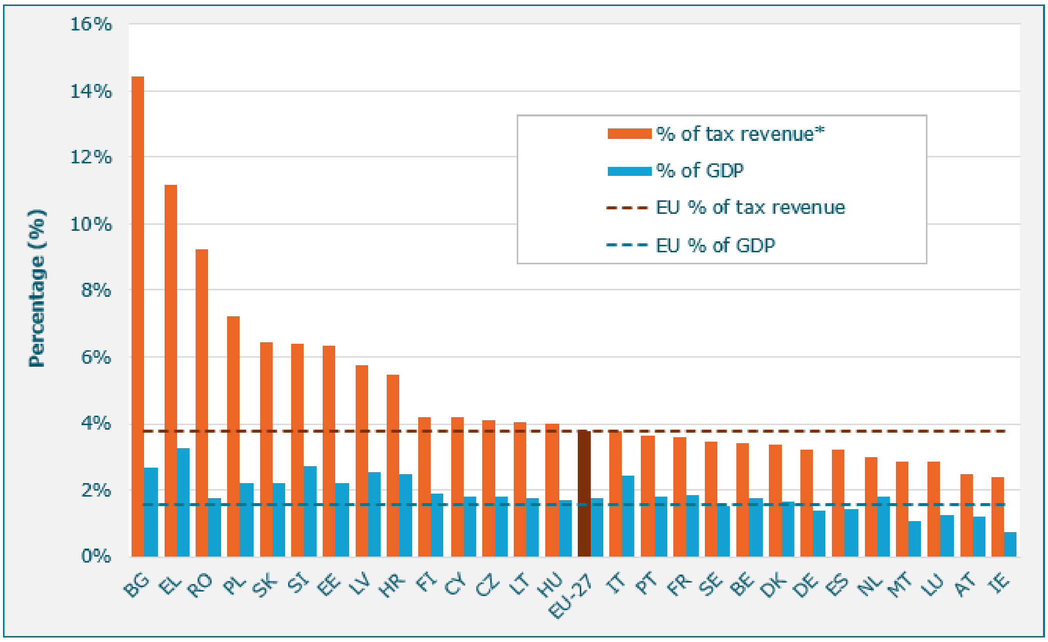


Figure 211: Energy taxes as a percentage of tax revenue and of GDP in 2022

Source: Eurostat (data series env_ac_tax)[442]

Energy taxes by energy consumed

Average energy tax revenue (including EU ETS and excluding levies) per 1 MWh of gross inland energy consumption was around EUR 16 in 2022, but there was a huge variation across MSs, from EUR 8 in Hungary to EUR 39 in Greece (cf. Figure 212). MSs combining high GDP with a high share of oil in the energy consumption mix tend to have higher energy taxes per 1 MWh of gross inland energy consumption, thus representing a substantial source of revenue for such states (eg. in Greece the share of oil in total final consumption reached 57% in 2022, 54% in Luxembourg, and 34% in Denmark).

[442] *Percentage of total revenues from taxes and social contributions (including imputed social contributions*

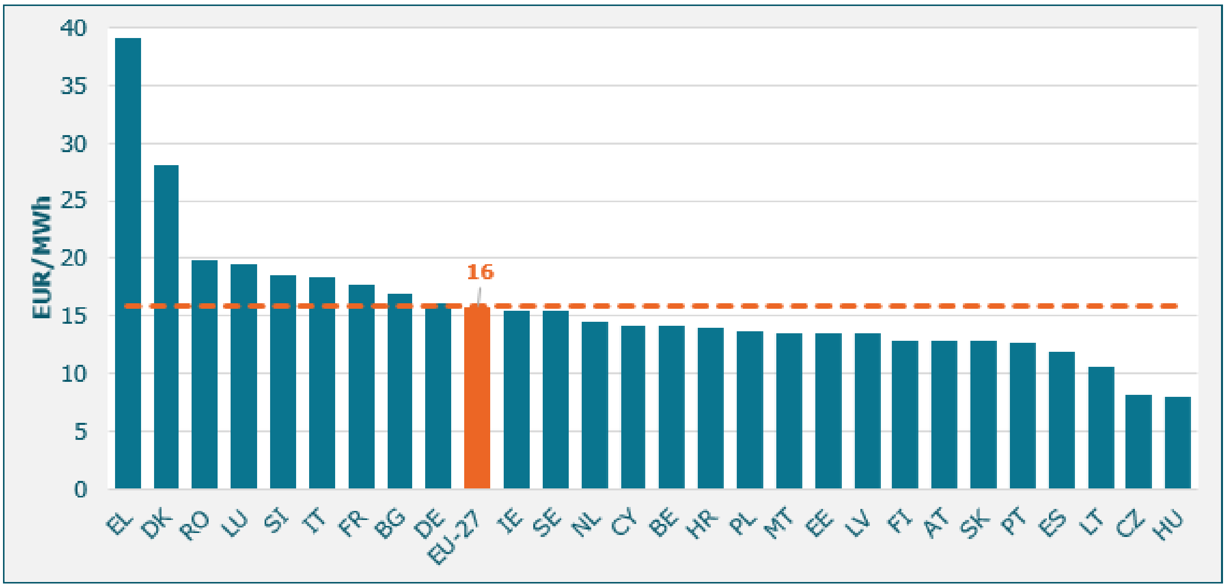


Figure 212: *Average energy tax for 1 MWh of gross inland energy consumption in 2022*

Source: DG energy calculation based on Eurostat data (data series env_ac_tax and nrg_100a)

Taxes and levies revenues by type

In 2021, 76% of revenues from energy taxes and levies in the EU-27 came from excise taxes, and 21% from mechanisms implemented to support the development of renewables (Figure 213**Error! Reference source not found.**). Excise taxes accounted for at least 80% of such revenues in 15 MSs. Amongst other results which stand out, renewable support mechanisms accounts for 35% in Germany, 33% in Czechia, 30% in Belgium, 26% in Spain, while environmental charges make up 21% of total revenue in Ireland and 20% in Luxembourg.

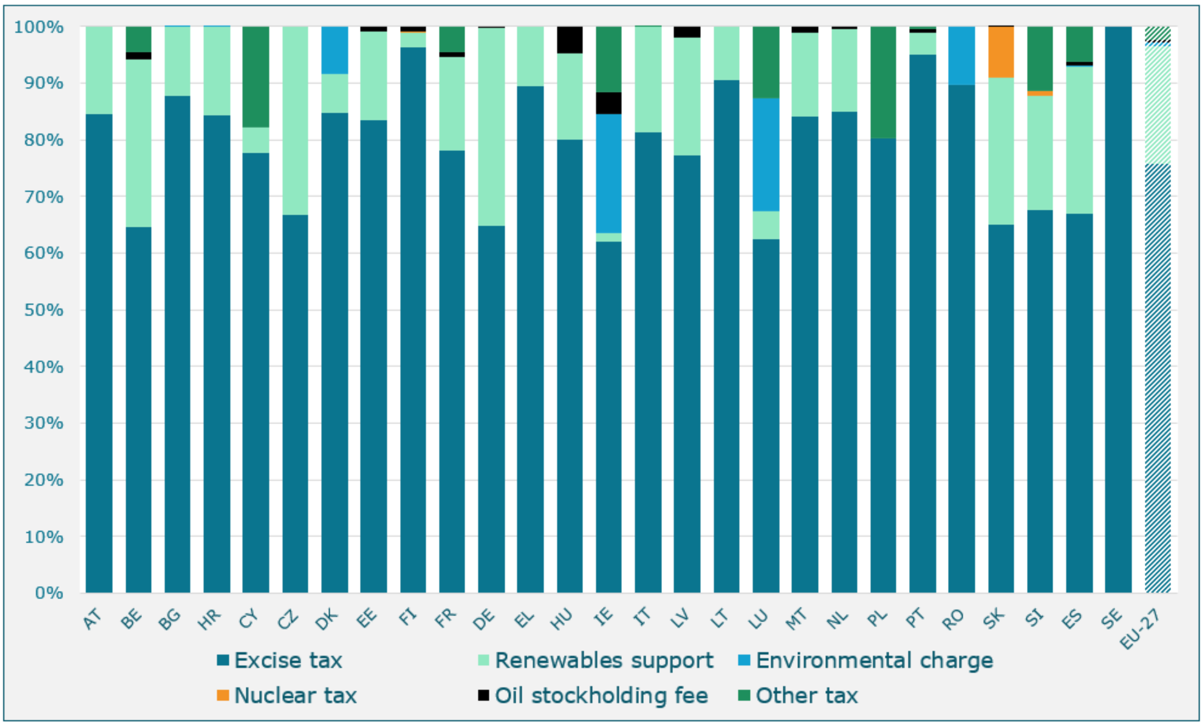


Figure 213: Share of energy tax and levies revenues by type of tax in the EU-27 (as of 2021)

Source: Eurostat - National Tax Lists (2023), & Subsidies study 2023 for RES charges data

The distribution of tax revenues and levies in the EU-27 by type has not much evolved since 2015. Between 2015-2021, around 75% of energy tax and levies revenues came from excise taxes, followed by renewable support (around 20%).

- Windfall taxes profits in Europe

From 2023 onwards, energy prices in Europe increased and/or fluctuated as a combined result of the geopolitical and economic context. This situation came as an opportunity for some energy firms which saw their profits and stock prices as they benefited from higher coal, oil, and natural gas prices. This surge led to substantial profits - named *windfall profits* - in the energy sector.

A *windfall tax* targets windfall profits and is defined as a tax levied by governments on industries when economic conditions allow those industries to experience significantly above-average profits[443].

On 6 October 2022, the Council of the European Union adopted[444] a windfall profit tax ("temporary solidarity contribution" under EU terms) on businesses in the crude petroleum, natural gas, coal and refinery sectors on profits that were above a 20% increase of the average yearly taxable profits for the period 2018-2021. The application period of the solidarity contribution started in 2022 and/or 2023 depending on the Member State's choice. The exceeding profits were to be taxed with a rate of at least 33%. This was on top of other ongoing taxes carried-out on industries in different MSs. Proceeds were meant to ease the effects of high energy prices. The solidarity contribution had the be adopted and applied by 31 December 2022.For Member States that preferred to implement national measures as an alternative to the solidarity contribution, those measures had to share similar objectives and be subject to similar rules as the solidarity contribution. In addition, these national measures had to generate comparable or higher proceeds than the estimated proceeds from the solidarity contribution. As per the solidarity contribution, deadline for the national measures application were also set at 31 December 2022.

As of September 2023[445], all Member States had introduced the solidarity contribution or equivalent national measures. Of the 27 MSs: 15 applied the solidarity contribution (AT, BG, DE, DK, EL, FI, FR, HR, IE, LT, NL, PL, RO, SI, SK), while 8 (BE, CZ, EE, ES, HU, IT, PT, SE) opted for the adoption or application of enacted equivalent national measures. In addition, 3 Member States (LU, LV, MT) reported they had no companies or permanent establishments in scope to which the solidarity contribution could apply, thus have not adopted any application measures. Some other MSs (FI, HR, SI) expected few or no companies to be in scope to apply the Council Regulation and have adopted application measures but expect to generate only few proceeds. Finally, 1 Member State (CY) was still in the process of adopting measures (see Figure 214).

[443] *Kagan (2024). Windfall Tax: Definition, Purposes and Examples*
[444] *European Council (2022). Council agrees on emergency measures to reduce energy prices; European Council (2022). Council Regulation EU/2022/1854*
[445] *European Commission (2023). Report on Solidarity contribution and enacted equivalent measures: stocktaking*

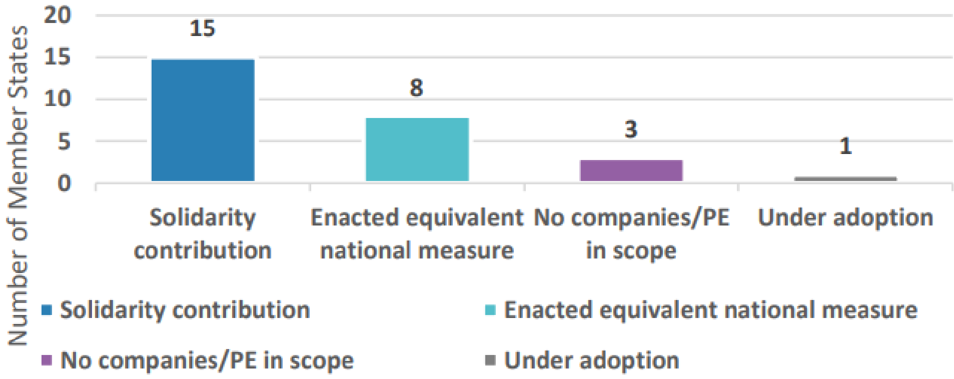


Figure 214: Overview of the application by Member States of Chapter III of the Council Regulation (as of Sept. 2023)

Source: European Commission, DG TAXUD[446]

Fiscal year application & rates for MSs applying the solidarity contribution

Out of the 15 MSs which applied the solidarity contribution, 6 applied it to both the fiscal years 2022 and 2023 (AT, BG, DE, IE, RO, SI). 6 MSs reported they applied it only on 2022 (EL, FR, NL, HR, PL, SK). 3 MSs applied it only on 2023 (DK, FI, LT). With respect to the applicable rate, 10 MSs applied the minimum rate of 33% (BG, DE, DK, EL, FI, FR, HR, LT, NL, PL) while 5 applied higher rates. In particular, the following higher rates have been reported: 40% (AT), 55% (SK), 60% (RO), 75% (IE), and 80% (SI).

Fiscal year application & rates for MSs applying equivalent national measures

4 MSs applied equivalent national measures to the fiscal years 2022 and 2023 (BE, PT, HU, ES). Estonia was the only country to apply its measure on 2022. 2 MSs applied their enacted national measures to the fiscal year 2023 (IT23, SE). One MS applied its measure to the fiscal years 2022-2025 (CZ).

Regarding applicable rates, 2 MSs applied the minimum tax rate set out by the Council Regulation of 33% (PT, SE). Higher rates include the following rates: 50% (IT), 60% (CZ). Spain applied 1.2% rate on a turnover base, while Hungary set a range that varied over time (the rate for the first measure was set at 31% for 2022 and 41% for 2023, and for the second measure the rate was 40% until 9 December 2022 and 95% from 10 December 2022). Finally, 2 MSs set variable rates: 6.9 per ton of crude oil processed (BE), or a rate to be fixed quarterly (EE) depending on minimum and maximum percentages, which were set per ton of the energy mineral resource.
As mentioned here-over, implemented tax rates varied between MSs (see Table 45): while a minimum tax rate was fixed at 33%, it reached 75% in Ireland.

Table 45: *Applicable tax rate on solidarity contribution or equivalent national measure implemented in the EU (as of September 2023)*

Rate	33%	>33%	Specific
Solidarity contribution applied	BG, DE, DK, EL, FI, FR, HR, LT, NL, PL	AT (40%), SK (55%), RO (60%), IE (75%), SI (80%)	
Equivalent national measures applied	PT, SE	IT (50%), CZ (60%)	ES (1.2% on net turnover) HU (range that varies between 31-95%) BE (variable rate) EE (rate fixed quarterly)

Source: European Commission, DG TAXUD

[446] European Commission (2023). Report on Solidarity contribution and enacted equivalent measures: stocktaking

12 Member States (namely BE, BG, DE, FR, EL, ES, HU, IE, IT, RO, SI, SK) provided the European Commission with their updated estimated proceeds during summer 2023 for the fiscal year 2022. The figure of estimated proceeds for the fiscal year 2022 (as of 12 September 2023) is EUR 17,574m (see Figure 215).

Country	Estimated total proceeds (in million EUR) as at 12 September 2023 as reported by Member States to the Commission Year 2022	Provisional estimated proceeds (in million EUR) as at 24 March 2023 as reported by Member States to the Commission (High point) Year 2022	Difference between the two reported figures (in million EUR) Year 2022
Netherlands	6,433	6,433	0
Poland	3,230	N/A	3,230
Italy	2,897	2,547	350
Spain	1,089.34	1,245	-156
Germany	1,000	1,500	-500
Romania	640.78	783.4	-143
Greece	630	556	74
Slovakia	520	521	-1
Hungary	446	476.5	-31
Belgium	289	300	-11
Ireland	167	240	-73
France	100	404	-304
Estonia	87.5	87.5	0
Bulgaria	43.3	44.8	-2
Slovenia	0.9	0.048	0.852
Austria	N/A	100	-100
Croatia	N/A	N/A	N/A
Cyprus	N/A	N/A	N/A
Czechia	N/A	N/A	N/A
Denmark	N/A	N/A	N/A
Finland	N/A	N/A	N/A
Latvia	N/A	N/A	N/A
Lithuania	N/A	N/A	N/A
Luxembourg	N/A	N/A	N/A
Malta	N/A	N/A	N/A
Portugal	N/A	82	-82
Sweden	N/A	N/A	N/A
Total	17,574	15,320	2,254

Figure 215: Overview of estimated proceeds (in million EUR) as reported by Member States to the Commission for the fiscal year 2022 (as of 12 Sept. 2023)

Source: European Commission, DG TAXUD

As of 30 June 2023, collected windfall tax profits proceeds for 2022 amounted to EUR 6,850m.[447] More up-to-date information regarding proceeds collected is expected to be published by the European Commission in mid-October 2024.

8.4. Excise duties

As seen previously (see, Figure 213), excise duties constitute the largest part of energy tax and levies revenues.

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 litre/kg/GJ/MWh). Accordingly, assuming rates do not change, the revenue will depend on the consumption of the specific product. In contrast, price changes should not impact revenues (at least not directly, but indirectly can lead to a decrease of energy consumption).

[447] European Commission (2023). *Report on Solidarity contribution and enacted equivalent measures: stocktaking*

Current EU rules for taxing energy products are laid down in Council Directive 2003/96/EC1744 (the Energy Taxation Directive, or ETD), which entered into force on 1 January 2004. The Directive covers petroleum products (gasoline, gasoil, kerosene, LPG, heavy fuel oil), natural gas, coal, coke and electricity. 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 current Directive is under revision, as to be discussed in Box H.

8.4.1. Analysis of excise duties revenues

From 2015 to 2019 the excise duty revenues on energy products were almost constantly increasing from EUR_{2022} 215 billion in 2015 to EUR_{2022} 233 billion in 2019 (cf. Figure 216). In 2020, the reduction of energy consumption in EU due to mobility restrictions and lockdowns, reduced the underlying tax base of excise duties leading to a 11% decrease of excise duties revenues. Excise duties revenues on petroleum products were the most impacted based on the decrease of transport energy consumption. In 2021, excise duties revenues greatly recovered to their previous level to EUR_{2022} 230 billion. In 2022, revenues decreased again (-8%) as some EU-27 countries took measures to reduce excise duties rates to contain the effect of rising energy prices on consumers.

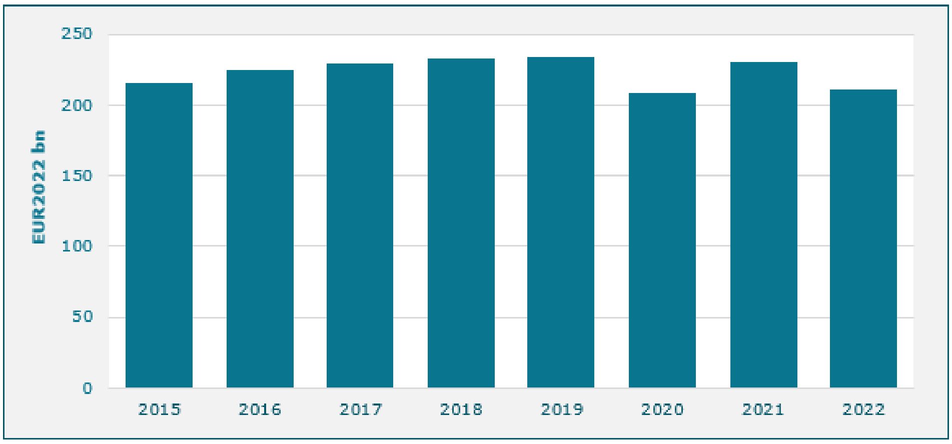


Figure 216: Excise duties revenues in the EU-27, 2015-2022 (EURbn)

Source: NTL database (Eurostat)

"Revenues on taxes on consumption" (i.e. excise duties and similar charges)448 other than VAT in the EU27 is much related to countries' GDP (cf. Figure 217). Revenues on excise taxes and similar charges ranged from around EUR 40 billion collected in Germany to EUR 97 million in Malta in 2022.

Most of the collected revenues from excise taxes and similar charges are collected on mineral oils. On EU27 average in 2022, 91% of these revenues came from mineral oils, followed by electricity (6%), and natural gas (3%) (cf. Figure 218). Revenues from coal excise duties is very low or even significant (0.4% in 2022) -as explained in Box H. Countries apply differently these excise duties and similar taxes, as an example, Cyprus' revenues came entirely from mineral oils while in Denmark they came from: mineral oils (55%), electricity (31%), natural gas (8%), and coal (6%).

[448] *European Commission (2023). Excise Duty Tables*

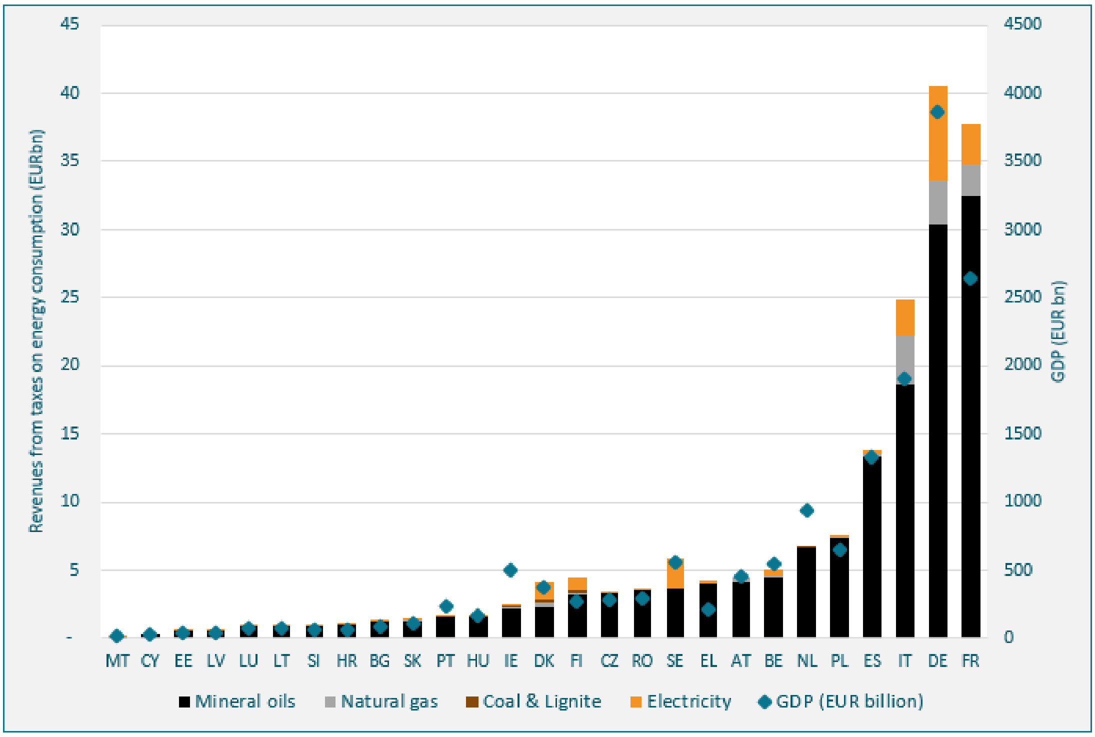


Figure 217: Revenues from taxes on energy consumption by energy VS GDP (EURbn, 2022)

Source: DG TAXUD

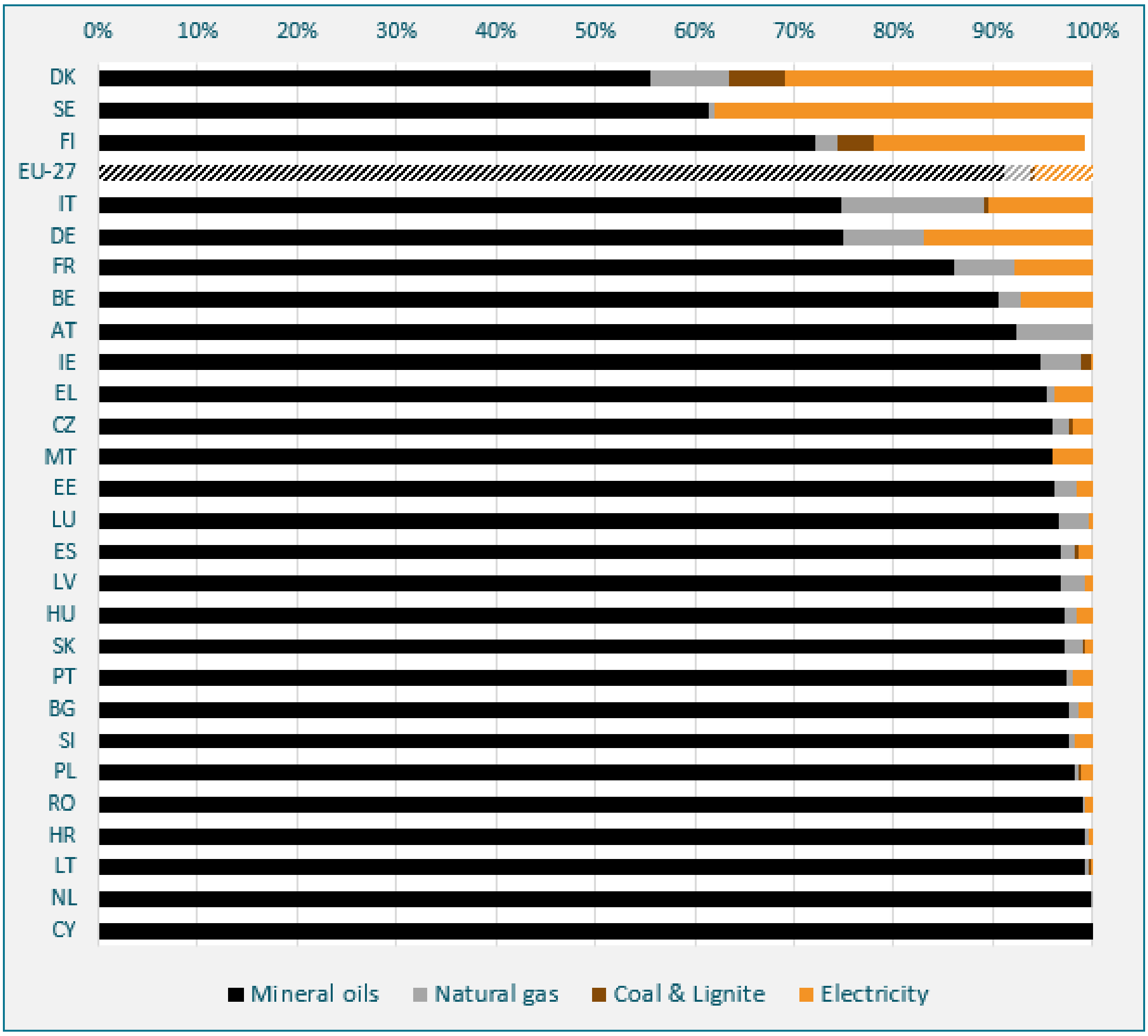


Figure 218: Distribution of revenues from taxes on consumption by energy type (2022)

Source: DG TAXUD

8.4.2. Analysis of excise duties rates

The Commission's Taxation and Customs Union Directorate-General (DG TAXUD) publishes the excise duty rates applicable in EU Member States[449] (in nominal terms).

Excise duty rates on petrol

On average in EU 27, the excise duty rate on leaded petrol has historically been higher than for unleaded petrol. Rates for both fuels have been increasing between 2008-2024: +14% for leaded petrol and +17% for unleaded petrol (Figure 219).

[449] *European Commission (2024). Taxed in Europe Database v4*

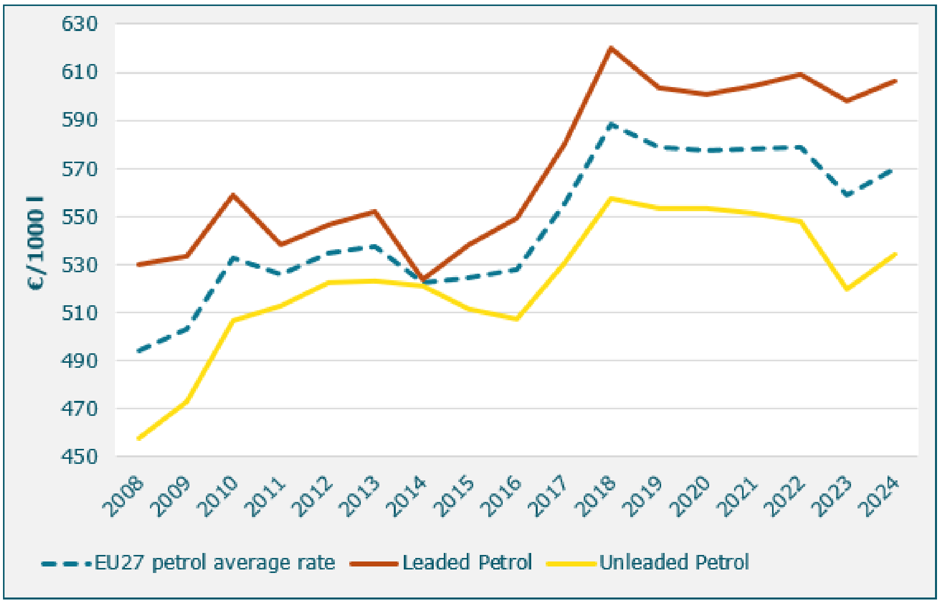


Figure 219: Average excise duty rates for petrol by ETD classes in EU-27 (as of Jan 1st of each year)

Source: DG Taxation and Customs Union[450]

Leaded petrol was withdrawn entirely from the EU market on 1 January 2000, apart from airplanes. As such the following analysis will focus only on unleaded petrol excise duty rates.

Recent years' crises have induced reductions in average excise duty rates in the EU-27**.** Indeed, while historically excise duty rates on unleaded petrol in the EU-27 increased since 2008 (+21% in 2020 vs 2008), it decreased by 2.1%/year between 2020-2023 to reach 520 EUR/1000 l (cf. Figure 220).

Since January 2022, many EU-27 countries were pushed to adjust their excise tax rates on unleaded petrol to reduce the impact on final consumers (Figure 221). The decrease between 2020 and 2023 was driven by 12 MS which decreased their excise duty rates on unleaded petrol to offset the consequences of rising prices of oil. Some countries drastically reduced their rates during this period, namely: Malta (-35%), Slovenia (-31%), Hungary (-23%), Portugal (-20%) and the Netherlands (-19%). Within the period, only 3 countries increased their rates: (Luxembourg (+14%), Czechia (+5%), and Finland (+3%).

As of 1 January 2024, the average EU-27 excise duty rate on unleaded petrol started to rebound for the first time since 2020 (+2.7% compared to 2023) to 534 EUR/1000 l. In 2024, 9 countries increased their rates on unleaded petrol (including Slovenia which increased back to its pre-COVID level at 529 EUR/1000 l).

[450] *European Commission (2024). Taxed in Europe Database v4*

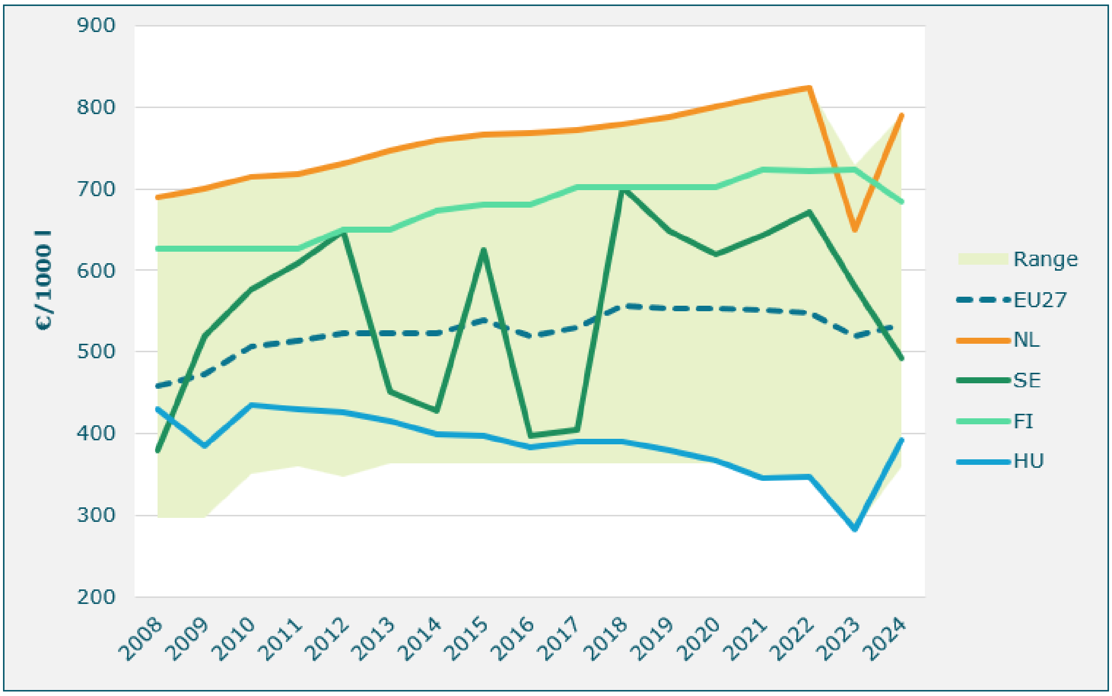


Figure 220 Excise duty rates on unleaded petrol in EU-27 (as of Jan 1st of each year)

Source : DG Taxation and Customs Union[451]

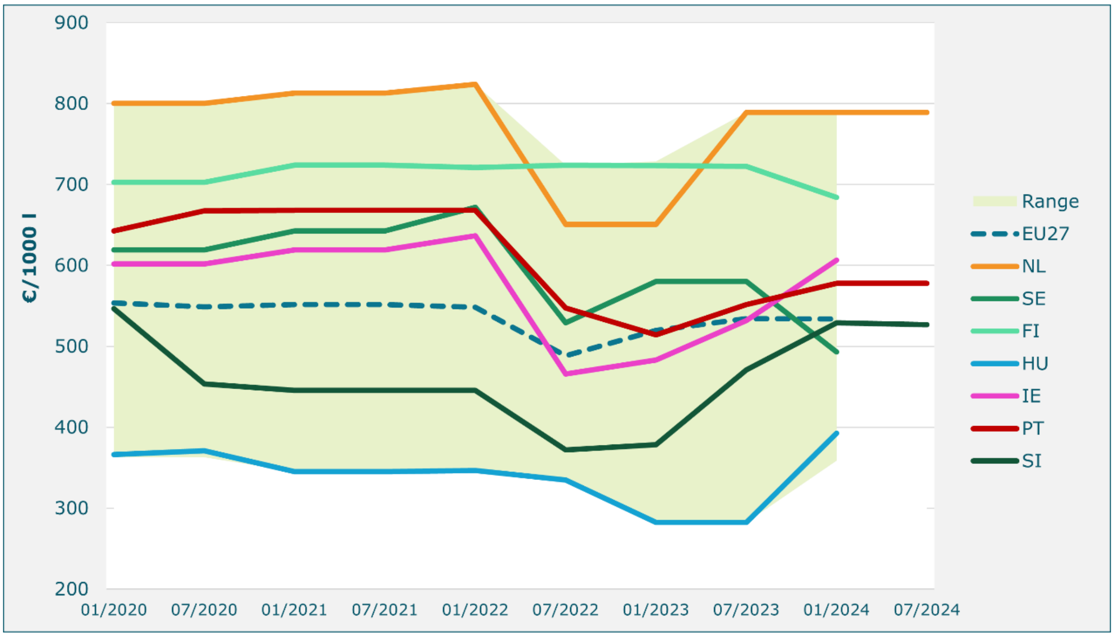


Figure 221 Excise tax rate on unleaded petrol (gasoline) EU-27 (6 month steps) between 2020-2024

Source : DG Taxation and Customs Union[452]

Excise duty rates on gasoil (diesel)

Gasoil's excise duty rate varies according to its final usage. Since 2008, gasoil used as a propellant has the highest average EU excise duty rate, followed by gasoil for commercial or industrial uses.

[451] European Commission (2024). *Taxed in Europe Database v4*
[452] European Commission (2024). *Taxed in Europe Database v4*

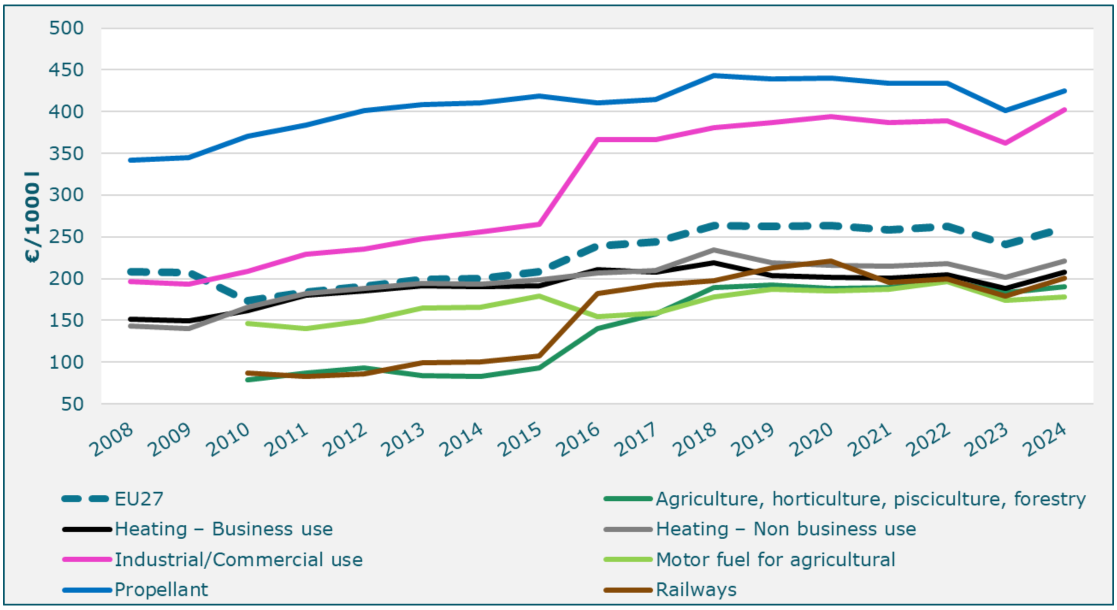


Figure 222: Average excise duty rates for gasoil by ETD class in the EU-27 (as of Jan 1st of each year)

Source: DG Taxation and Customs Union[453]

The excise duty on gasoil propellant (diesel) on average for the EU-27 increased by 27% between 2008 and 2018 and remained quite stable until the beginning of 2022 (cf. Figure 223). The average excise duties rates on diesel in the EU-27 decreased by 7.6% in 2023 (compared to 2021) to offset the increasing prices of fuels. 11 countries decreased their rates in 2023, notably Portugal (-33%), Slovenia (-25%), and Belgium (-24%). Only 3 countries increased their rates in 2023, namely Finland (+8%), Luxembourg (+3%), and Denmark (+1%).

In January 2024, excise duty rates on diesel increased on average by 5.8% in the EU-27 as 11 countries increased their rates. Countries which most increased their rates were the same that most decreased in 2023: Belgium (+32%, back to 2022 level), Slovenia (+31%), and Portugal (+29%).

[453] *European Commission (2024). Taxed in Europe Database v4*

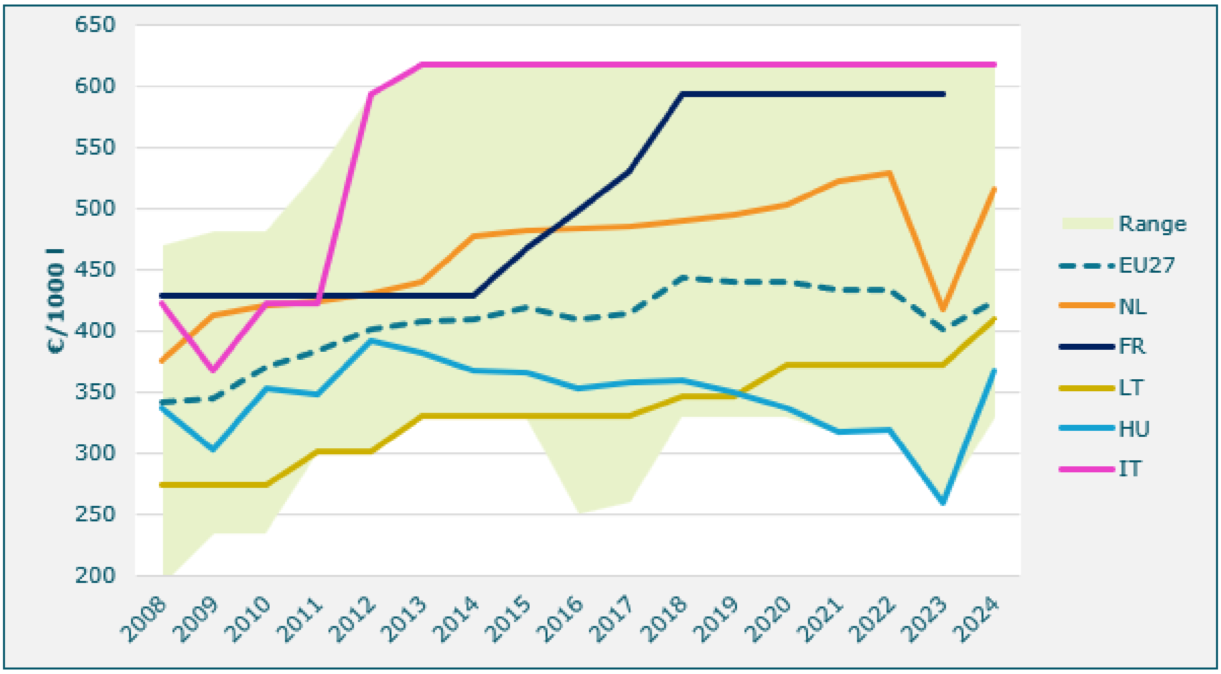


Figure 223: Excise duty rates on gasoil (propellant) in EU-27 (as of Jan 1st of each year)

Source : DG Taxation and Customs Union[454]

Within the period 01/2022 till 01/2024, excise tax rates on gasoil have been very volatile (as seen in Figure 224). While a large drop-tendency was in the year 2022 (actions taken against rising prices), they started to increase again since January 2023 (at different pace for each EU country).

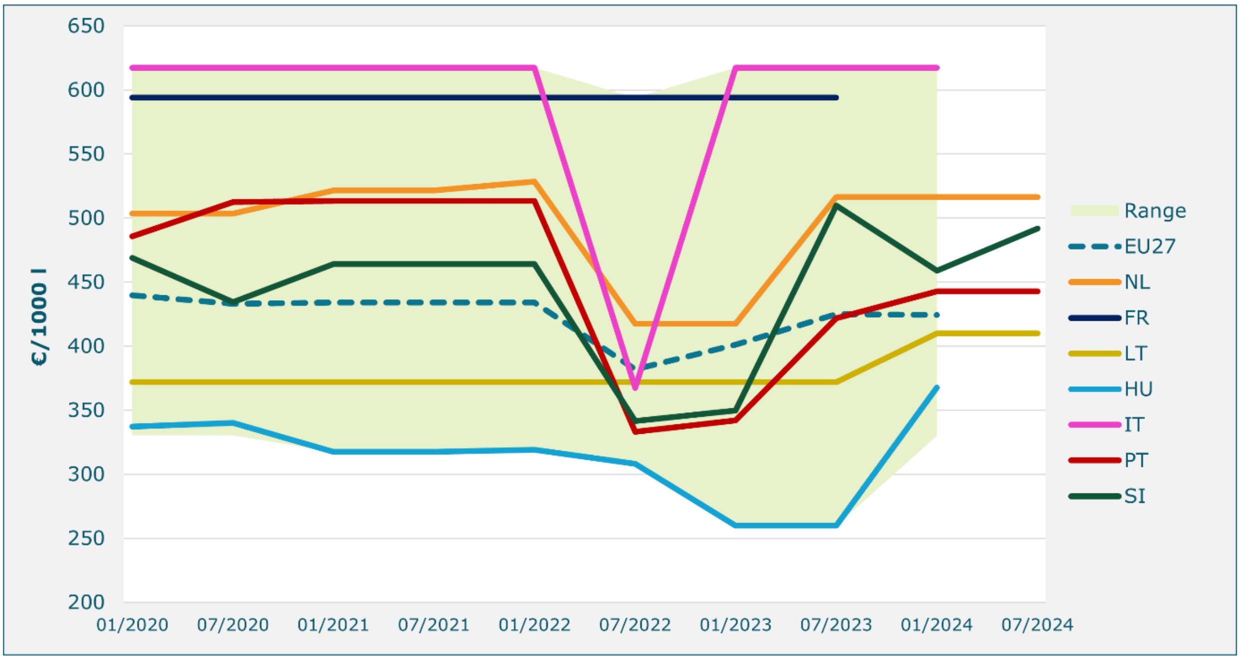


Figure 224: Excise tax rate for Gasoil (propellant) in EU-27 (6 month steps) between 2020-2024

Source : DG Taxation and Customs Union[455]

[454] European Commission (2024). Taxed in Europe Database v4
[455] European Commission (2024). Taxed in Europe Database v4

Excise duty rates on electricity

The electricity excise duty rate is the highest for non-business use (i.e. private households) on average in EU-27 since 2008 (cf.

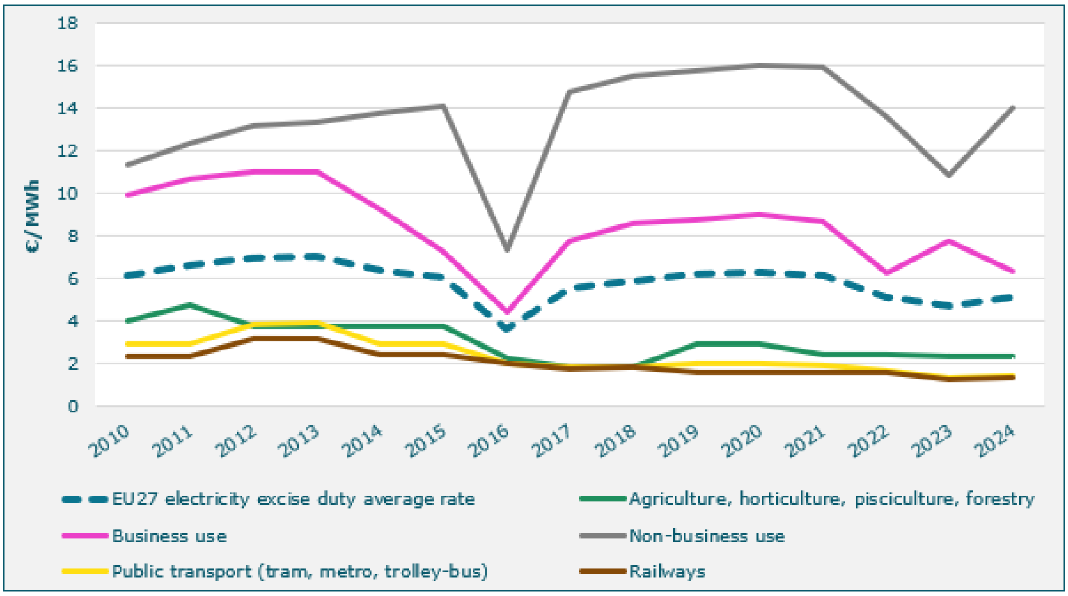
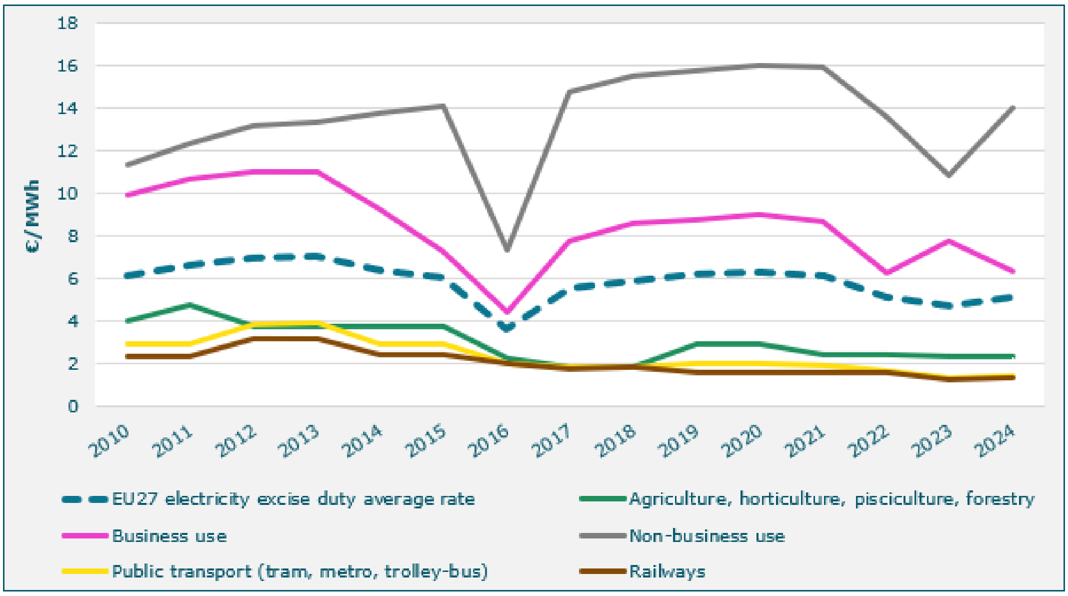


Figure 225



). The second highest excise rates are applied to electricity used for businesses (i.e. industry, construction, trade and services). The least taxed sectors for electricity are the transport sector (railways, public transport), as well as agriculture.

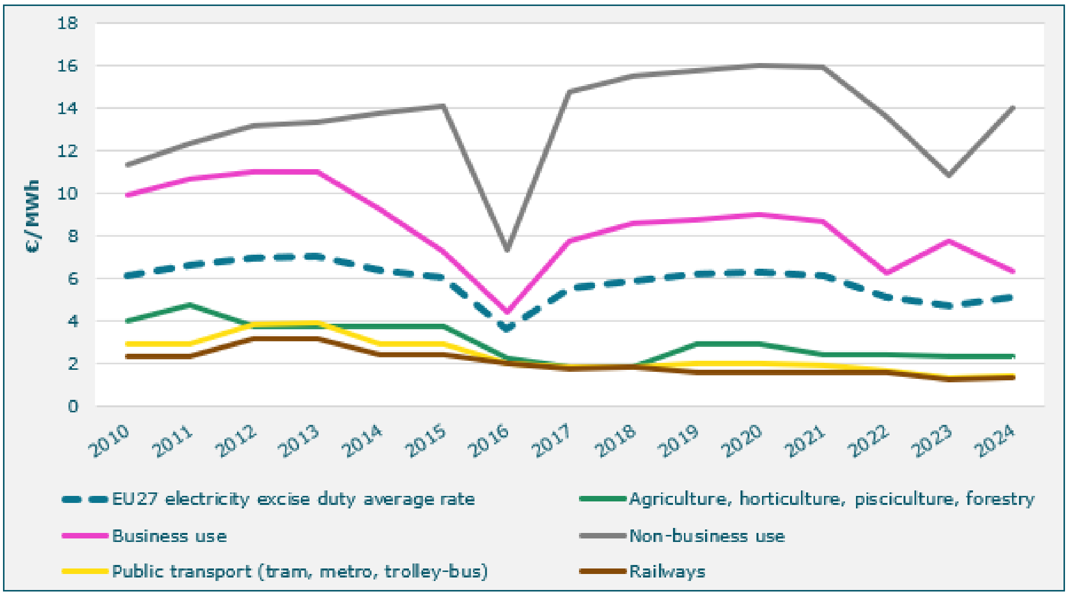
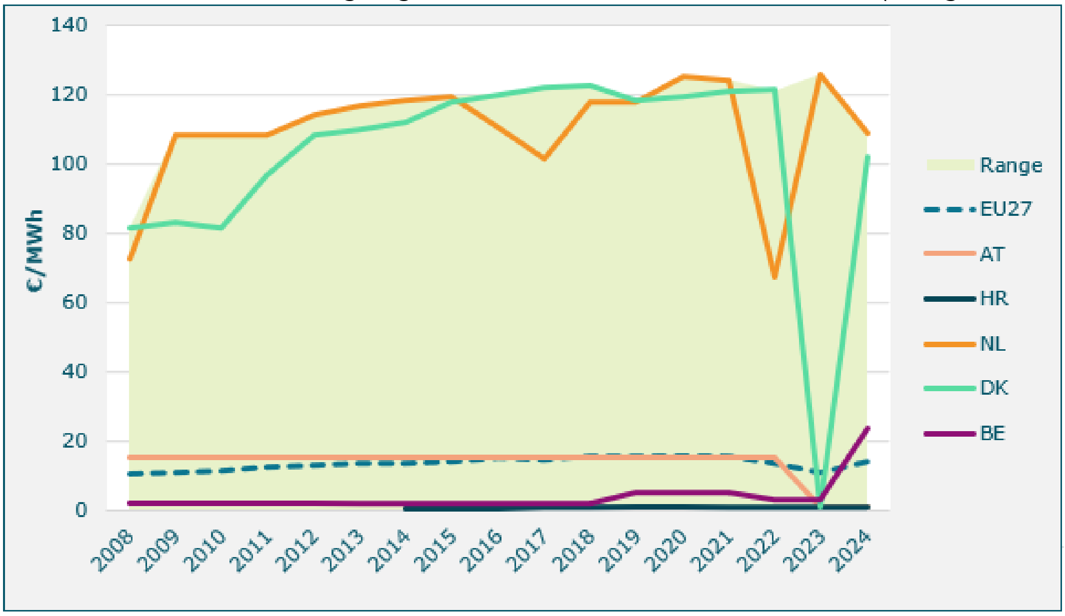


Figure 225: *Average excise duty rates for electricity by ETD class in the EU-27 (Jan 1st of each year)*

Source : DG Taxation and Customs Union[456]

[456] European Commission (2024). *Taxed in Europe Database v4*

The excise duty rate on electricity for residential users (non-business use) in the EU-27 increased by 53% between 2008 and 2021 going from 10.4 EUR/MWh to 15.9 EUR/MWh (cf. Figure 226



). On average for the EU-27, the excise duty rate strongly decreased between 2021-2023 (-31.8%). This decrease was led by 8 MSs to offset the increasing prices of electricity.

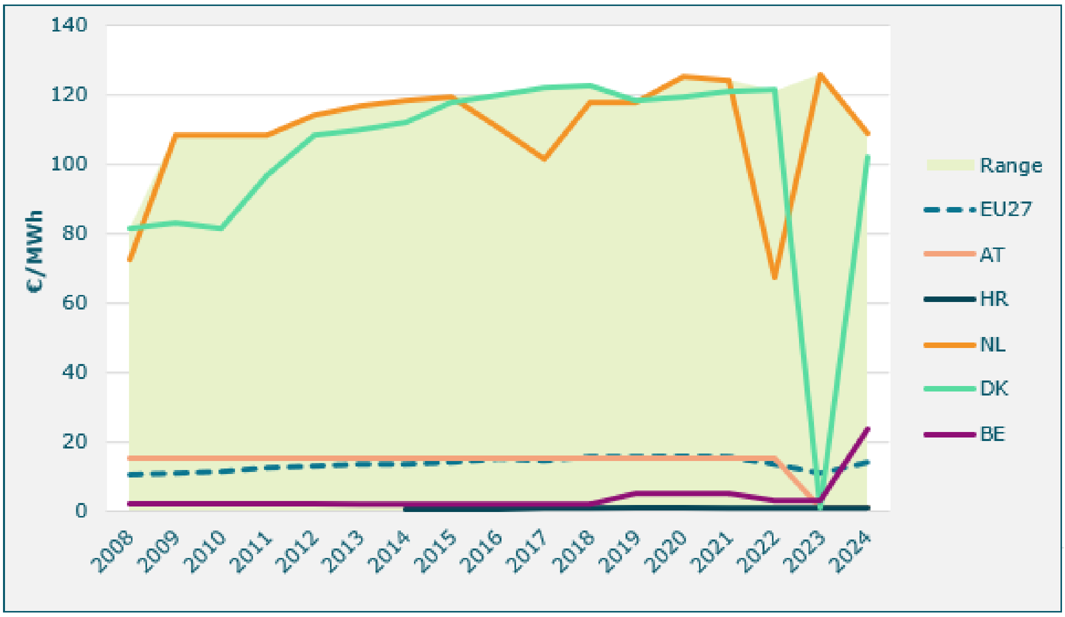


Figure 226: *Excise duty rates for electricity (non-business use) in EU-27 (as of Jan 1st of each year)*

Source : DG Taxation and Customs Union

As of 1 January 2024, excise duty rates on electricity increased (back close to 2021 levels) on average by 29.5% in the EU-27 as 7 countries increased their rates. Countries which increased their rates most were: Denmark (from 1 EUR/MWh to 102 EUR/MWh)[457], and Belgium (from 3 EUR/MWh to 24 EUR/MWh).

[457] *"From 1 October 2022, the general electricity tax was reduced by EUR 0.5/kWh, then reduced to €0.11/kWh in first half 2023. The scheme is valid for 12 months." Source: https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices*

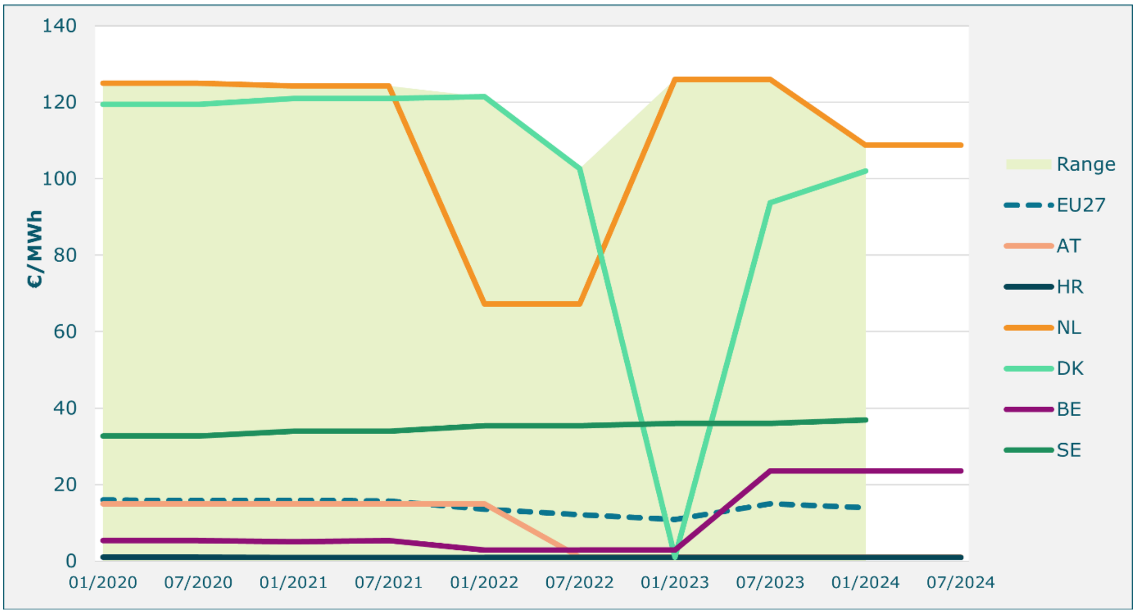


Figure 227: *Excise duty rates for electricity (non-business use) (6 month steps) for 2020-2024*

Source : DG Taxation and Customs Union[458]

[458] European Commission (2024). *Taxed in Europe Database v4*

Excise duty rates on natural gas

Natural gas used as a propellant has the highest excise duty rate on average since 2008 and has been varying between EUR 1.77/GJ and reached a peak in 2018 at EUR 3.38/GJ (cf. Figure 228). The fuel is mostly used for heating[459] in Europe. Excise duty rates on gas for heating purpose for non-business use and business-uses have the lowest excise duty rates, with respectively: EUR 2.15/GJ and EUR 2.54/GJ in January 2024.

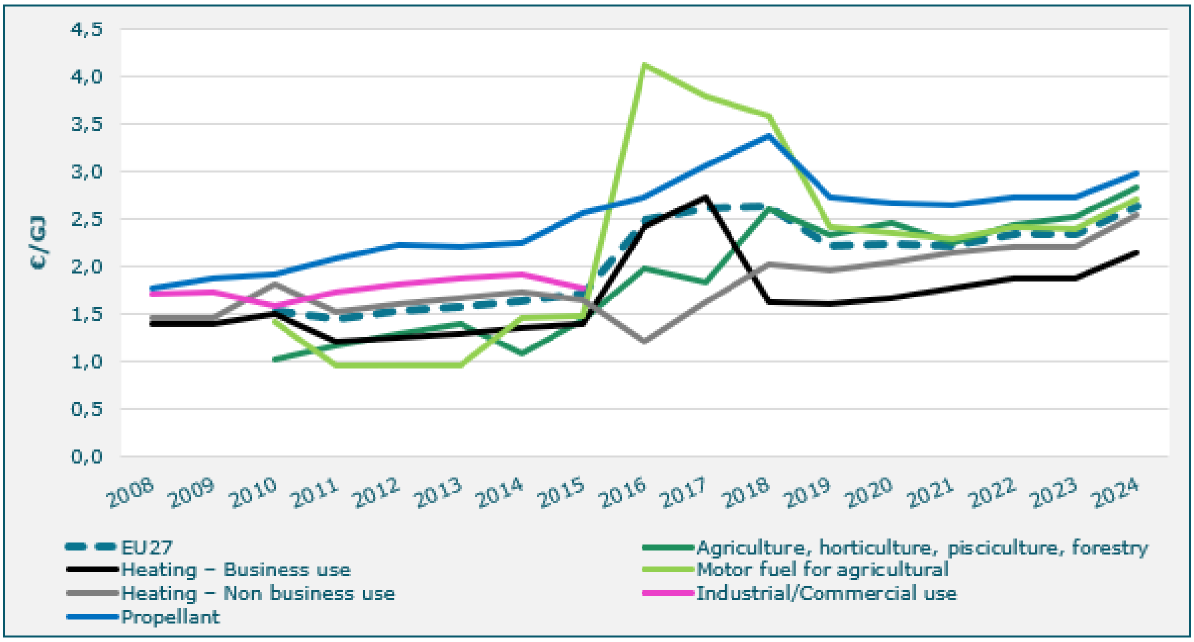


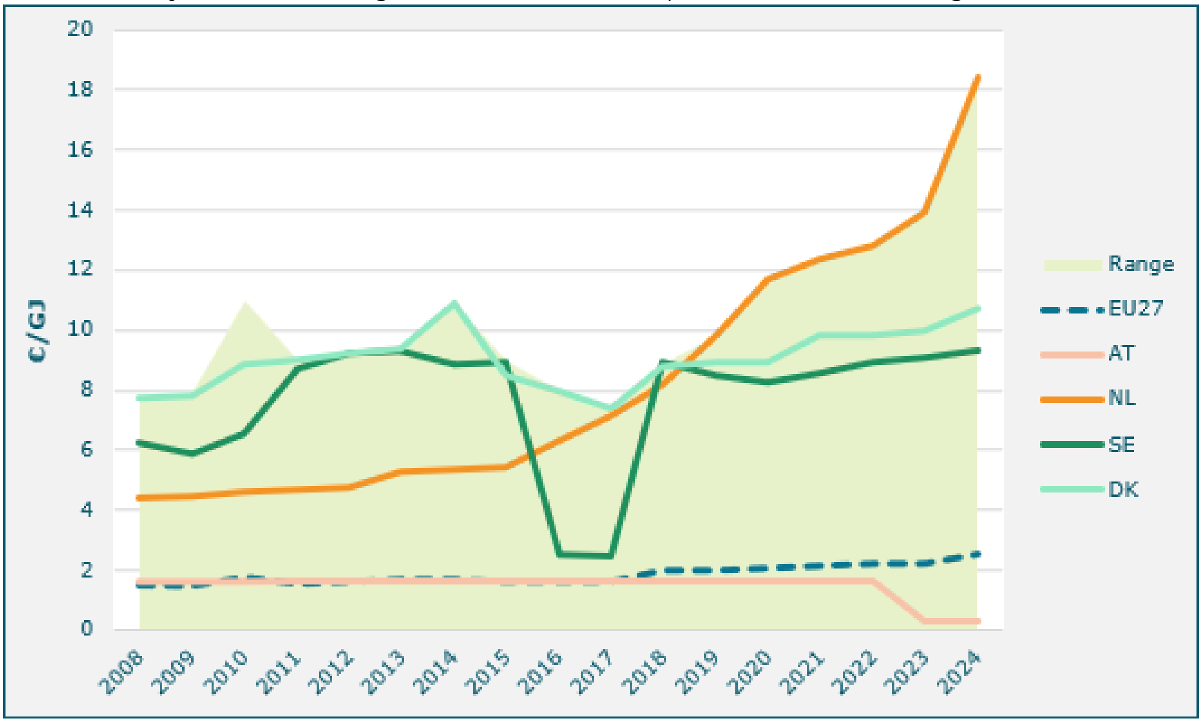
Figure 228: *Average excise duty rates for natural gas by ETD class in the EU-27 (Jan 1st each year)*

Source : DG Taxation and Customs Union[460]

[459] In 2022 over 30% of EU households were heating using natural gas (i.e. around 25.5% of total gas consumption)- source: https://www.consilium.europa.eu/en/infographics/eu-gas-supply/#:~:text=In%202022%2C%20the%2027%20countries,EU%20are%20heated%20using%20gas.

[460] *European Commission (2024). Taxed in Europe Database v4*

The excise duty rate on natural gas for residential users (non-business use, cf. Figure 229



) on average for the EU-27 increased by 51% between 2008 and 2023 going from 1.5 EUR/GJ to 2.2 EUR/GJ. Contrary to excise duty rate on electricity, gasoil and gasoline, only 5 MSs decreased their excise rate between 2020 and 2023, namely: Austria (from 2 to 0 EUR/GJ), Belgium (from 0.4 to 0.3 EUR/GJ), Estonia (from 2 to 1 EUR/GJ), and Hungary (from 1 to 0 EUR/GJ).

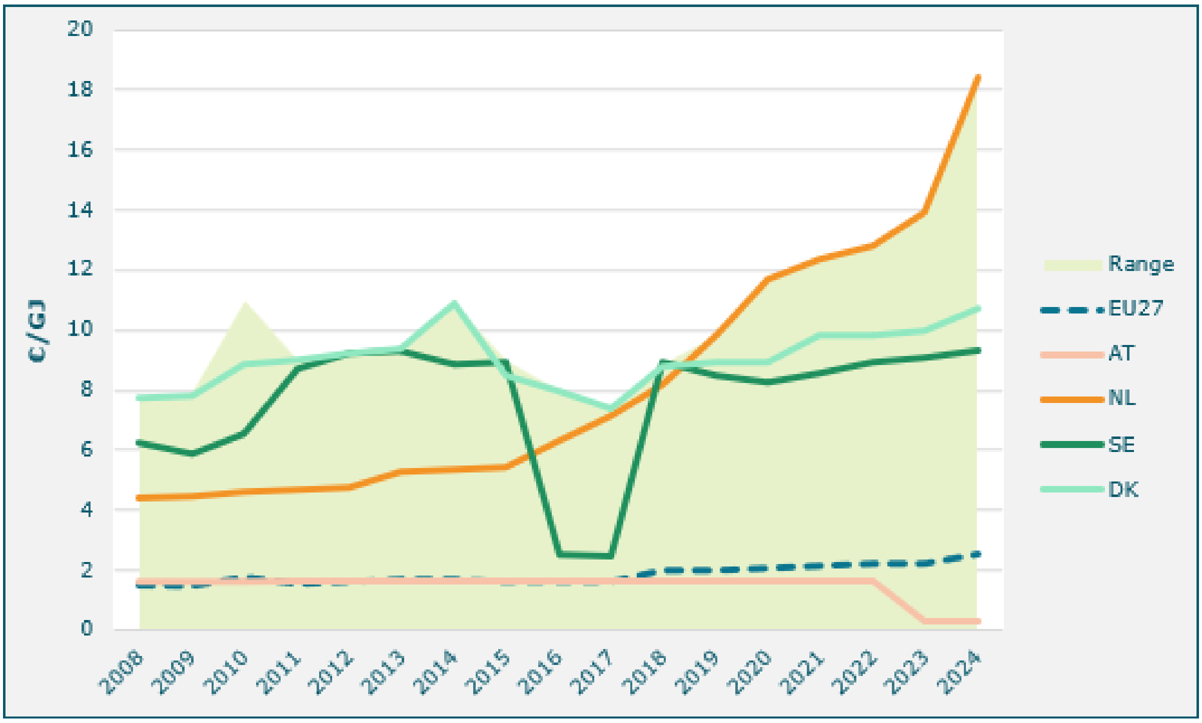


Figure 229: *Excise duty rates for natural gas - heating (non-business use) EU27 (Jan 1st each year)*

Source : DG Taxation and Customs Union[461]

The average EU-27 excise duty rate on natural gas increased by 14% in January 2024, led by Portugal (+110% from 1.7 to 3.5 EUR/GJ), and the Netherlands (+32% from 13.9 to 18.4 EUR/GJ) (Figure 230).

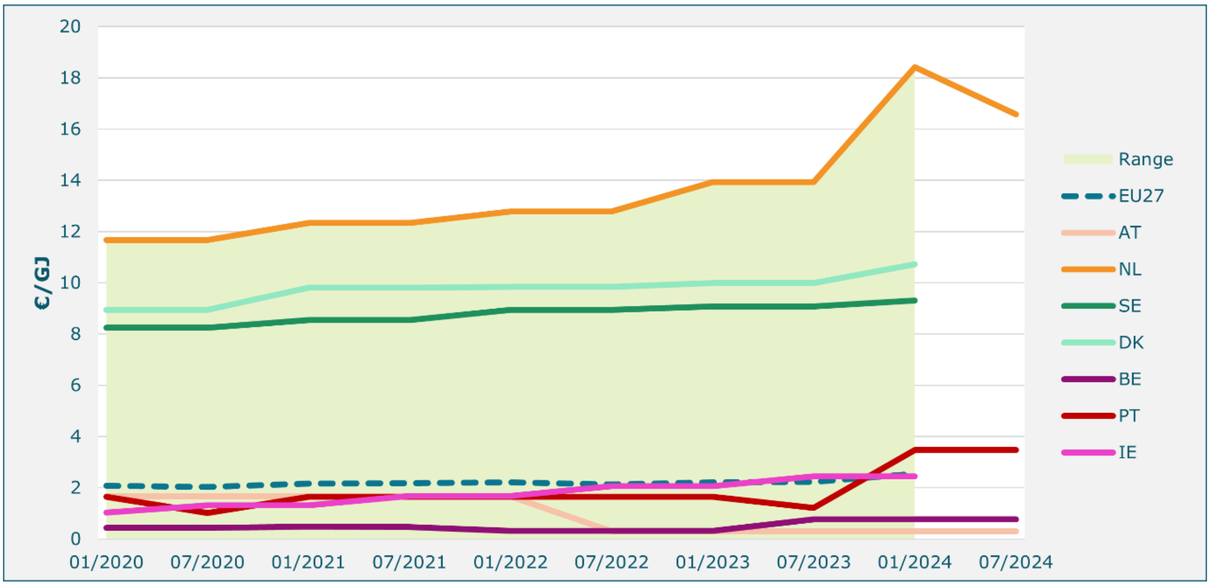


Figure 230: *Excise duty rates for natural gas - heating (non-business use) EU-27 (6 month steps)*

Source : DG Taxation and Customs Union[462]

[461] *https://ec.europa.eu/taxation_customs/tedb/*
[462] *https://ec.europa.eu/taxation_customs/tedb/*

As seen in the previous graphs, the Netherlands is one of the EU-27 countries with the highest excise duties rates on unleaded petrol, electricity, and natural gas. The national choice is set to encourage Dutch population to use energy more efficiently by making energy more expensive[463].

On the other hand, Hungary sticks to minimum fuel excise duties rates to attract investments[464]. Also, the country's rates are set in Forint, resulting in an average rate slightly below the EU minimum after exchange rate fluctuations[465]. It is also interesting to note that while the country offers a low excise tax environment, it also levies the highest VAT rates to counter-balance revenues (cf. Part 8.5.).

Box H: *Coal excise duty taxation in the EU-27*

As of end 2022, coal domestic consumption in the EU-27 reached 476 Mt (a large decrease compared to 700 Mt in 2010). Four countries covered 3/4 of this consumption, namely: Germany (171 Mt, i.e. 36%), Poland (113 Mt, i.e. 24%), Czechia (39 Mt, 8%), and Bulgaria (36 Mt, 8%).

A common element to EU countries is the main usage of coal for power generation. In Germany, 86% (144 Mt) of the coal consumed is used in power plants, 82% (92 Mt) in Poland, 80% (32 Mt) in Czechia, and 90% (32 Mt) in Bulgaria. To analyse coal excise duty taxation, its use for power generation will be excluded here (as to avoid double taxation issues, coal used for power generation is not taxed as final electricity produced is taxed).

In Germany, coal in final consumption (excluding its use for power generation) has decreased by 19% since 2010, from 21 Mt to 17 Mt. It is nearly exclusively used for industries (16 Mt, 99%) - mostly in the steel industry - the remaining 1% is used in the residential and tertiary sector. In Poland, coal in final consumption (excluding its use for power generation) decreased by 38% since 2010, from 24 Mt to 15 Mt. It is used in the residential sector (8 Mt, 57%), and in the steel production industry (6 Mt, 43%). In 2021, around 21%[466] of Polish households used coal for space heating.

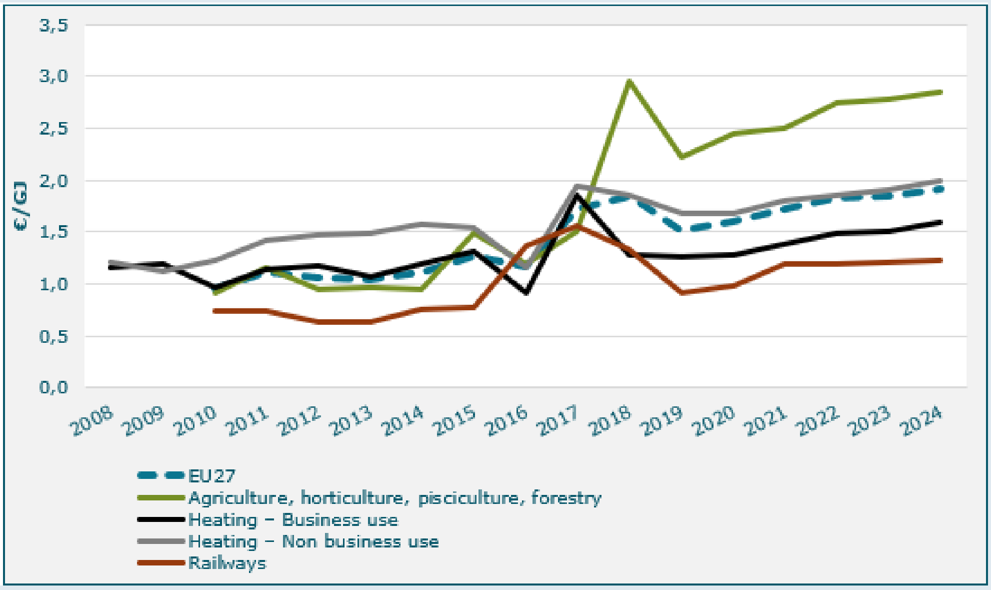


Figure 231: Coal excise duty rates in the EU-27 (as of Jan 1rst each year)

[463]*https://www.government.nl/topics/environmental-taxes/energy-tax#:~:text=The%20government%20wants%20people%20to,people%20to%20use%20less%20energy.*

[464] *https://www.reuters.com/markets/europe/hungary-still-opposed-job-killing-global-minimum-tax-orban-says-2022-12-02/*

[465] *https://taxfoundation.org/data/all/eu/gas-taxes-in-europe-2022/*

[466] *https://stat.gov.pl/en/topics/environment-energy/energy/energy-consumption-in-households-in-2021,11,2.html*

Source: DG Taxation and Customs Union[467]

In Europe, countries cannot set excise taxes for coal below 0.15 0EUR /GJ for business use and 0.30 EUR /GJ for non-business use. In Poland, the excise tax stands at 0.30 EUR /GJ, and 0.33EUR /GJ[468] in Germany (for both business and non-business uses).

While coal is taxed differently according to its energy related end-use, very few is indeed consumed. Coal is no longer used for transportation in Europe. Agriculture has also stopped using coal, except for Poland, which used 1 Mt in 2022. Few countries still use coal for residential purposes (Poland, 7 Mt; Czechia, 1.6 Mt). Industry is the main user of coal, but it is not taxed as an energy source, rather as a chemical feedstock, which explains why this sector is not included in Figure 231.

As in Europe coal is primarily used for power generation (80% of EU-27 coal consumption in 2022) and the steel industry (10% of EU-27 coal consumption in 2022), which are both excluded from coal excise duties (as taxed as electricity and non-energy use product), the revenue from coal excise taxes is very low or even insignificant in the EU-27 (it represents 0.4% of total excise revenues in 2022).

Towards an update of the Energy Taxation Directive?

As part of ongoing changes to the treatment of fossil fuels, the EU is moving towards the adoption of a new regime for energy taxation, but not without difficulties. Indeed, although the text was proposed in 2021, its adoption remains highly uncertain to date considering divergent positions amongst Member States. This programme, called the updated Energy Taxation Directive (ETD), will set new minimum rates for fuel taxation across the EU. These changes are explained in greater detail below in the Box I, but the broad implications are that minimum rates will more closely reflect a fuel's level of pollution per unit of energy, rather than the other economic, social and political factors which governed the existing taxation regime.

[467] European Commission (2024). *Taxed in Europe Database v4*
[468] *European Commission (2024). Access2Markets*

Box I: *Changes to the Energy Taxation Directive*

The ETD scheme has formed the basis of regulating energy taxes in the European Union for 20 years without significant revision, nor adjustment for inflation[469].

In June 2021, a proposal to update this regime started the legislative process to become EU law. This new proposal is intended to have three effects on minimum tax rates for all Member States: base unit, change in the scope, and intent of the tax regime.

1) The base unit of taxation will shift from volumetric measures (litres, kilogrammes) to energy content (GJ). While these two units are related, the change towards real energy content is designed to prioritise efficiency improvements and incentivise transitions away from the most polluting fuels.[470]

2) Change of scope mainly entails the creation of a set of four fuel "types" depending upon their level of emissions. Rather than having a specific rate for petrol vs. diesel, these types of carbon intensive fuels will have their minimum rates at an equal level. This categorisation system is intended to help with incentivising fuels with lower environmental impact. The four types currently proposed are further disaggregated based on 3 usage categories (propellants, motor fuel for non-road uses, and heating fuel). An example is listed below of minimum rates for propellants (along with % change compared to current minimums)[471]:

- EUR 10.75/GJ – Petrol (+2%), Gasoil/diesel (+22%), Kerosene (+23%), Non-sustainable biofuels
- EUR 7.17/GJ – Liquid Petroleum Gas (+47%), Natural gas (+176%), Non-sustainable biogas, Non-renewable fuels of non-biological origin
- EUR 5.38/GJ – Sustainable biofuels/biogas
- EUR 0.15/GJ – Low-Carbon Fuels (renewable fuels of non-biological origin, advanced sustainable biofuels/biogas)

*** Note: several "transition" fuels will have their minimum rates gradually increased in the 10 years following the directive's commencement, e.g., natural gas will rise from EUR 7.17 to EUR 10.75 between 2023 and 2033.

3) The overall intent of this new regime is to align the taxation system with the green transition and environmental goals of the EU. Notably, the proposed ETD specifically introduces fuel taxation for fishing, maritime shipping, and aviation sectors for the first time, which have been slower in their decarbonisation efforts, with fuel tax exemptions playing a role alongside larger technical challenges.[472]

8.5. Value Added Tax (VAT)

VAT imposed on energy products is another important source of government revenue.

The VAT is a general consumption tax imposed on the value added to goods and services. It applies to practically all goods and services (including energy products) that are bought and sold for use or

[469] Council Directive COM/2021/563 (EC). EUR-Lex Database2021. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0563
[470] Council Directive COM/2021/563 (EC). EUR-Lex Database2021. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0563
[471] DRAFT REPORT on the proposal for a Council directive restructuring the Union framework for the taxation of energy products and electricity (recast). Available at: https://www.europarl.europa.eu/doceo/document/ECON-PR-719624_EN.pdf
[472] Council Directive COM/2021/563 (EC). EUR-Lex Database2021. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0563

consumption in the EU. The VAT is borne ultimately by the final consumer; companies can reclaim the VAT they pay on the products and services they use as an input. VAT is charged as a percentage of the price (including taxes, duties, levies and charges, other than the VAT itself), which means that an increase in price will entail an increase in the VAT, and inversely.

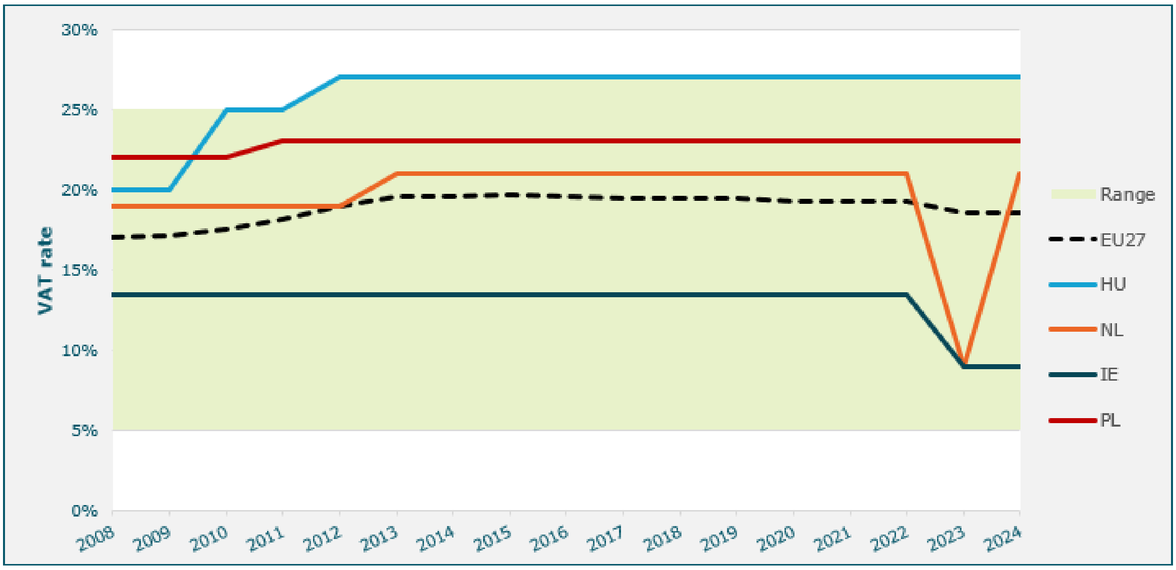
The VAT Directive (2006/112/EC)[473] requires that the standard VAT rate must be at least 15% and Member States can apply one or two reduced rates of at least 5%, but only to goods or services listed in Annex III of the Directive (energy products are not in the list). In addition, there are multiple exceptions to the basic rules (usually with conditions/ deadlines), including:

- possibility of reduced rates for goods and services other than those listed in the directive (e.g. Article 102 allows the use of reduced rate to the supply of natural gas, electricity and district heating, "provided that no risk of distortion of competition thereby arises");
- several country-specific exceptions, including the permission to use "super reduced" rates under 5% (including zero rates) for certain (including energy) products.

In December 2021[474], EU finance ministers agreed to update the current rules governing VAT rates for goods and services. These new rules[475] came into force in April 2022 and are meant to provide governments with more flexibility in the rates they can apply and to ensure equal treatment between EU Member States. MSs can reduce VAT rates on goods and services from their standards rates to their reduced rates (reduced rates must not be below 5%). The updated legislation brings VAT rules in line with common EU priorities such as fighting climate change, supporting digitalisation, and protecting public health.

[473] Council Directive (2006). 2006/112/EC on the common system of value added tax
[474] European Commission (2021). New rules on VAT rates offer Member States more flexibility while supporting the EU's green, digital and public health priorities
[475] Council Directive (2022). (EU) 2022/542 amending Directives 2006/112/EC and (EU) 2020/285 as regards rates of value added tax

The average EU-27 VAT rate for electricity remained quite stable between 2013 and 2022 (cf. Figure 232)[476].



Since the beginning of 2022, various countries (including Poland, Belgium, the Netherlands, Ireland, and Luxembourg) decreased their rates to fight rising electricity prices (Figure 233).

Belgium reduced its VAT rates from 21% to 6% in July 2022; the reduction was supposed to be temporary, but since 1 April 2023, this measure has become permanent for individuals. Belgian small businesses have seen the rate go back up to 21%[477].

Ireland's VAT temporarily dropped to 9% since May 2022, and this reduction will continue until end of October 2024; it is expected to then return to its previous rate of 13,5%[478].

Luxembourg and the Netherlands also reduced their rates in 2023 but increased their rates again in January 2024: from 7% to 8% (Luxembourg); and down from 21% (2022) to 9% (2023) and back to 21% (January 2024) for the Netherlands.

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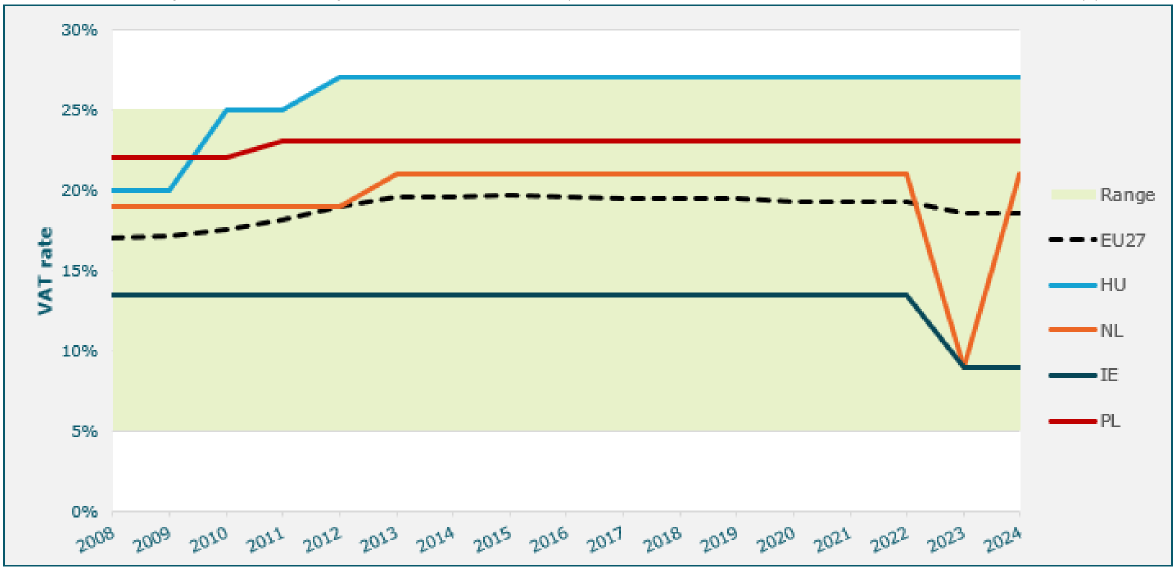
[476] *For clarity sake only the most representative MSs were selected to appear in*



.6/112/

[477] *Enerco, 2023 "Baisse de la TVA de 21 à 6%"*

[478] *KPMG Ireland, 2023 "VAT registration threshold"*

The average EU-27 VAT rate of 18.5% in January 2024 (Figure 233) for electricity hides huge differences. Since January 2024, Malta, Greece and Belgium have a rate of 5%, 6% and 6%, respectively, whereas Hungary has a rate of 27%, while Denmark, Croatia and Sweden have a rate of 25%.

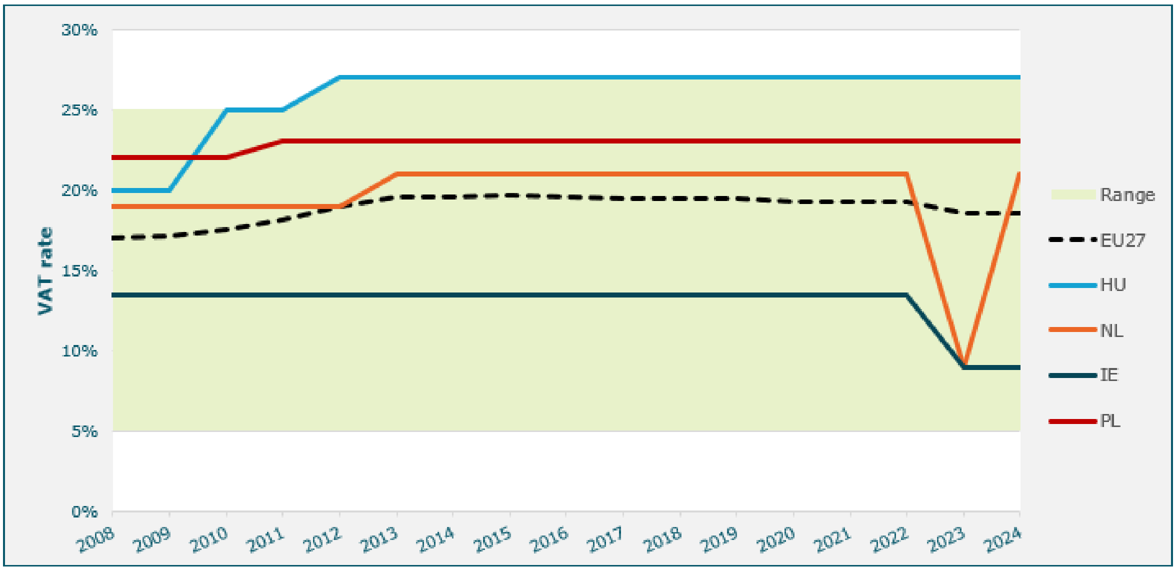


Figure 232:*VAT rates for electricity in the EU-27 since 2008 (as of 1st January each year)*

Source: DG Taxation and Customs Union

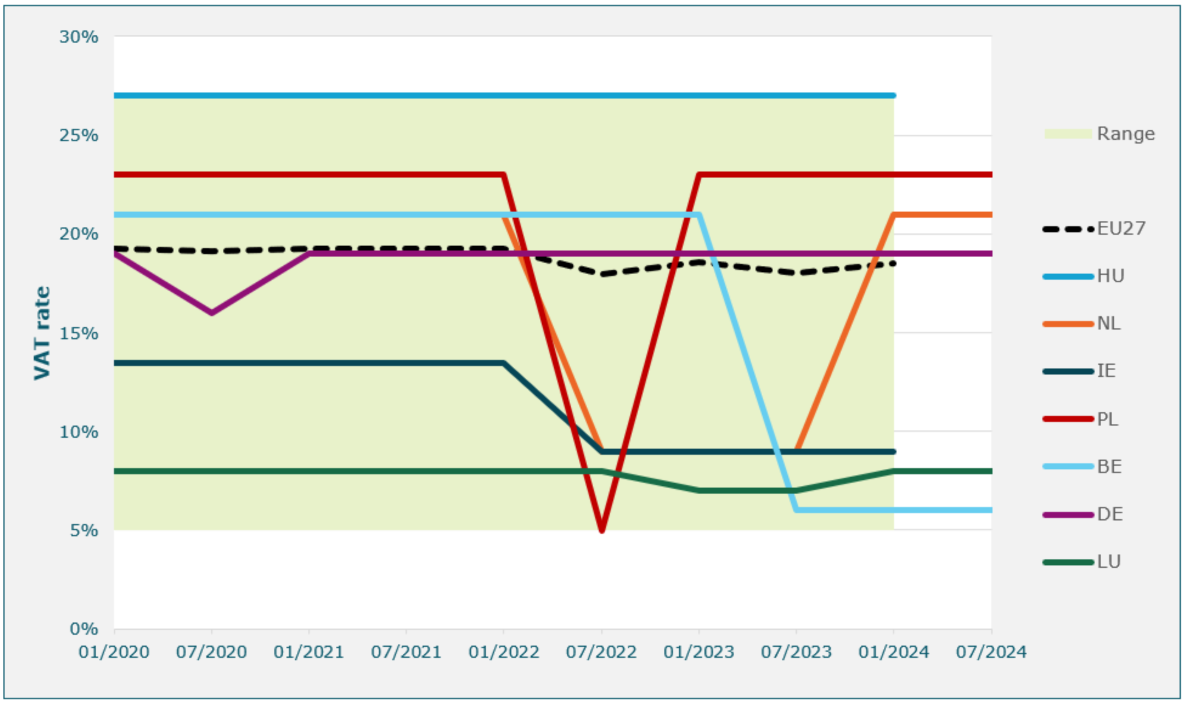


Figure 233: *VAT rates for electricity in the EU-27 (6 month steps) for 2020-2024*

Source: DG Taxation and Customs Union

The average VAT rate for natural gas in the EU-27 increased by 13% between 2008 and 2022 going from 16.6% to 19.7% (cf. Figure 234).

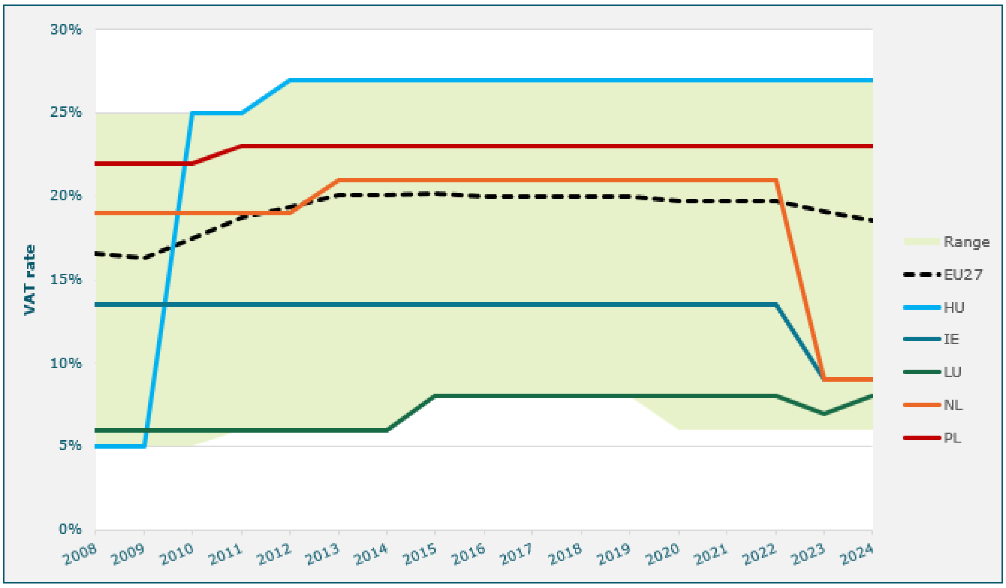


Figure 234: *VAT rates for natural gas in the EU-27 since 2008 (as of January 1st each year)*

Source: DG Taxation and Customs Union

From 2022 until January 2024, average VAT rates on natural gas in the EU-27 decreased by 1.4 percentage points, led by four countries which massively reduced their VAT to fight rising natural gas prices and inflation. Those four countries were Belgium (from 21% to 6%), Ireland (14% to 9%), Italy[479] (10% to 5%), and the Netherlands[480] (21% to 9%). In April 2023, the Belgian Chamber of Representatives gave the green light to the permanent VAT reduction to 6% for supplies of gas and electricity.

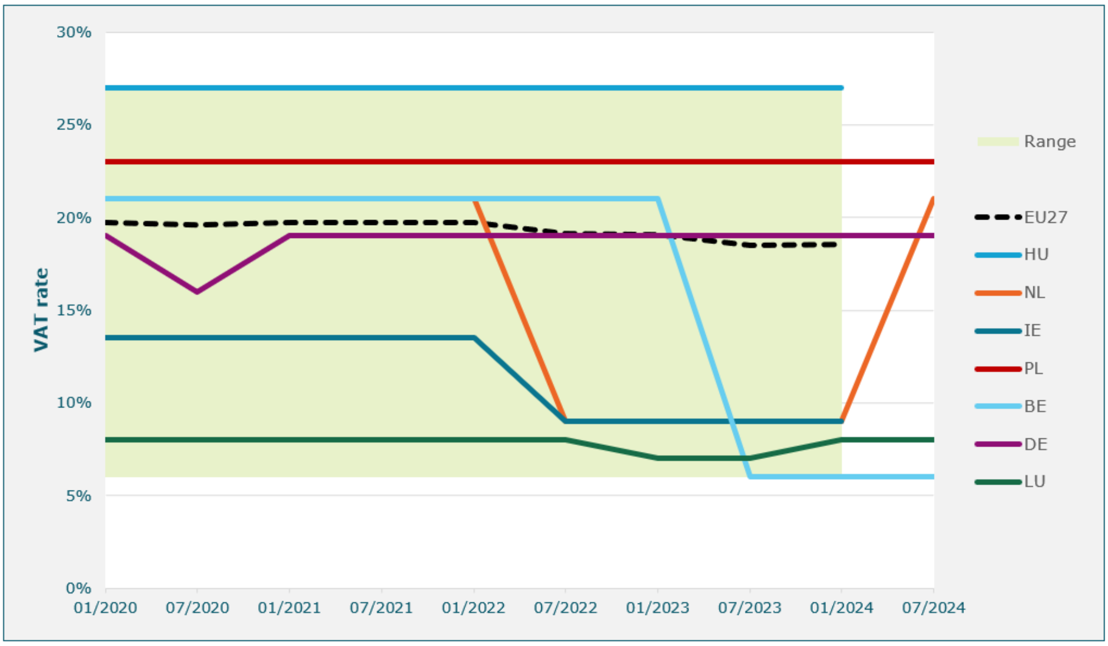


Figure 235: *VAT rates for natural gas in the EU-27 (6 month steps) for 2020-2024*

Source: DG Taxation and Customs Union

[479] *Global VAT Compliance, https://www.globalvatcompliance.com/globalvatnews/italy-vat-energy/*

[480] *KPMG (2023). https://kpmg.com/us/en/home/insights/2022/07/tnf-netherlands-temporary-reduction-vat-energy-excise-duties-fuel.html*

The average VAT rate for heating gas oil in the EU-27 went from 18.8% to 21.4% (cf. Figure 236) between 2008 and 1 January 2024. The range between Member States has remained stable since 2008 at around 13 percentage points. Only Luxembourg reduced its VAT on heavy fuel oil from 14% to 13% between 2022 and 2023, before increasing it again to 14% in January 2024. No other significant change on VAT rates for heating oil in the EU-27 has been identified since 2020.

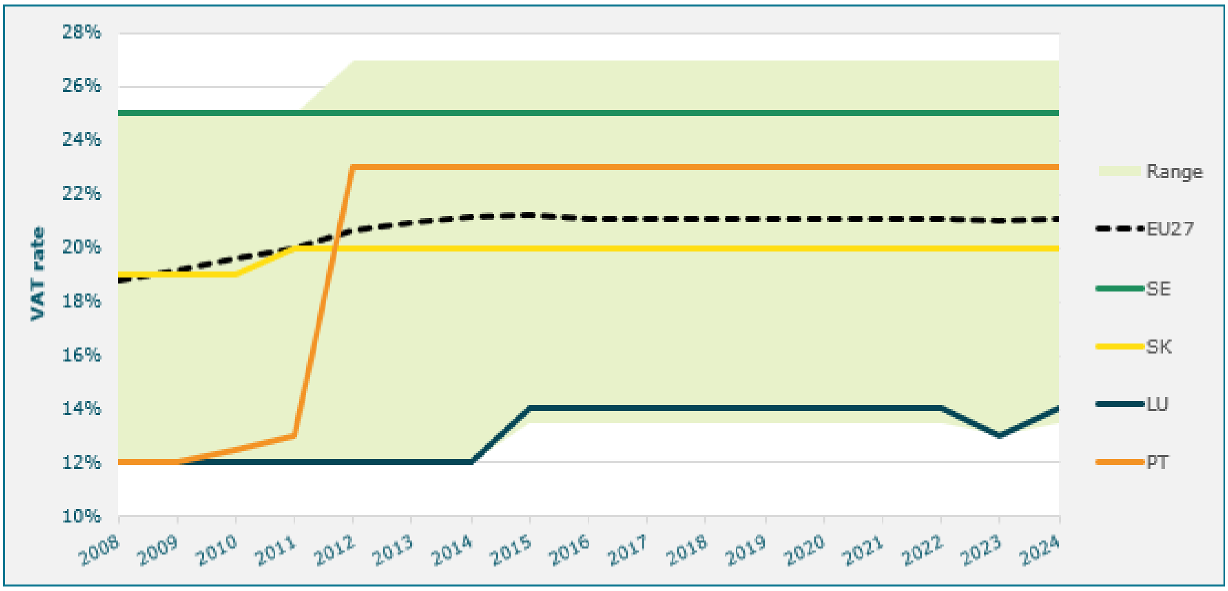


Figure 236: *VAT rates for Heating gas oil in the EU-27 since 2008 (as of January 1rst each year)*

Source: DG Taxation and Customs Union

The average VAT rate for diesel in the EU-27 increased from 19.6% to 21.5% between 2008 and 2013 and remained at this level until January 2024 (cf. Figure 237).

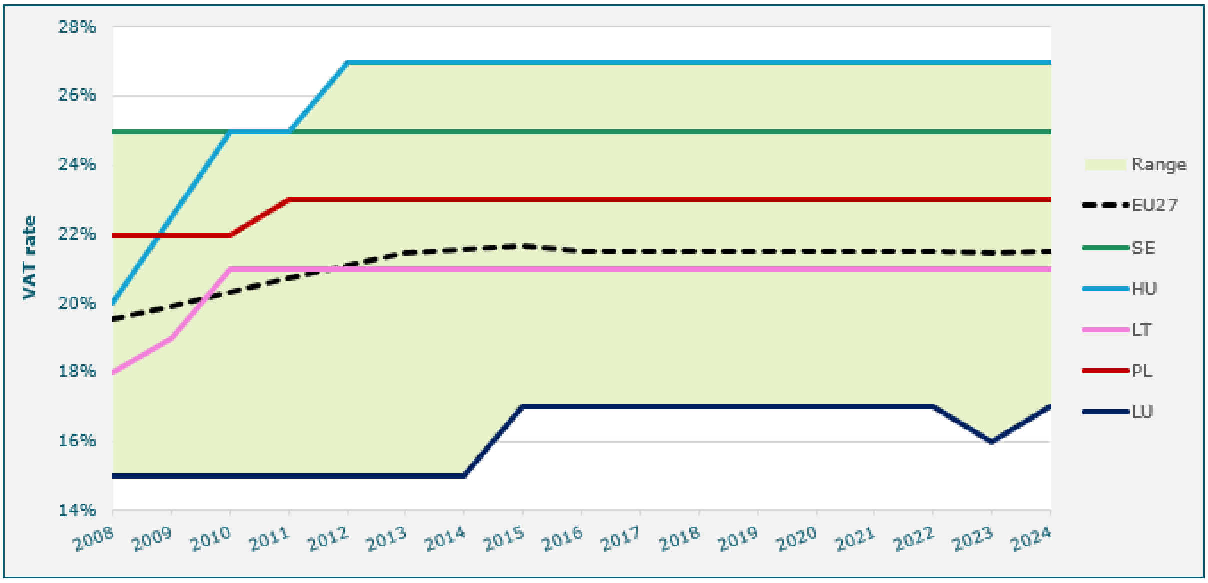


Figure 237: *VAT rates on Gas oil - propellant (diesel) & same rates for Euro-super 95 (gasoline) in the EU-27 since 2008 (as of January 1st each year)*

Source: DG Taxation and Customs Union

In 2022, Poland reduced the VAT on diesel through its Anti-Inflation Shield 2.0, going from 23% to 8%; then increased it back to 23% in 2023. Luxembourg reduced its VAT on diesel in 2023 from 17% to 16%, to then increase it back to 17% in January 2024 (See). The average VAT rate for Euro-super 95 in the EU-27 has evolved similarly to diesel rates since 2008.

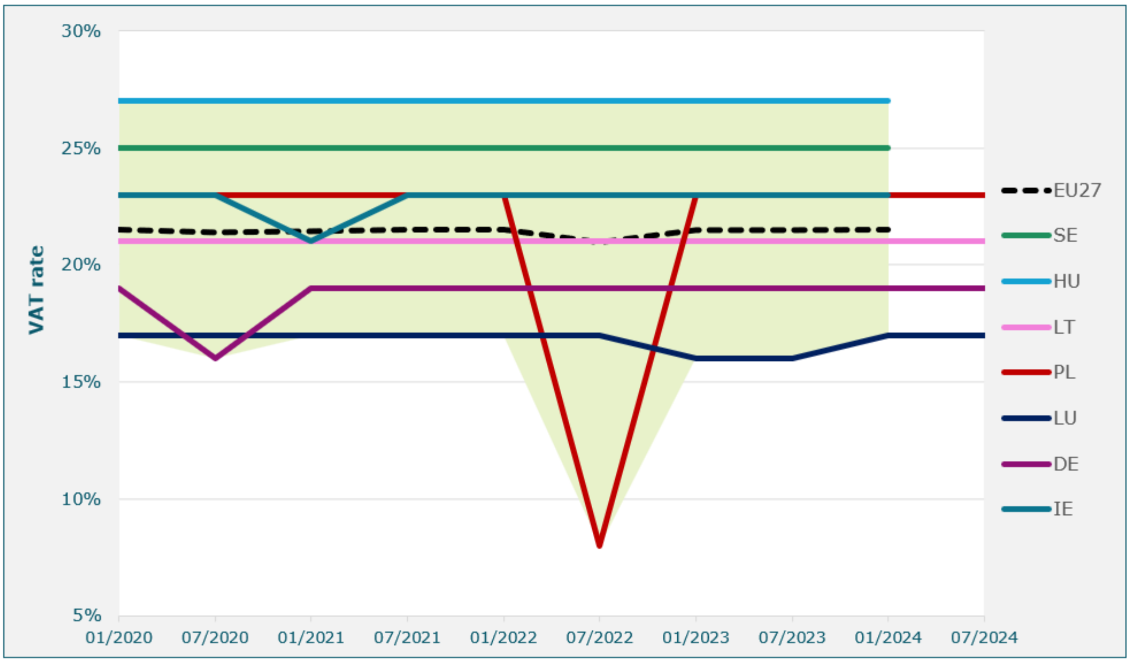


Figure 238: *VAT rates on Gas oil - propellant (diesel) & same rates for Euro-super 95 (gasoline) in the EU-27 (6 month steps) for 2020-2024*

Source: DG Taxation and Customs Union

As seen in Part 8.6. of this report, many VAT rates have been adjusted since 2021 as a means for Member States to fight rising energy prices to alleviate the financial pressure on households and stabilise the economy.

As seen in the different graphs in this part, most of the VAT rates adjustments were taken in the second semester of 2022 and aimed at electricity and natural gas (energies the most impacted by the energy price increase). While electricity VAT rates are starting to regain their prior-to-crisis level, natural VAT rates are maintained low even in beginning 2024.

8.6. Energy price inflation in the EU-27

This sub-part of the report analyses the evolution of inflation with the main questions: *How has inflation of energy price for households and industry evolved since 2008 and more specifically since 2021 in the EU-27? What were the main drivers of energy price inflation for households and industries since 2021 and how did Member States experience this price inflation?*

To answer these questions, a first part is dedicated to the evolution of energy prices' inflation for households, while a second part is dedicated to industry. In this section, the term "inflation" is often used as an abbreviation for "price inflation".

8.6.1. Analysis of inflation on households

The impact of inflation on households: consumer price inflation vs inflation on energy

To analyse the evolution of inflation for households, data on the Harmonised Index Consumer Price (HICP) indicator were used. The HICP indicator measures changes in the prices of goods and services that households purchase for consumption. It is "harmonised" as each EU Member State follows the same methodology, allowing comparisons[481]. The HICP indicator provides the official measure of consumer inflation in the Euro area and the EU.

As seen in Figure 239, between 2008 and 2019, household's global annual HICP[482] (all goods including energy: food products, passenger transports goods and services, health services and goods, energy, recreation and culture, education, insurance, equipment) increased steadily, while energy-products related HICP were more volatile.

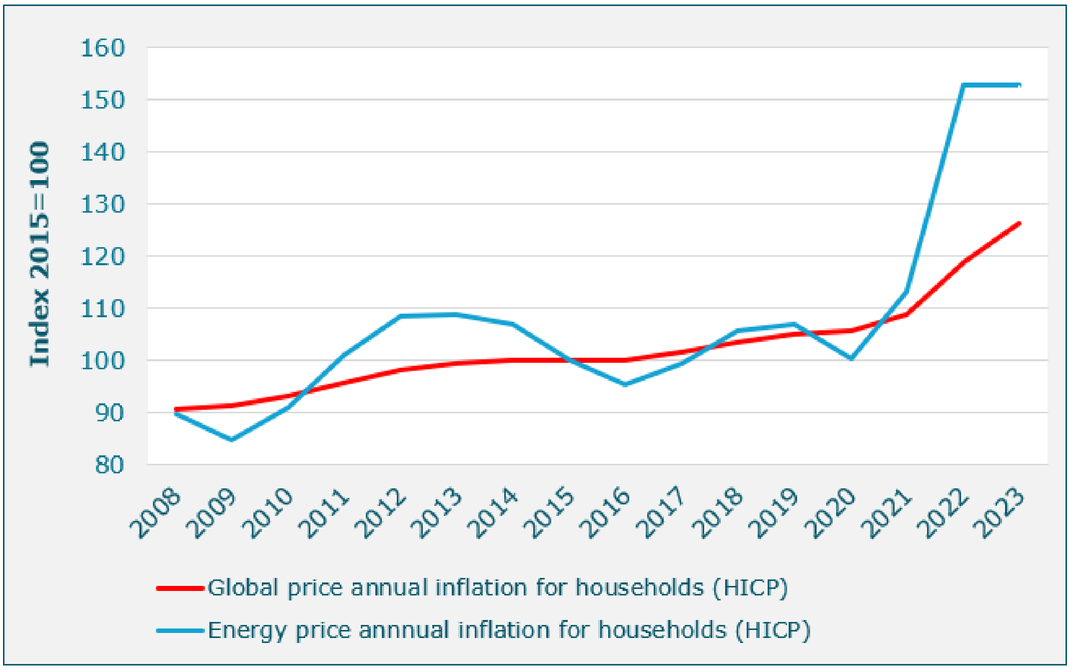


Figure 239: *Evolution of household's HICP against energy items in EU-27*

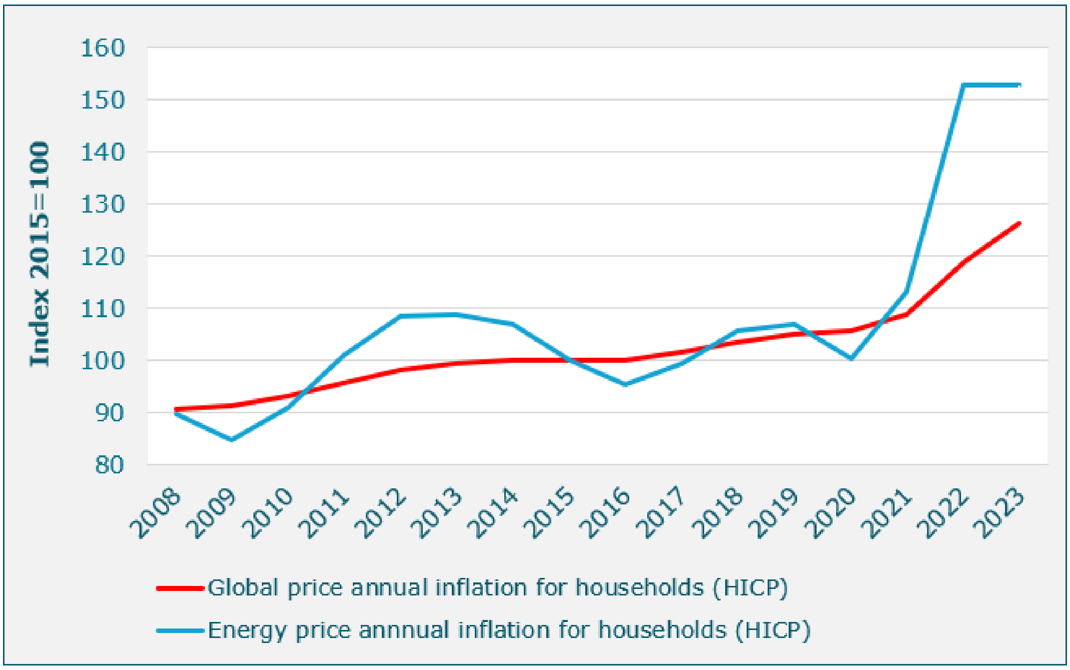
Source: Eurostat (HICP - annual data, average index and rate of change)

In 2020, annual energy-products HICP decreased due to the COVID-19 crisis and related collapse in oil prices in spring 2020[483].

From 2021, energy prices started to rise exponentially, as energy consumption returned to pre-COVID-19 levels, driven primarily by an increase in oil prices. In 2022, the inflation rate on energy reached its highest level since the HICP was first published in 1997.[484]

[481] *The harmonisation methodology for HICP is available here: HICP methodology - Statistics Explained (europa.eu)*
[482] *Annual inflation is the change of the price level of consumer goods and services between the current month and the same month of the previous year. Monthly inflation is the change of the price level between the current month and the previous month.*
[483] *Source: ECB 2021: "As a result of the coronavirus (COVID-19)-related collapse in oil prices in spring 2020, prices for personal transportation fuels also fell sharply – leading to a drop in energy inflation as large as that recorded during the 2009 financial crisis."*
[484] Eurostat (2022). *Energy inflation rate continues upward hike, hits 27%*

In 2023, energy-products HICP was 0 (i.e. energy-products related price inflation did not increase but prices remained at the high level observed in 2022) (Figure 239



) while total annual HICP (all goods including energy) for households continued to rise.

Since May 2023, energy is the only category for which monthly HICP started its decrease (cf. Table 46), whereas services, food, alcohol and tobacco's prices continued to increase. This decrease is consistent with a decrease of wholesale electricity and gas prices since December 2022. It is also consistent with the price-based measures introduced by governments to contain changes in consumer's purchasing power over time (including VAT or excise duties reductions).

Table 46: *Euro area monthly HICP by category (in percentage points, monthly)*

	12/22	01/23	02/23	04/23	06/23	08/23	10/23	12/23	01/24	02/24
Food (incl. alcohol & tobacco)	2.88	2.94	3.10	2.75	2.35	1.98	1.48	1.21	1.13	0.79
Non-energy industrial goods	1.70	1.73	1.74	1.62	1.42	1.19	0.90	0.66	0.53	0.42
Energy	2.79	2.17	1.64	0.37	-0.57	-0.34	-1.46	-0.68	-0.62	-0.36
Services (excl. goods)	1.83	1.81	2.02	2.21	2.31	2.41	1.97	1.74	1.73	1.73

Source: Eurostat (HICP - contributions to euro area annual inflation)

Energy HICP evolution in the EU 27 since 2008, by energy product

In this subsection, EU-27 price inflation evolution will be analysed using the HICP of four different energy products from 2008 to 2023: liquid fuels, electricity, natural gas and heat energy[485].

Following the 2008 energy crisis, households experienced greater price volatility on liquid fuels compared to other energy products. As shown in Figure 240, from 2008 to 2021 gas, electricity and heat energy HICPs followed similar trends, rising and falling simultaneously and at comparable levels. HICP for liquid fuels exhibited similar patterns over time but with greater amplitude.

Between 2020 and 2022, the spike in energy price inflation was mainly driven by liquid fuels and natural gas, followed by electricity and heating. In 2022, liquid fuels HICP reached record levels of 182 (+102% compared to 2020, while gas HICP hit 166). The price of oil experienced significant increases[486], mainly due to OPEC+ production cuts and a surge in global demand following the post-COVID-19 economic rebound. In comparison between 2020 and 2022, electricity price inflation rose by 44% reaching 153 and heat energy price inflation increased by 24% reaching 128.

Higher gas prices in 2022 could be explained by the European gas storing objectives before the 2022 winter in the context of the war in Ukraine. Storing gas represents a significant cost, which is largely passed on users' bills[487].

In 2023 all energy products' HICP remained high (50% higher than 2020's inflation level). Gas prices declined in the second half of 2023, resulting mostly from lower raw energy, supply and network costs[488]. Electricity HICP decreased as supply and network costs decreased in the second semester of 2023[489]. Electricity prices decreased in 2023, partly offset by the reduction or removal of consumer alleviation measures at national level[490].

[485] *Heat energy corresponds to Eurostat classification code "CP0455" which includes "hot water and steam purchased from district heating plants. Also includes: associated expenditure such as hire of meters, reading of meters, standing charges, etc. and ice used for cooling and refrigeration purposes" ShowVoc (europa.eu)*
[486] *European Central Bank, source: https://www.ecb.europa.eu/press/economic-bulletin/focus/2021/html/ecb.ebbox202103_04~0a0c8f0814.en.html*
[487] *Gas prices: what are the European solutions to limit their increase?*
[488] *Electricity and gas: EU prices decrease after 2022 surge - Eurostat (europa.eu)*
[489] *Electricity and gas: EU prices decrease after 2022 surge - Eurostat (europa.eu)*
[490] *Electricity and gas: EU prices decrease after 2022 surge - Eurostat (europa.eu)*

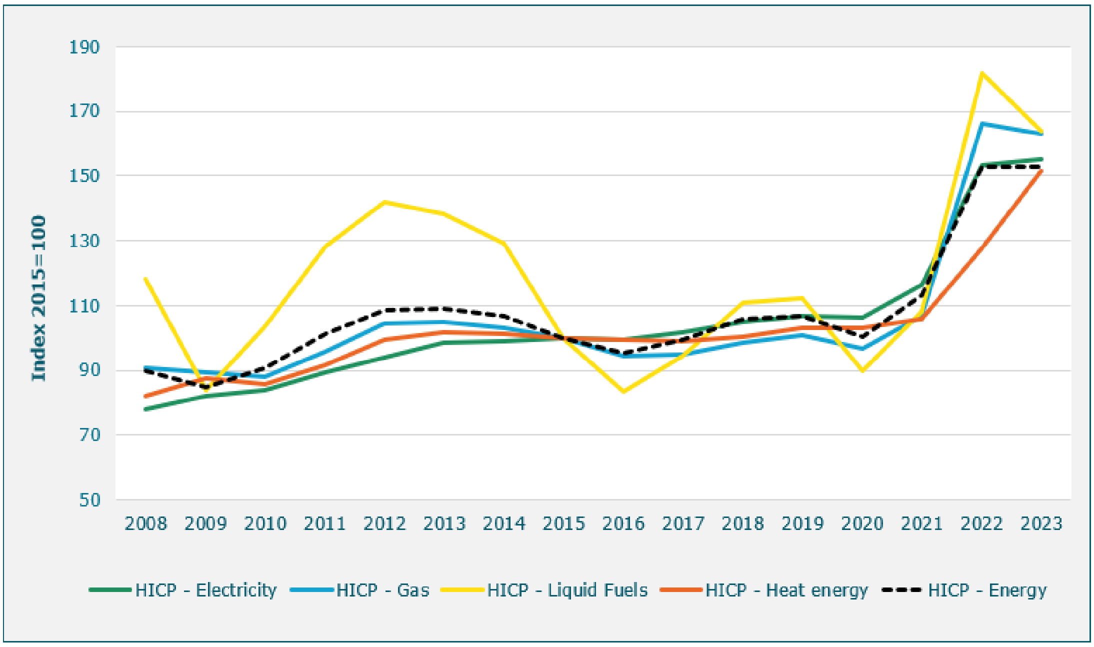


Figure 240: *HICP detailed by energy product in EU-27*

Source: Eurostat (HICP - annual data, average index and rate of change)

To conclude, from 2008 to 2023 liquid fuels emerged as the main driver of household energy price inflation compared to other energy products. Moreover, 2022 saw record-high levels for liquid fuels, electricity and gas HICPs since 2015.

Comparing 2020-2023 HICP evolution between Member States

In the three coming graphs (Figure 241, Figure 242 and Figure 243), HICPs on liquid fuels, natural gas and electricity were used to compare consumer price inflation in EU-27 Member States in 2020 vs 2023 (both years compared to a 2015 basis, i.e. Index 2015 = 100).

- **Liquid-fuels**

In 2020, liquid fuels HICP was fairly uniform across Member States and close to the EU-27 average. In 2023, it increased in all Member States however reaching different levels. As shown in Figure 241, in 2023 price inflation was above the EU-27 average in Poland, France, Finland, Denmark, and Austria, with liquid fuels HICP surpassing 170. On the other hand, price inflation in 2023 were contained (below 140) in Romania, Italy, Slovenia, and Cyprus.

To help citizens face rising prices, many MSs chose to subsidise fuels in 2022, mostly through tax reductions, but also through direct transfer to consumers (Greece and Sweden) or price caps (Hungary and Slovenia). Luxembourg, Bulgaria and the Netherlands implemented excise tax reductions on petrol and diesel[491]. Portugal froze the update of its carbon emissions tax addition.

Although fuel subsidies seemed necessary given the surge in energy prices, they represented a departure from recent trends in environmental policies. Several MSs introduced preventive measures to fight energy poverty and promote green transition, simultaneously. It includes e.g. grants, the promotion of the development of renewable energy or the creation of guidelines on ways to save energy. As such, Slovenia set maximum cooling and heating temperatures in the public sector to encourage energy savings through behavioural changes[492]; and Spain[493] implemented similar

[491] *Measures to lessen the impact of the inflation and energy crisis on citizens | European Foundation for the Improvement of Living and Working Conditions (europa.eu) ; EU PolicyWatch | European Foundation for the Improvement of Living and Working Conditions (europa.eu)*
[492] *How cold can it be in public sector offices? - N1 (n1info.si)*
[493] *All of the energy-saving measures decreed by the Spanish government (elnacional.cat)*

restrictions in administrative, commercial, and public buildings, along with restrictions on lighting hours and information-sharing campaigns[494].

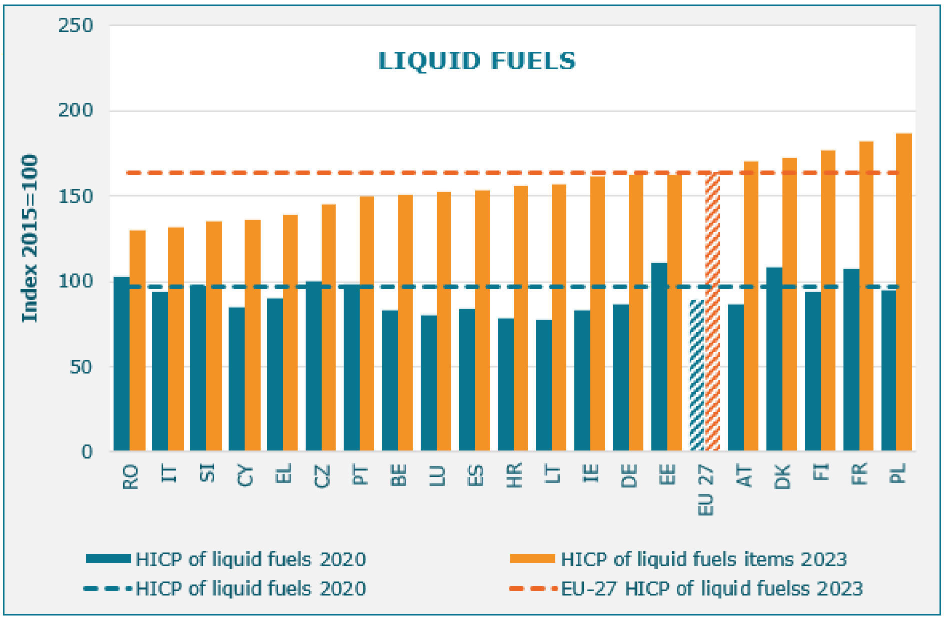


Figure 241: *HICP of liquid fuels across Member States in 2020 and in 2023*

Source: Eurostat (HICP, total -annual data)

- **Natural gas**

Regarding natural gas, in 2020 the HICP values dispersion across MSs was uniform and close to the EU-27 average as seen in Figure 242. In 2023, values dispersion increased significantly – from 10 to 16 – with a greater deviation from the EU-27 HICP average.

Austria recorded the highest inflation of gas prices with its HICP tripling to 273 and Ireland, Latvia and Romania followed with HICP roughly doubling to 200-230.

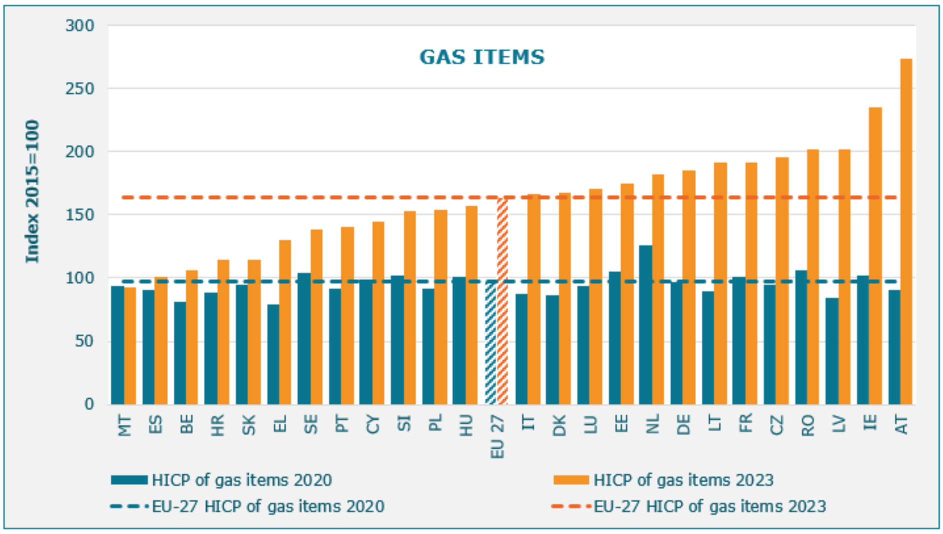


Figure 242: *HICP of gas across Member States in 2020 and in 2023*

Source: Eurostat (HICP, total -annual data)

[494] *Measures to lessen the impact of the inflation and energy crisis on citizens | European Foundation for the Improvement of Living and Working Conditions (europa.eu)*

- **Electricity**

With respect to electricity, MSs' HICP levels remained quite close to the EU average at 107 in 2020 (cf. Figure 243). In 2023, electricity HICP levels demonstrated high heterogeneity amongst MSs compared to liquid-fuels and gas. 11 MSs recorded a small increase of its HICP (reaching a level below 126), 10 MSs a medium increase (between 144 and 155) and 4 MSs a high increase (200 to 350). In 2023, electricity HICP in Estonia has more than tripled compared to the 2020 level. Similarly, the electricity HICP level doubled in Italy, Ireland and Czechia. On the other hand, no increases of HICP were recorded in 2023 compared to 2020 in Malta, Spain and Portugal.

Several factors can explain these HICP disparities: the national power mix, the proportion of taxes and provision of subsidies in final electricity price paid by households and the presence or absence of regulated tariffs[495]. For instance, with regards to subsidies, almost half of EU MS provided one-time direct subsidies to households' electricity bills in 2022: these ranged from up to EUR 120 in Hungary to EUR 800 in Denmark and up to EUR 800 in the Netherlands[496]. In these three countries electricity price inflation for households remained relatively stable between 2020 and 2023. With regards to taxation, some countries chose to significantly reduce their taxes - most commonly by reducing the VAT - on electricity prices or even implemented negative taxations. Thanks to negative taxes, in the first semester of 2023, Ireland reduced electricity prices by 41%, Luxembourg by 35% and Portugal by 27%. Finally, on the regulatory front, Malta used price regulations through its sole electricity company, ENEMALTA to contain electricity price inflation from 2020 to 2023. Portugal, Slovakia, and France also intervened through state-owned companies in the sector.

Box J: *The Iberian Exception*

The low HICP level recorded in 2023 compared to 2020 in Spain and Portugal (cf. Figure 243) can be partially explained by the introduction in May 2022 of an approved one-year price mechanism for reducing wholesale electricity prices on the Iberian Electricity Market (MIBEL) -also known as the "Iberian Mechanism"-.

The measure aimed for both countries to reduce the input costs of power plants by granting a subsidy to help cover their fuel expenses. The price cap was set at €40/MWh from June to December 2022, with an increase of €5 per month following the initial six months. The measure expired on 31 December 2023. This Iberian exception effectively contained prices for Iberian consumers (average spot prices in the Iberian market reached €149/MWh compared to €332/MWh without the cap), therefore it also caused an increase in exports from Spain to France (+1.6 GW compared to 2022) as prices were lower.

In a nutshell, while effectively containing high prices on final consumers, such a price cap also caused distorts market signals, increasing exports and gas demand during a supply crunch (and could create price volatility in other interconnected countries if installed in other EU countries).

In some countries, anti-inflation measures impacted environmental policies. In Austria, the contribution dedicated to the promotion of green electricity was suspended, and in Portugal, the update of the carbon emission tax addition was frozen. Conversely, Slovenia introduced lower taxes for producing electricity from renewable energy sources and through high-efficiency cogeneration, to reduce household's energy bills[497].

[495] *Source : What are electricity prices in Europe?*
[496] *Measures to lessen the impact of the inflation and energy crisis on citizens | European Foundation for the Improvement of Living and Working Conditions (europa.eu)*
[497] *Eurofound (2023). Measures to lessen the impact of the inflation and energy crisis on citizens*

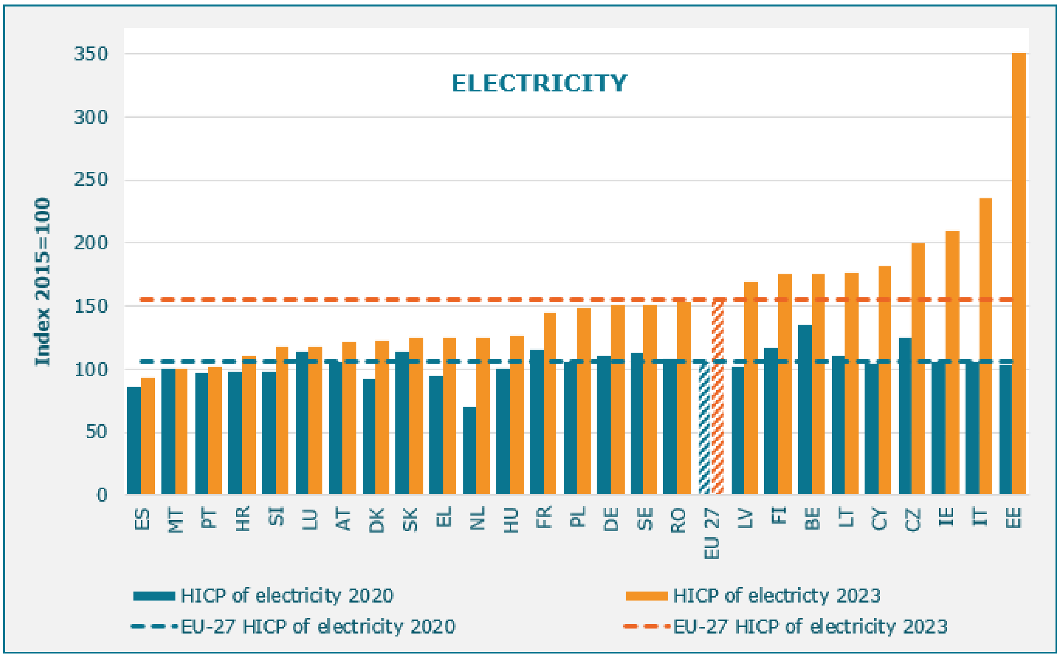


Figure 243: *HICP of electricity across Member States in 2020 and in 2023*

Source: Eurostat (HICP, total -annual data)

8.6.2. Analysis of the impact of inflation for the industrial sector

To analyse the evolution of inflation for industries, the Industrial Producer Price (IPP) index was used. The IPP index measures changes in the trading price of industrial products from the point of view of producers/manufacturers of a product[498]. The IPP reflects basic prices, which exclude VAT and similar deductible taxes directly linked to turnover. There are two sub-indices for the IPP index, one for the domestic market and one for the non-domestic market which are combined to give the change in the IPP for a given industry. IPPs track price movements prior to the retail level. Therefore, they may indicate subsequent price changes for businesses and households[499]. Usually, when IPP rises, HICP rises too, since manufacturers tend to pass on higher costs to consumers[500].

The terms "Whole industry sector IPP" and "Energy activities IPP" (which will be used in the coming section) are defined as follows:

- "Whole industry sector IPP" measures changes in the trading price of all industrial products coming from: 1) mining and quarrying activities, 2) manufacturing of food products, textiles, chemical products, machinery and equipment, etc, 3) as well as electricity, gas, steam, and air conditioning supply activities[501].
- "Energy activities IPP"[502] measures changes in the trading price of industrial products coming from the following energy activities: 1) mining of coal & lignite, 2) extraction of crude petroleum and natural gas, 3) manufacturing of coke and refined petroleum products, 4) electricity, gas, steam and air conditioning supply and water collection, treatment, and supply.

Between 2008 and 2019, the Whole industry sector IPP in annual rate of change has been steadily increasing (Figure 244). In comparison, Energy activities IPP[503] fluctuated during the period.

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[498] *Source: Industrial producer price index overview - Statistics Explained (europa.eu)*
[499] *Source: Industrial producer price index overview - Statistics Explained (europa.eu)*
[500] *Macro Micro, 2024. Source : https://en.macromicro.me/charts/17797/dif-ppi-cpi-euro*
[501] *Category "Industry [B-E36]" Statistics | Eurostat (europa.eu). See NACE codes as defined by Regulation (EU) 2020/1197*
[502] *Also named IPP of Main Industrial Grouping "Energy" or "MIG Energy" by Eurostat, with the same definition as follows.*
[503] *Also named IPP of Main Industrial Grouping "Energy" or "MIG Energy" by Eurostat*

In 2020 Energy activities IPP decreased due to the COVID-19. In 2021, annual Energy activities IPP started to increase, driven by higher energy consumption. In 2022, annual Energy activities IPP dramatically increased by 86% while the Whole industry sector IPP increased by 27%. Meanwhile, households energy HICP increased at a slower pace (by 35%) while total HICP increased by 9%.

In 2023, Energy activities IPP decreased by 14%, however, it remained two times higher than in 2020 while the Whole industry sector IPP stabilised.

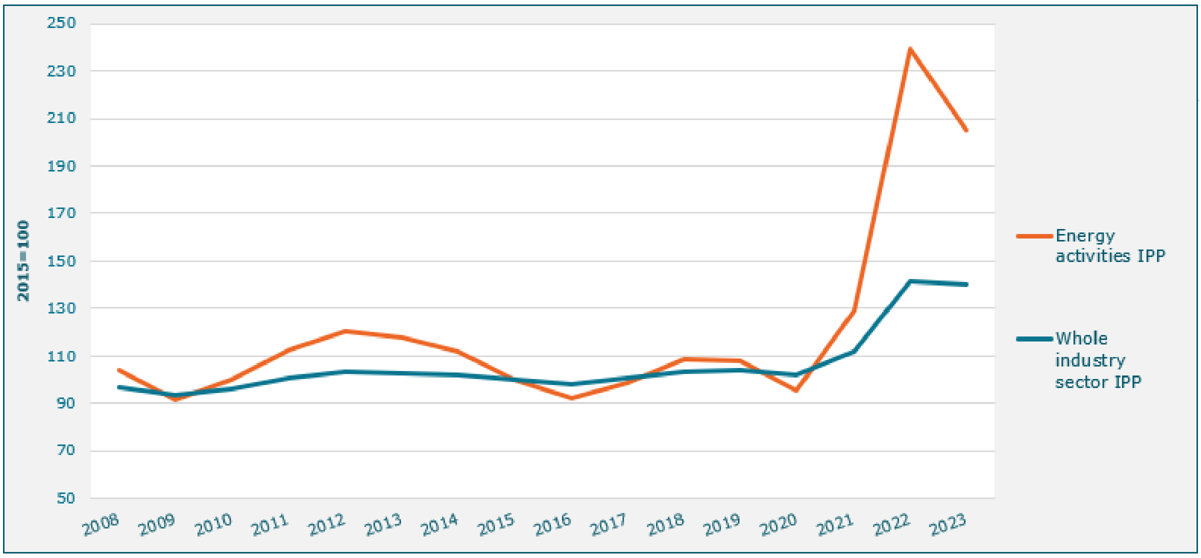

Figure 244: *Evolution of industrial producer prices on all items against energy items in EU-27*

Source: Eurostat (HICP - annual data, average index and rate of change ; IPP - annual data, average index and rate of change)

Comparing 2020-2023 energy IPP evolution between Member States

This subsection takes a deeper look at the Energy activities IPP for different MSs in 2020 vs 2023. The analysis could not be conducted for specific energy products due to missing data on the IPP of petroleum products, natural gas and electricity in each Member State.

In 2020, national Energy activities IPP were distributed quite uniformly across MSs, aligning closely with the EU-27 average. However, in 2023 IPPs varied significantly across MSs, increasing by a factor of 1.5 to 3.3. As shown in Figure 245, industrial manufacturers in Hungary, Romania, Denmark and Slovakia experienced the highest energy price inflation, with Energy activities IPP tripling (over 275) and nearly quadrupling in Denmark. On the other hand, Portugal, Greece, Austria and Bulgaria experienced the lowest price inflation, with their IPP remaining below 175.

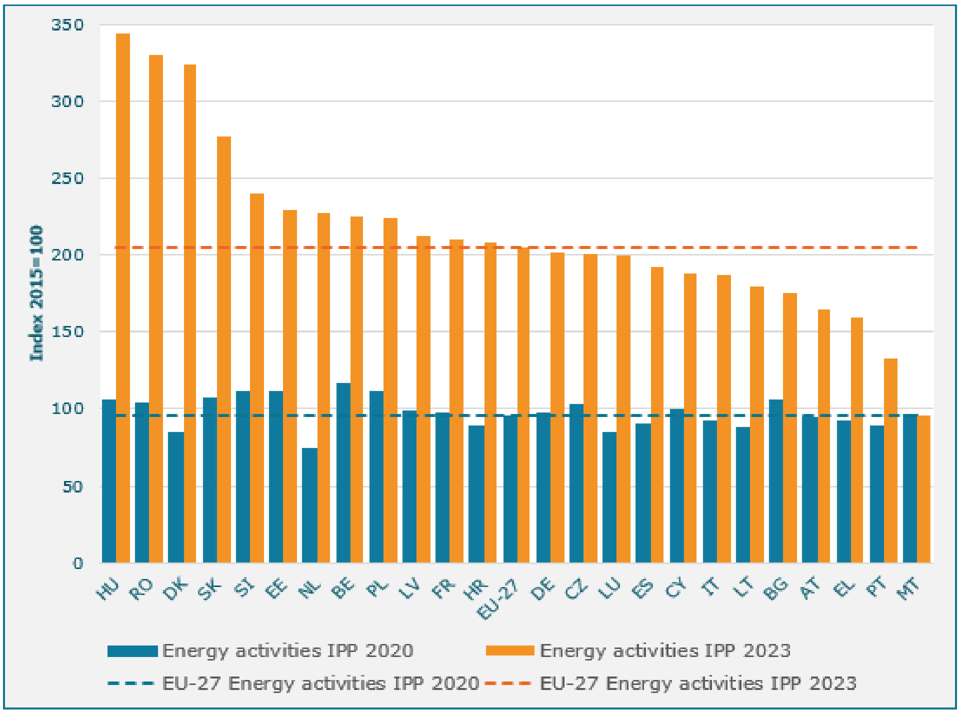

Figure 245: *Energy activities IPP across Member States in 2020 & 2023*

Source: Eurostat (IPP - annual data, average index and rate of change)

IPP of three main industrial energy activities' evolution in the EU 27 since 2008

In this subsection, a closer look will be given to the 2008-2023 evolution of IPP for three different industrial energy activities at different stages of the supply chain: 1) manufacturing of refined petroleum products, 2) extraction of natural gas, 3) and power generation, transmission, and distribution. These three categories are included (amongst other categories) in the "Energy activities IPP"[504] global Eurostat IPP database. Only these three categories were chosen to be analysed due to data missing[505].

As shown Figure 246, from 2008 to 2021 the IPP of manufacture of refined petroleum products and IPP of power generation, transmission and distribution, followed similar trends, rising and falling simultaneously at comparable levels. IPP of natural gas extraction decreased more significantly than other energy products between 2018 and 2020.

Between 2020 and 2022, IPP of natural gas extraction surged exponentially (+535%), reaching unprecedented levels (376 in index 2015=100). In 2022, the rising price of natural gas can be partly explained by the consequences of the war in Ukraine and of the European sanctions taken against Russia[506].

In 2023, the IPPs of these three industrial energy activities remained extremely high i.e. around two times higher than in 2020. However, IPP of natural gas extraction decreased largely whereas IPP of manufacture of refined petroleum products and IPP of power generation, transmission and distribution decreased to lesser extents. The decline in IPP of natural gas extraction occurred amid reduced cost of raw natural gas, supply, and network cost for the industry[507].

[504] As mentioned previously, Eurostat's broader category "Energy activities IPP" refers to "MIG energy.
[505] E.g. data was available for IPP of 'manufacture of refined petroleum products" but not for IPP of "Extraction of crude petroleum"
[506] 2023, Toute l'Europe - What are the electricity prices in Europe?
507 Electricity and gas: EU prices decrease after 2022 surge - Eurostat (europa.eu)

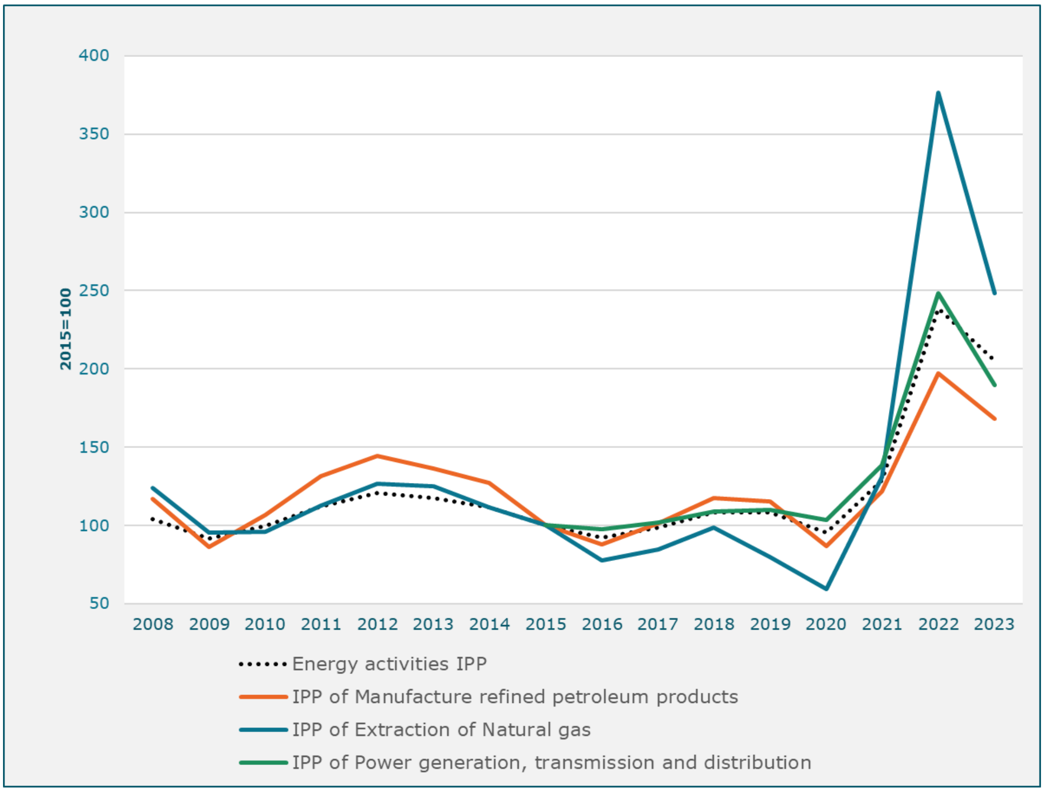

Figure 246: *IPP detailed by three industrial energy activities, as part of MIG Energy in EU-27*

Source: Eurostat (IPP - annual data, average index and rate of change)

To conclude, from 2008 to 2023, IPP of extraction of natural gas has shown greater volatility and had an important role in industrial energy price inflation since 2021, compared to the three other industrial energy activities.

Evolution of energy IPP compared to energy HICP in the EU-27 since 2008

Both average EU-27 industrial producer prices (IPP) and household inflation consumer prices (HICP) indexes followed quite similar trends[508] between 2008 and 2019 (as shown in Figure 247).

In 2022 the EU-27 average IPP on energy surged by +86% (to 239 index 2015=100) while average HICP on energy[509] increased by +35% (to 153 index 2015=100). In other words, since 2022 industrials experienced a higher inflation than households. This is partly explained by national fiscal measures[510] taken to protect households from energy price increases. These policies acted as a cushion but did not fully offset the impact of energy inflation[511].

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[508] *Comparisons between HICP and IPP has been studied previously here: https://en.macromicro.me/charts/17797/dif-ppi-cpi-euro*
[509] *The gap between HICP and IPP equaled to 16 index points in 2021 and 86 index points in 2022.*
[510] *Bruegel 2023, National fiscal policy responses to the energy crisis (bruegel.org)*
[511] *European Central Bank, 2022. Source: https://www.ecb.europa.eu/press/economic-bulletin/focus/2022/html/ecb.ebbox202207_04~a89ec1a6fe.en.html*

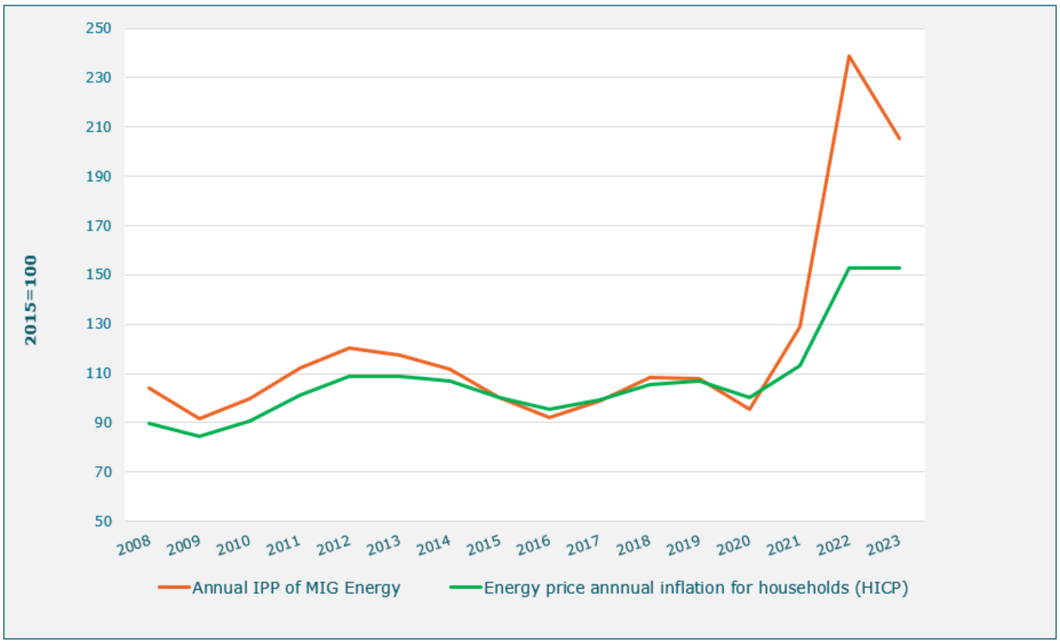


Figure 247: *Evolution of industrial producer prices against energy items in EU-27*

Source: Eurostat (HICP - annual data, average index and rate of change)

8.7. International comparisons

In order to compare EU MSs tax policies with their major trading partners, data on energy taxes were sourced from the OECD. Indeed, this institution provides data and indicators on energy taxes using definitions common to those of Eurostat -allowing 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, in addition to data for EU countries whose coverage is exhaustive, three neighbouring European countries in light blue (Iceland, Norway, and Switzerland [512]) and only five G20 countries in orange (Argentina, Türkiye, the United Kingdom, USA and Japan[513]) provide data. Consequently, other important trading 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, South Africa, Russia, Saudi Arabia, Canada, Australia, and South Korea.

2022 has been used as the reference year for comparisons as it is the latest reference year provided by the OECD.

According to latest data available, the situation is varied, with half of the countries recording an increase in real revenues from energy taxes, while the other half recorded a decrease between 2008 and 2022. Overall higher energy tax revenue evolutions were recorded for EU countries than for major G20 trading partners (cf. Figure 248).

[512] *Digit country codes namely: IS, NO, and CH.*
[513] *Digit country codes namely: AR, TR, UK, US and JP.*

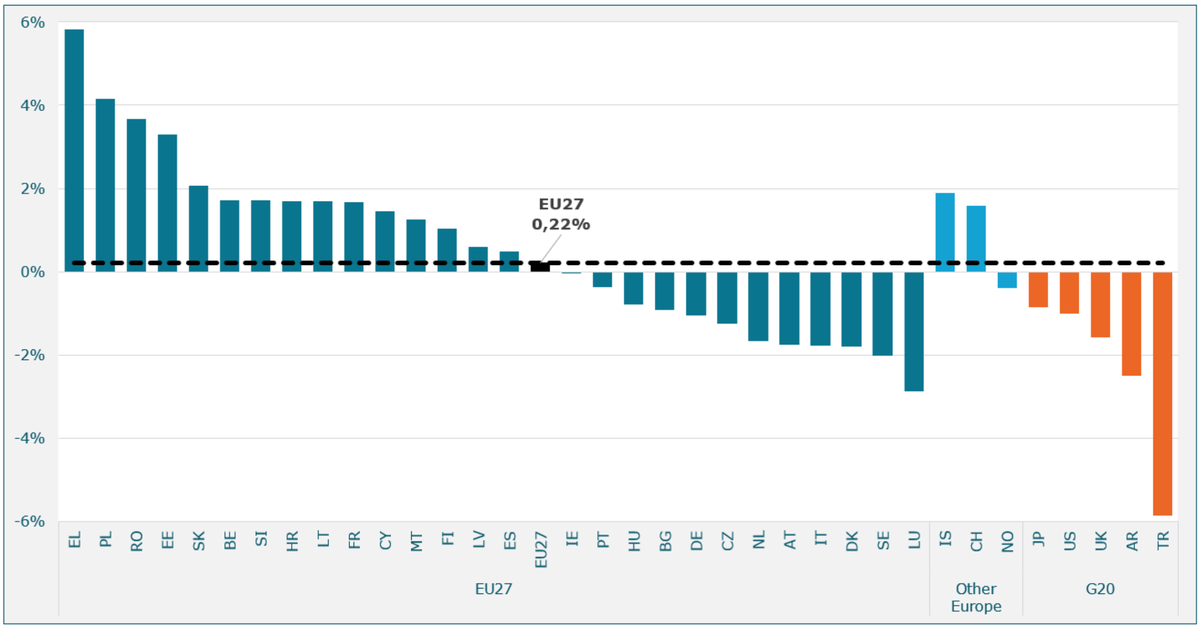


Figure 248: *Energy tax revenue evolution (CAGR 2008/2022, in USD 2015 PPP)*

Source: OECD, Environmental Policy Database

The worldwide incidence of COVID-19 led to decreasing energy tax revenues worldwide between 2019-2022 (cf.

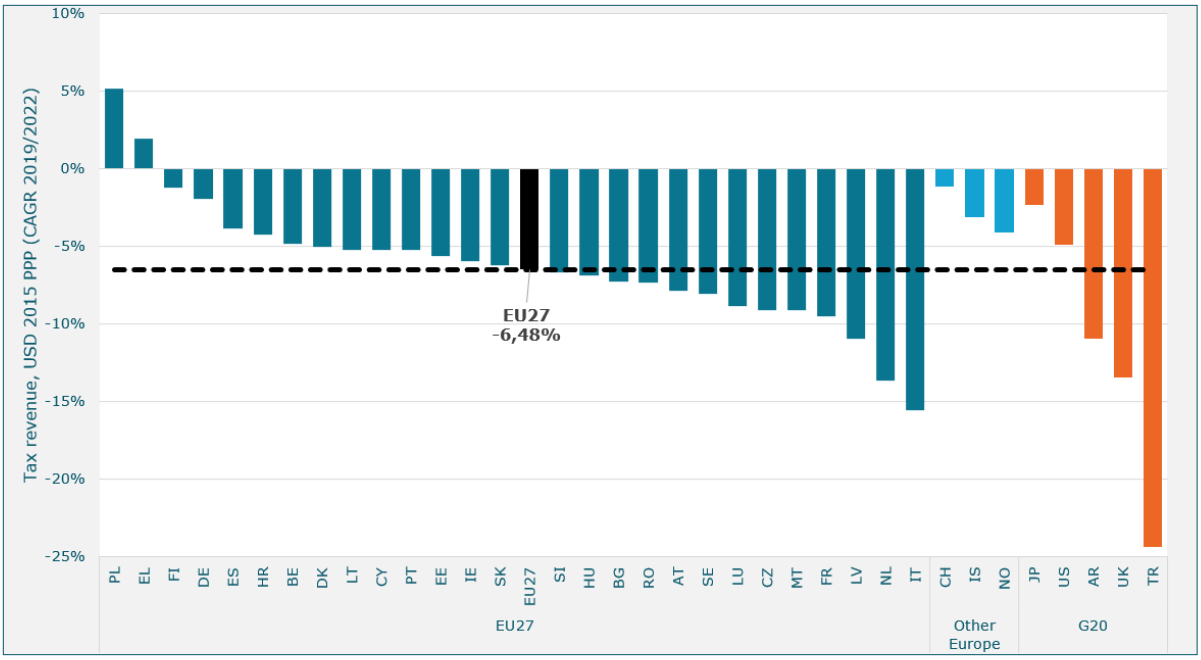


Figure 249).

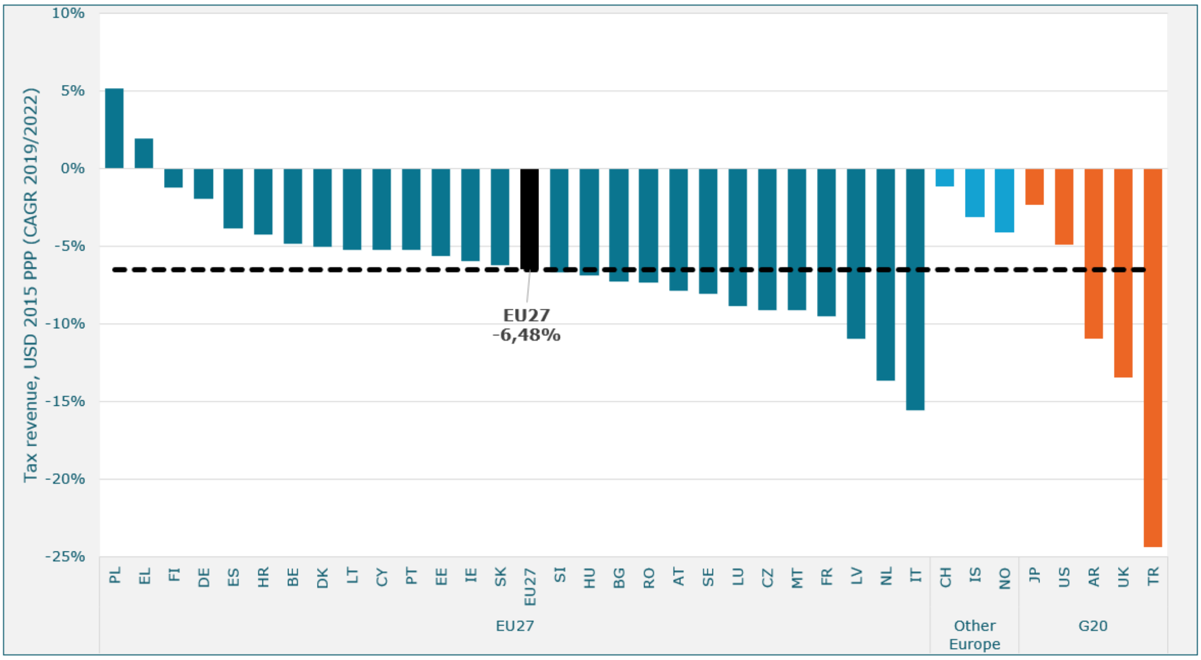


Figure 249: *Energy tax revenue evolution (CAGR 2019/2022, in USD 2015 PPP)*

Source: OECD, Environmental Policy Database

8.7.1. Energy tax revenue as a percentage of the GDP

The first interesting indicator for comparing countries is the percentage that energy tax revenues represent in relation to domestic GDP. Figure 250 shows that the ratio of energy tax revenues to GDP is significantly higher in the EU-27 (the EU-27 average reached 1.56% in 2022) than all its trading partners. This ratio is even significantly higher than that of Japan, a country that is also a major energy importer, and those of Argentina, Türkiye and the USA.

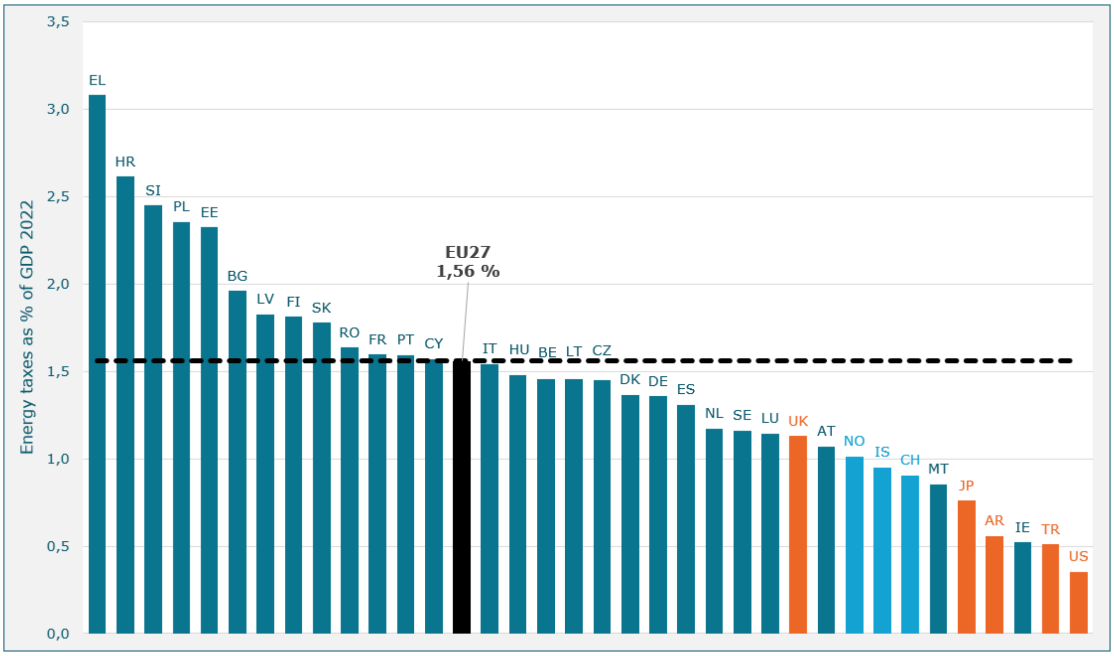


Figure 250: *Energy tax revenue as a percentage of GDP in 2022 (%)*

Source: OECD, Environmental Policy Database

Figure 251 illustrates how the ratio of revenue from energy taxes to GDP has evolved between 2008 and 2022 for the EU-27. This ratio slightly decreased during this period (the average percentage of energy tax revenues relative to domestic GDP reached -0.15%). EU-27 revenues from energy taxes have therefore not grown at roughly the same rate as GDP[514]. On the other hand, all the selected trading partners recorded an even greater decrease of their ratio over the same period (such as the United Kingdom reaching -0.53% or Türkiye reaching -1.88%).

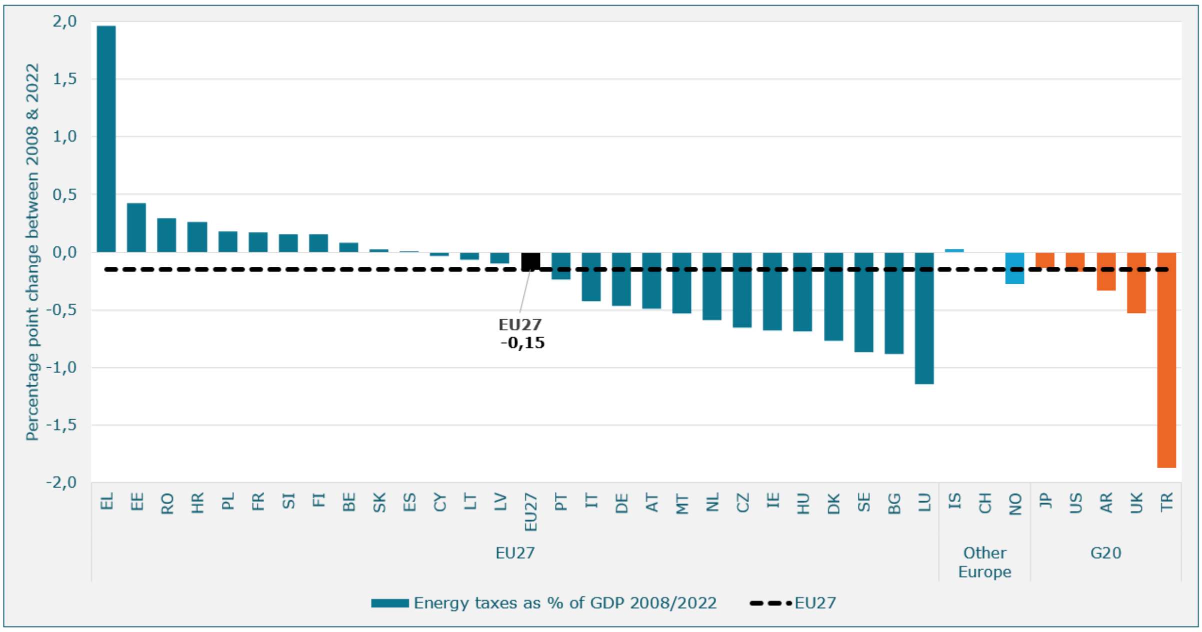


Figure 251: *Energy tax revenue as a percentage of GDP evolution between 2008 and 2022 (pp)*

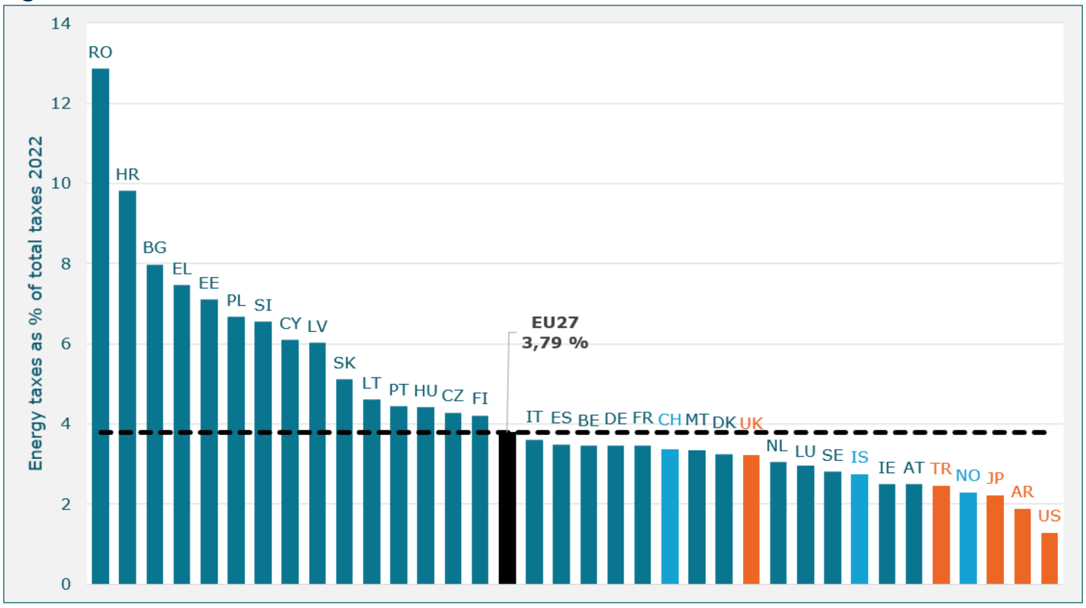
Source: OECD, Environmental Policy Database

8.7.2. Energy tax revenue as a percentage of total tax revenue

The second indicator used is the ratio between energy tax revenue and total tax revenue. This ratio allows to measure the dependence of State budget financing on income from energy taxes (cf

[514] *The EU-27 average GDP CAGR between 2008-2021 reached 1.09%. Source: Enerdata GED.*

Figure 252



). As previously, the EU ratio is higher than that of the selected major trading partners (Japan, Argentina, United Kingdom, Türkiye, USA). USA and Argentina show levels which are almost half as high as those of the EU-27. This therefore means that EU MSs are more dependent on energy tax revenues than their partners to balance their budgets.

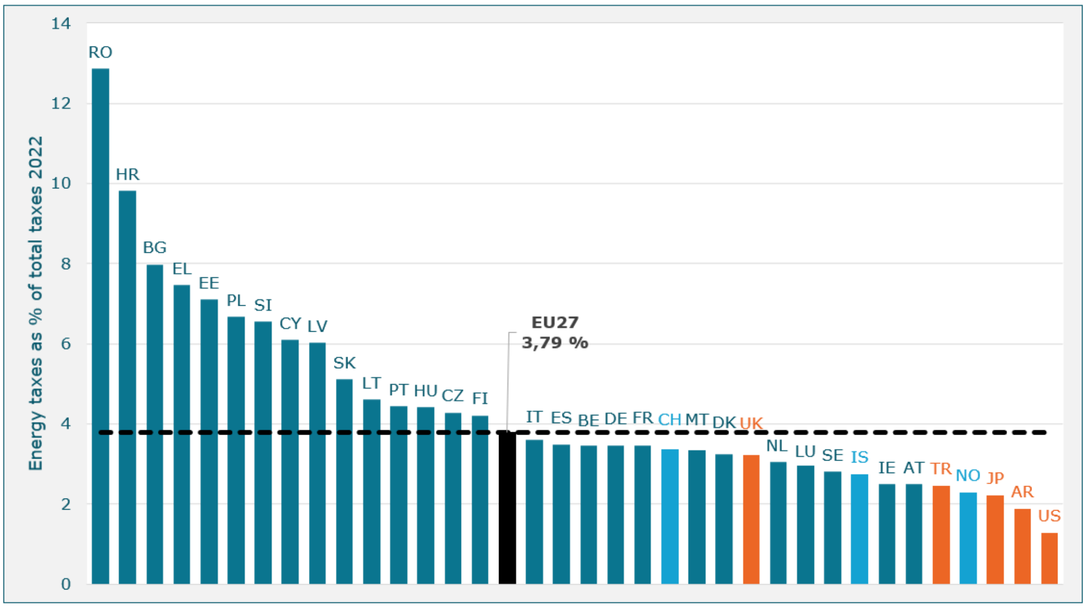


Figure 252: *Energy tax revenue as a percentage of total tax revenue in 2022 (%)*

Source: OECD, Environmental Policy Database

The evolution of the energy tax to total tax revenues (cf. Figure 253) ratio also shows a slight decrease in the EU between 2008 and 2022, indicating a decline in the share of energy taxation in overall tax revenues. This trend is even more significant in G20 countries, i.e. Japan, Argentina, United Kingdom and Türkiye.

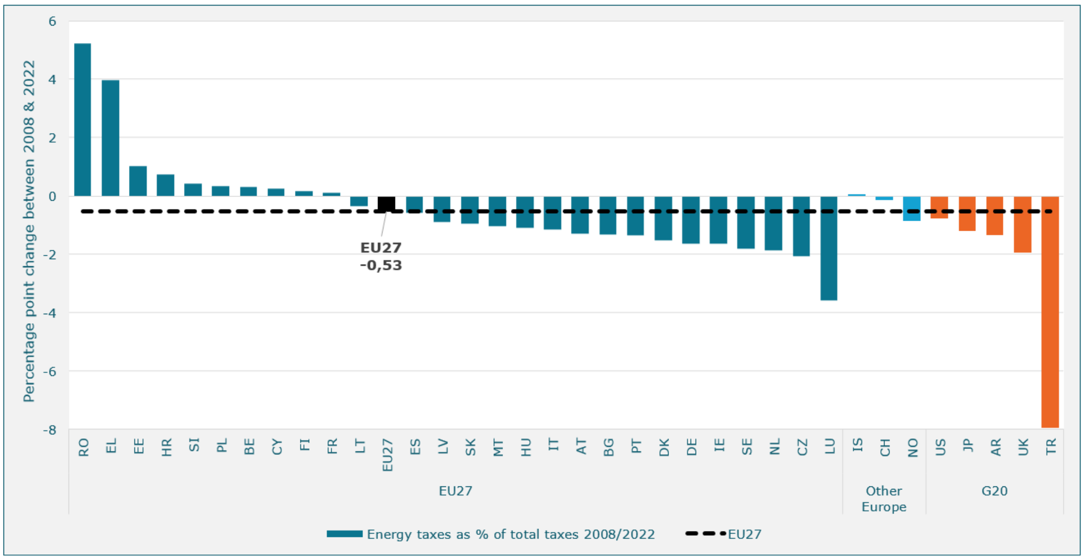


Figure 253: *Energy tax revenue as a % of total tax revenue between 2008-2022 (% point)*

Source: OECD, Environmental Policy Database

Regarding 2019-2022 the evolution of the energy tax to total tax revenues (cf. Figure 254), has decreased in countries with the exemption of Poland.

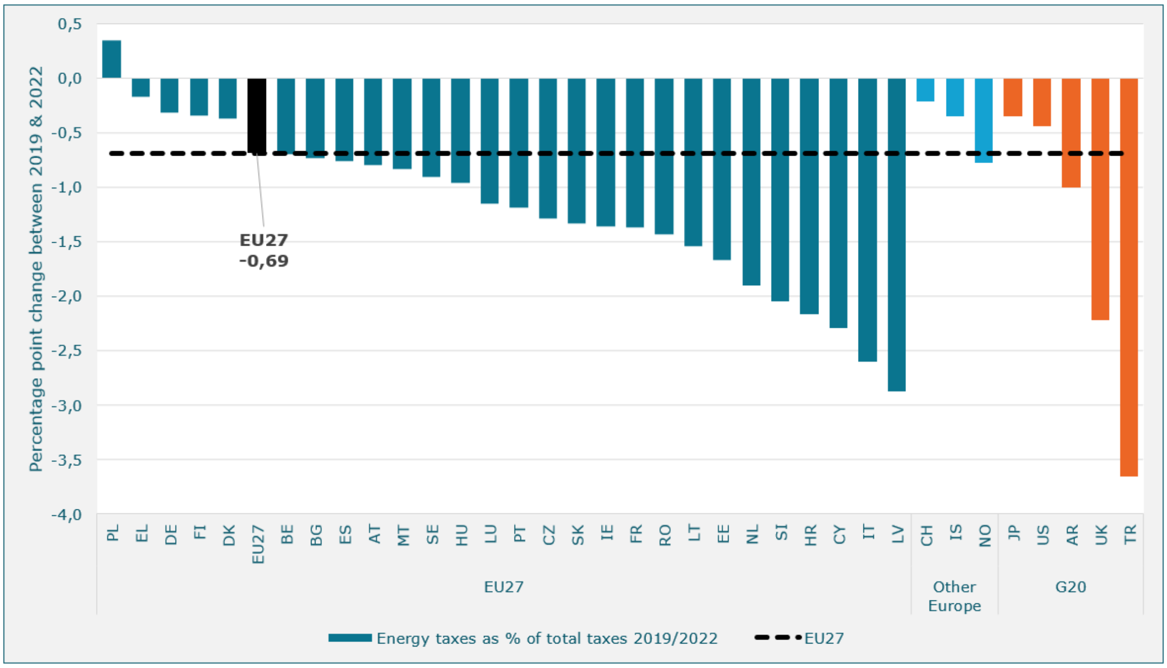


Figure 254: *Energy tax revenue as a % of total tax revenue between 2019 and 2022 (pp)*

Source: OECD, Environmental Policy Database

8.7.3. International comparisons of VAT on electricity and natural gas

Electricity

Worldwide VAT rates are quite heterogeneous, but in the same range as the different EU-27 Member States (cf. Figure 255). The average VAT rate for electricity in the EU-27 decreased by 1% point between

2018 and 2024 (from 19,5% to 18,5%). The EU-27 range[515] did not change during this period, remaining at 22% points. While several EU countries decreased their VAT rates on electricity within the 2021-2023 period (i.e. Belgium, Ireland, Luxembourg and the Netherlands -cf. part 8.5. of this report), international trading partners kept their VAT rates stable. The VAT range for selected trading partners outside the EU remained between 5% and 21%. Only Japan changed its rate from 8% in 2018 to 9% in 2019, before stabilizing at 10% in 2020. UK's electricity VAT is equal to the lowest VAT in the EU (Malta: 5%).

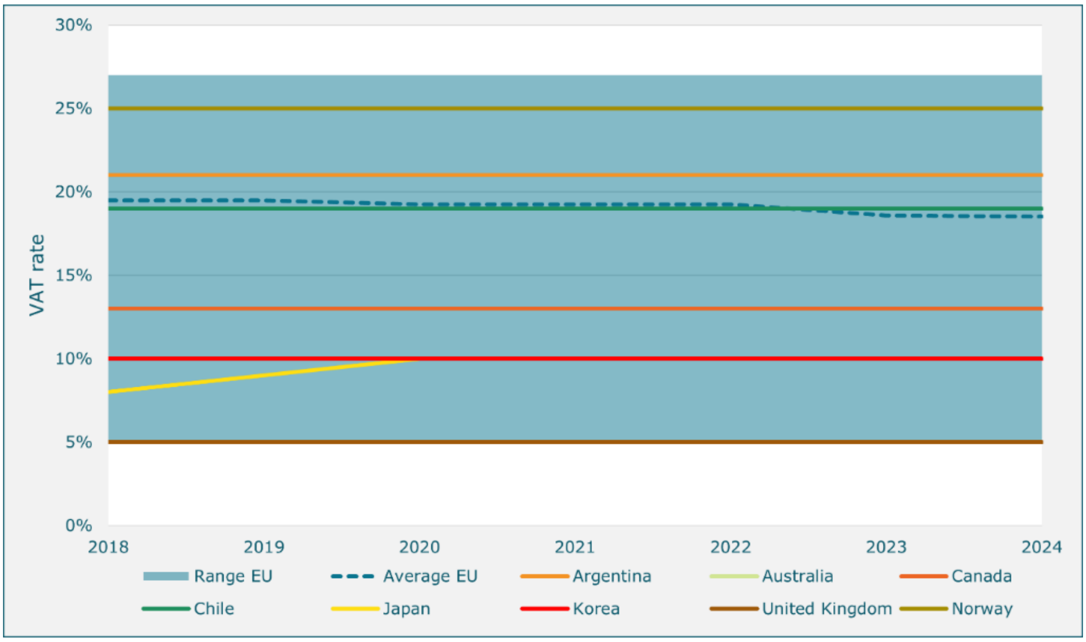


Figure 255: VAT rate on electricity in EU-27 trading partners compared to the EU-27 average between 2018-2024

Source: IEA Energy Prices – Extract of taxation information 2023

Natural gas

Comparably to electricity, the average VAT rate on natural gas in the EU-27 decreased by 1.4% points between 2018 and 2024 (from 20% to 18,6%). However, the range of VAT rates for natural gas in the EU-27 is smaller than for electricity. As for electricity, the selected trading partners' VAT rates on natural gas remained stable in the recent years (cf. Figure 256). It has to be noted that the UK's natural gas VAT is even below the lowest VAT rate in the EU.

[515] *The EU-27 range represents the range between all EU-27 MSs (Hungary has the EU's highest VAT rate on electricity at 27% while the lowest is Malta with 5% in 2024).*

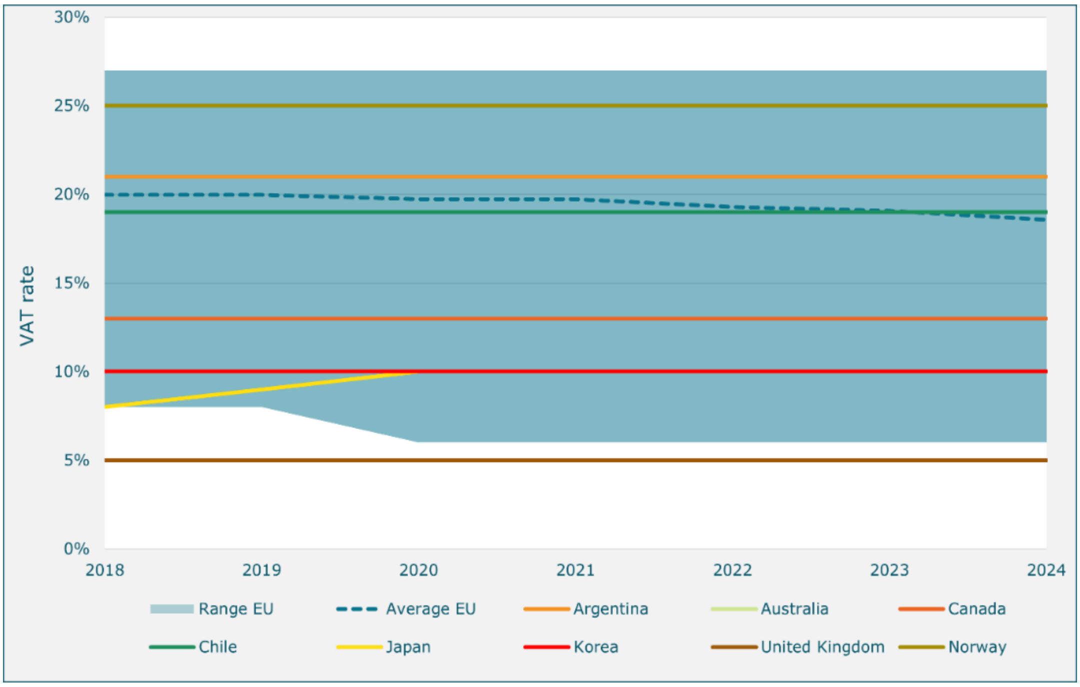


Figure 256: *VAT rate on gas in EU-27 trading partners compared to EU-27 average 2018-2024*

Source: IEA Energy Prices – Extract of taxation information 2023

8.7.4. The United States

In addition to this overall international comparison, it seems interesting to address the case of the USA and their energy taxation.

According to the OECD, environment-related[516] tax revenues in the USA amounted to US$145bn in 2021, including US$92.3bn from the energy sector. Fossil fuels taxation revenues represented 63.6% of these energy-related tax revenues. The excise taxes levied by the federal administration and those of the states being the most important, the focus is on the evolution of these two taxes. Excise tax on gasoline and gasoil increased slightly since 2008, solely due to state actions, as federal rates have remained unchanged since 1993. The federal tax rate on gasoline is set at 4.4 $cEUR_{2024}$/l and 5.9 $cEUR_{2024}$/l for gasoil.

From 2015 to 2024, the median excise taxes on gasoline (cf. Figure 257) have consistently fallen below the USA average: 9.5 cEUR/l (2015) and 11.6 cEUR/l (2024) for the median[517], and 9.7 cEUR/l (2015) and 12.2 cEUR/l (2024) for the average[518]. As a comparison, the average EU excise taxes on gasoline reached 53.4 cEUR/l in January 2024. Most states impose lower taxes on gasoline compared to the national average. The average is primarily high because of the taxes of three states (Pennsylvania, California, Illinois). In 2023, the taxes in these states were twice as high as the national average (Illinois 21 cEUR/l; California 20.5 cEUR/l; Pennsylvania 19.8 cEUR/l)[519].

[516] *According to the OECD, environmentally related tax revenues include revenues from Energy, Pollution, Transport and Ressources categories. Source: Fossil Fuel Support - Detailed Indicators (oecd.org)*
[517] *The median excise taxes on gasoline is represented by the straight line in the yearly coloured boxes.*
[518] *The average excise taxes on gasoline is represented by the cross in the yearly coloured boxes.*
[519] *These three state's taxes are illustrated as the points on the top of the graphs.*

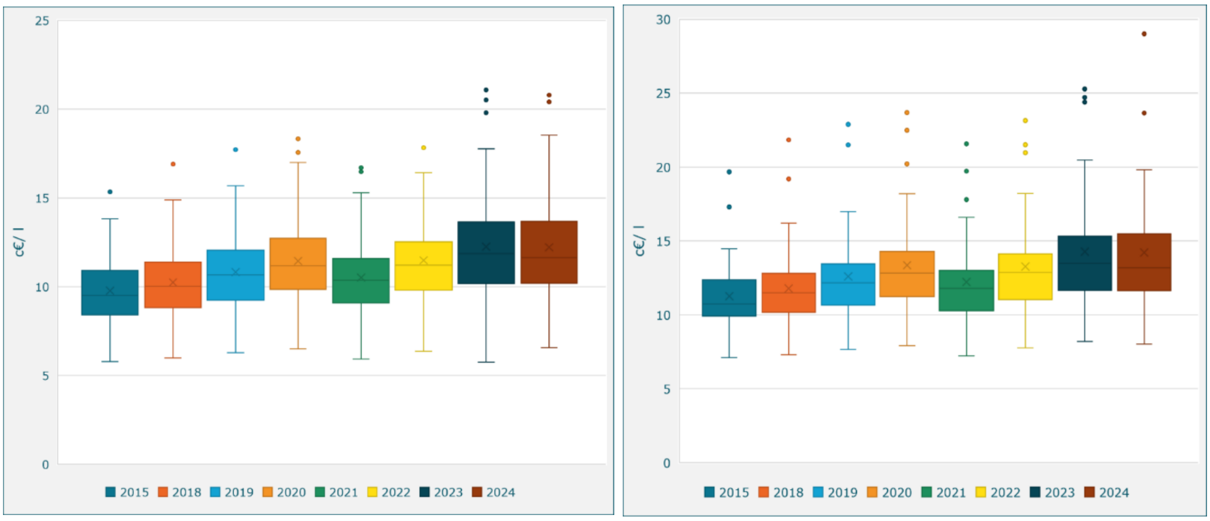


Figure 257: Evolution of excise taxes (states + federal) between 2015 and 2024 (cEUR/l) on gasoline (left), on gasoil (right)

Source: Federal and state motor fuel taxes, EIA, 2024

Regarding gasoline, from 2015 to 2024, the median excise taxes on gasoil ranged from 10.7 cEUR/l (2015) to 13.1 cEUR/l (2024) while the average varied from 11.2 cEUR/l (2015) and 14.2 cEUR/l (2024). As a comparison, the average EU excise taxes on gasoline reached 42.4 cEUR/l in January 2024. More than half of the states have excise taxes lower than the national average. The average is primarily high because of the same three states with taxes twice as high as the average (in 2023: Pennsylvania 25.2 cEUR/l; California 24.7 cEUR/l; Illinois 24.3 cEUR/l).

The evolution of average excise taxes in the American states shows a certain stability in gasoline taxes and a slight increase in gasoil taxes (cf

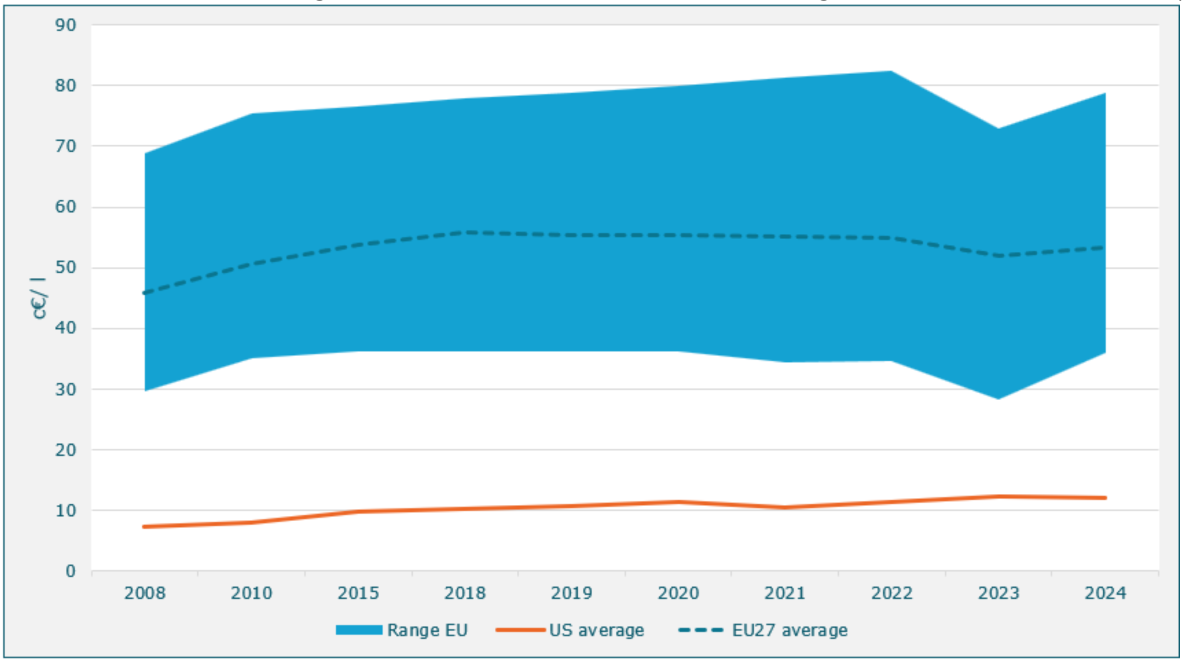


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Figure 258 and

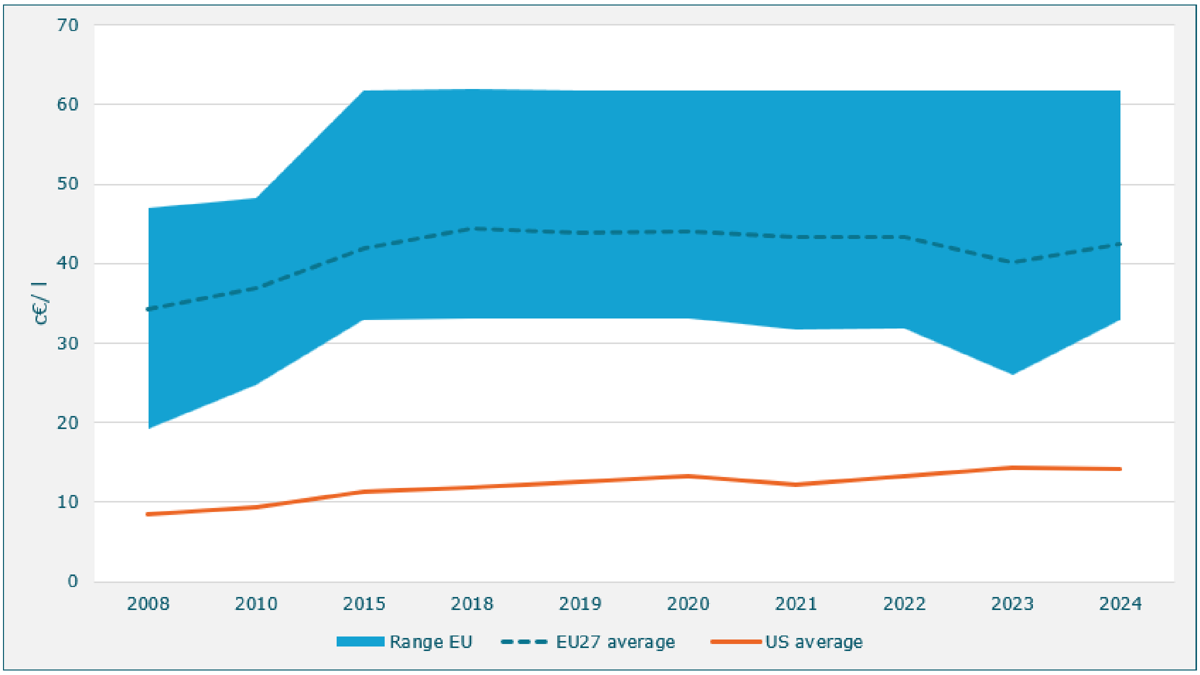

Figure 259). Excise taxes are approximately 5 times higher in Europe than the USA for gasoline and 4 times higher for gasoil.

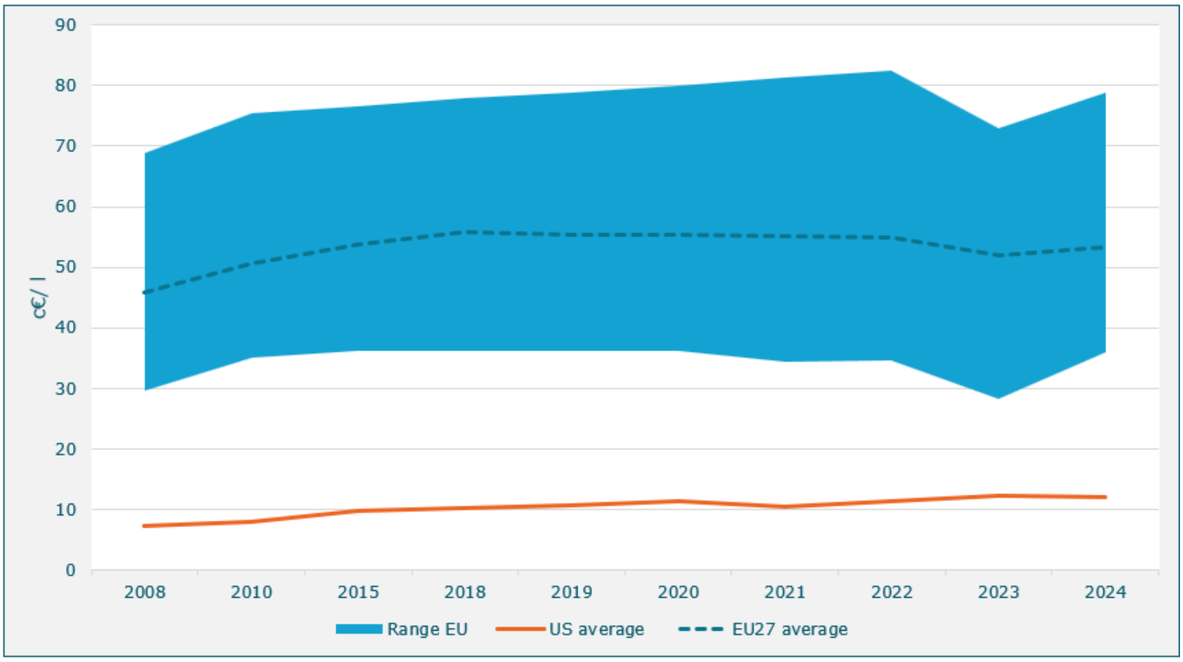

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Figure 258: *Evolution of excise taxes on gasoline in the EU and the USA 2015-2024 (cEUR/l)*

Source: Federal and state motor fuel taxes, EIA, 2024

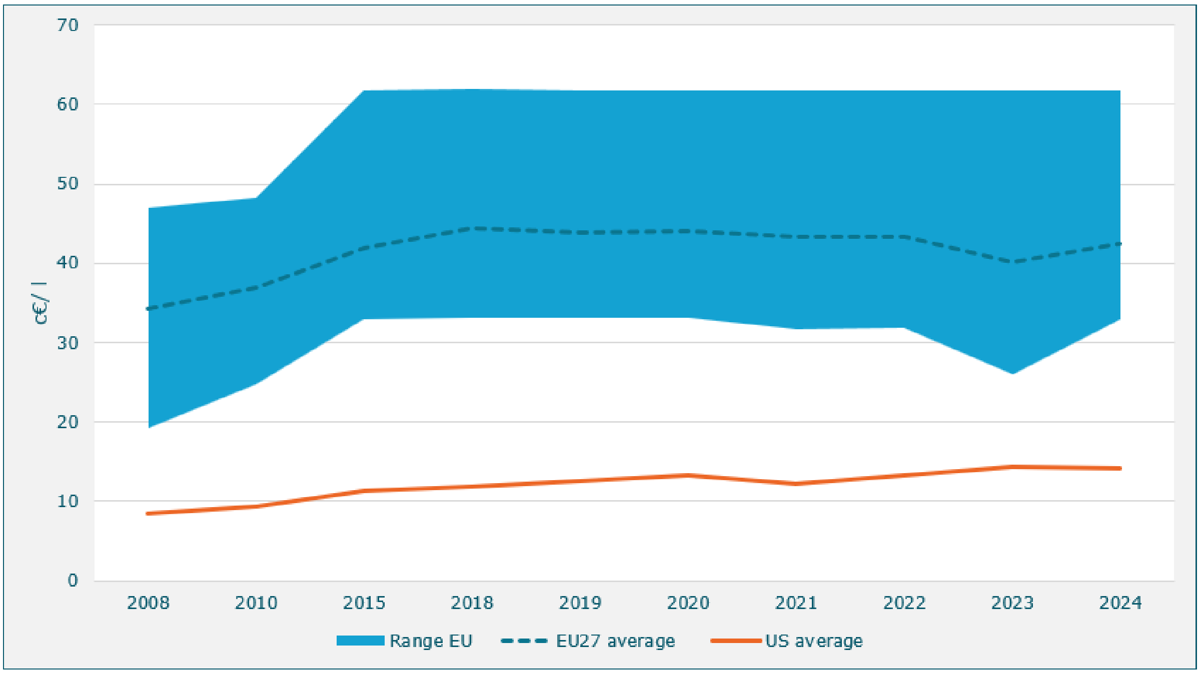

Figure 259: *Evolution of excise taxes on gasoil in the EU and the USA 2008 and 2024 (cEUR/l)*

Source: Federal and state motor fuel taxes, EIA, 2024

8.8. Link with subsidies distribution

In this section, we look at the potential links between energy taxes and subsidies at EU level. We attempt to compare the amounts and trends both by country and by economic sector.

In theory, there is a hermetic separation between the 2 components of a government's budget, with revenue (in this case, taxes) on one side and expenditure (in this case, subsidies) on the other. In this analysis, subsidies cover a broad spectrum of measures including tax reduction or tax exemption which not strictly count as expenditures, but as reduced revenues. It should also be remembered that a revenue item does not, by definition, have a corresponding expenditure item identified in advance. Instead, each revenue item contributes to the overall State budget.

Nevertheless, it is possible to analyse changes in the amounts collected relative to the amounts granted. If we assume that a budget is necessarily balanced, any change on one side potentially generates an impact on the other.

8.8.1. Comparison of revenues and subsidies, by country

Analysing amounts in absolute terms between countries is tricky because energy data only represents a small share of each Member State's budget (around 6.8% of revenues for taxes, and 2.6% of expenditures for subsidies).

However, Figure 260 shows the amounts of tax revenue and subsidies for a number of EU27 countries; and we note that, generally, the amounts of revenue generated by taxes are higher than subsidies amounts (at least, the portion included in the scope here).

There are also major differences from one country to another, as subsidies represent between 33% (PT) and 100% (NL) of tax revenues.

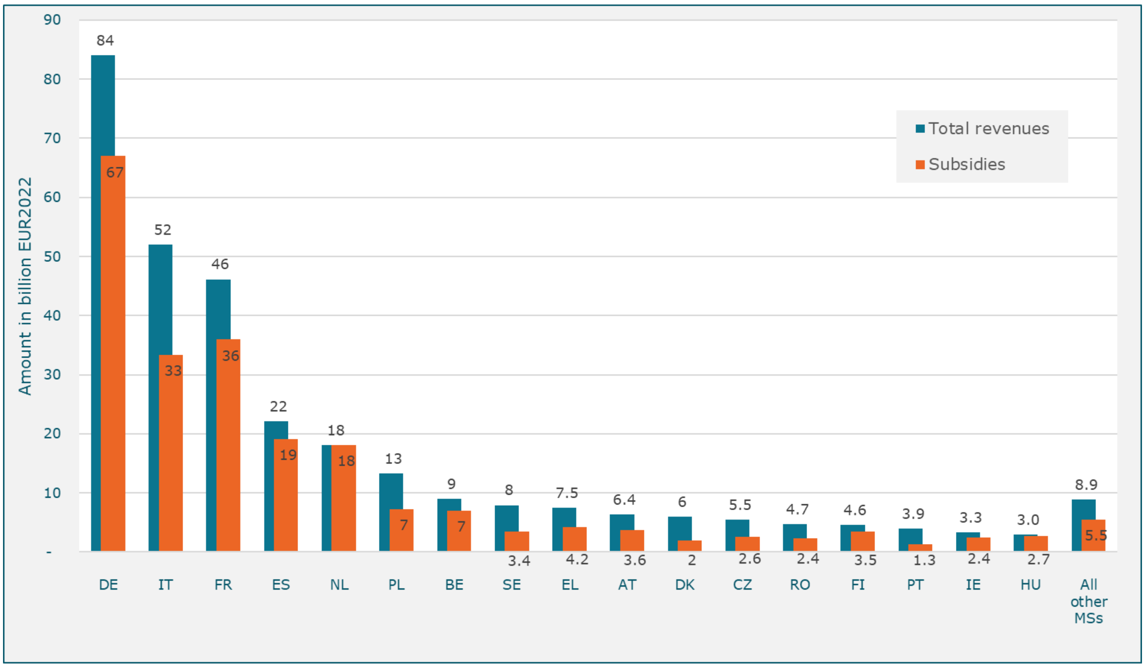

Figure 260: *Energy tax revenues and energy subsidies, by MS (EUR2022 billion), in 2021*

Source: Authors' elaboration

Comparing amounts between Member States is therefore made difficult with this partial data, and conclusions are risky. This is why it seems more relevant to compare trends by Member State, over the period 2015-2021 (see Figure 261 hereafter).

The graph below details the contribution of each Member State to the variation in income for the EU-27 between 2015 and 2021. The latter having fallen by EUR 12.6 bn over the period.

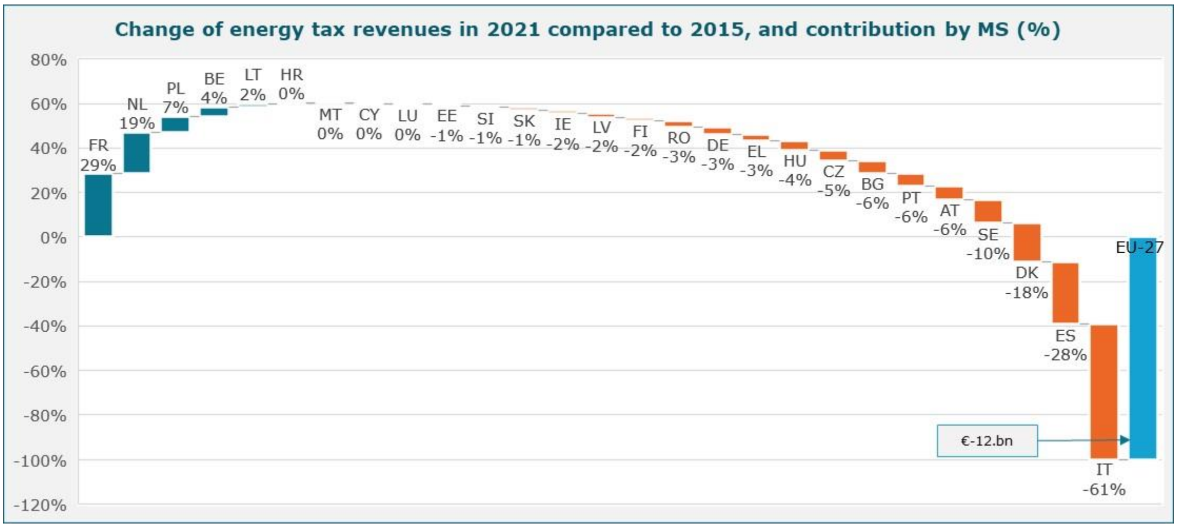

Figure 261: *Change of energy tax revenues in 2021 compared to 2015, by MS (%)*

Source: Authors' elaboration

Data shows that the fall in energy tax revenues of the EU27 is mainly driven by 4 countries (IT, ES, DK, SE), while 3 countries (FR, NL, PL) lead its increase.

Figure 262 below shows the contribution of each Member State to the increase in subsidies in the EU-27. The latter increased by EUR 32.1 bn over the period.

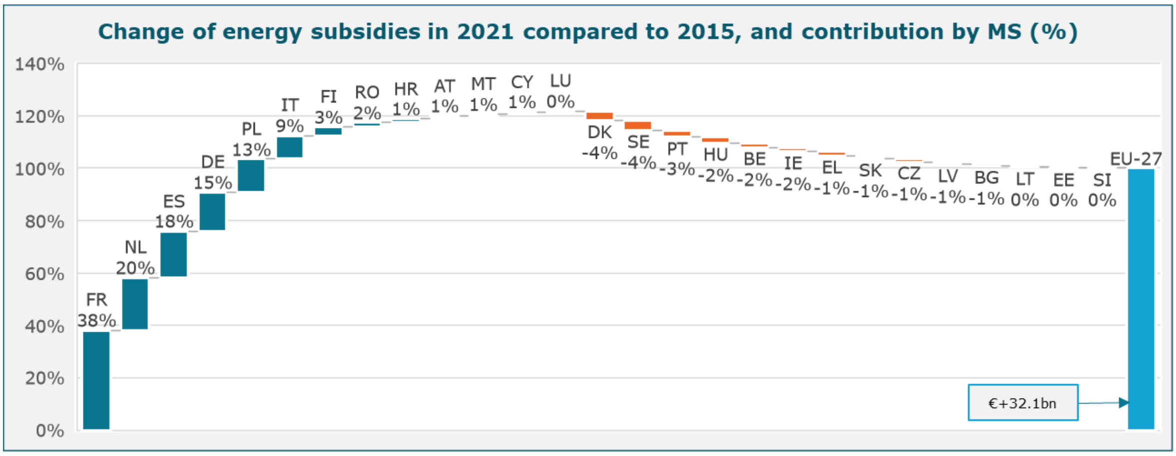

Figure 262:*Change of energy subsidies in 2021 compared to 2015, by MS (%)*

Source: Authors' elaboration

Data shows that the increase in energy subsidies is mainly driven by 5 countries (FR, NL, ES, DE, PL).

8.8.2. Comparison of revenues and subsidies, by economic sector

The following analysis examines the economic sectors in which funds were either allocated (for subsidies) or received (as tax revenues) for each year from 2015 to 2021, and even up to 2023 for subsidies where more recent data is available. The findings are illustrated in Figure 263 and Figure 264.

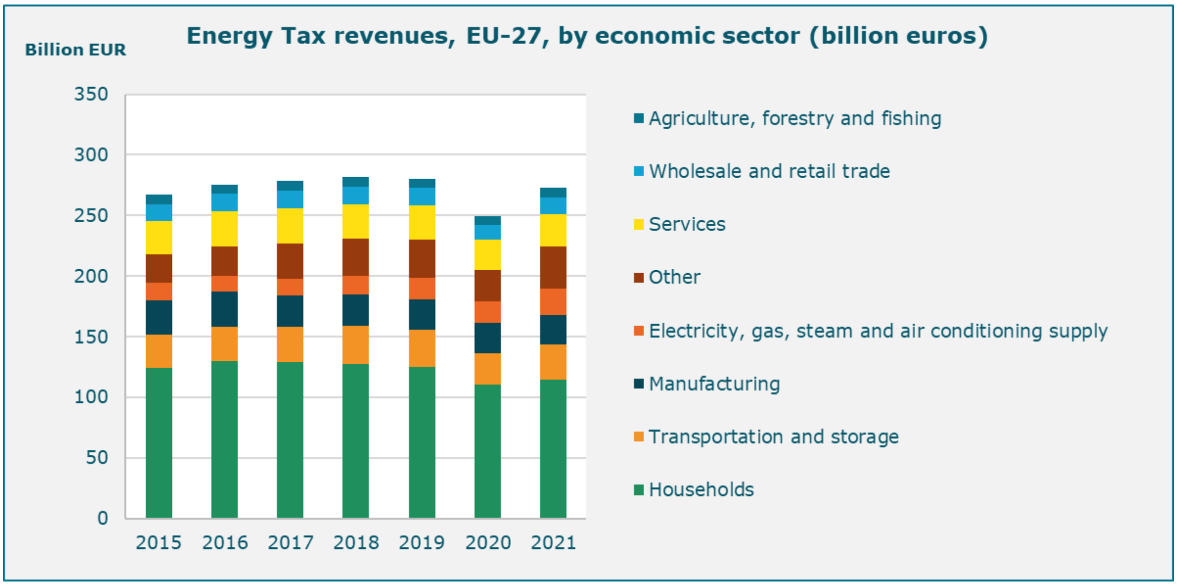

Figure 263: *Evolution of energy tax revenues in the EU-27, by economic sector*[520]

Source: Authors' elaboration

[520] *Other includes revenues in Cross sectors, Public, Mining, Energy infrastructures*

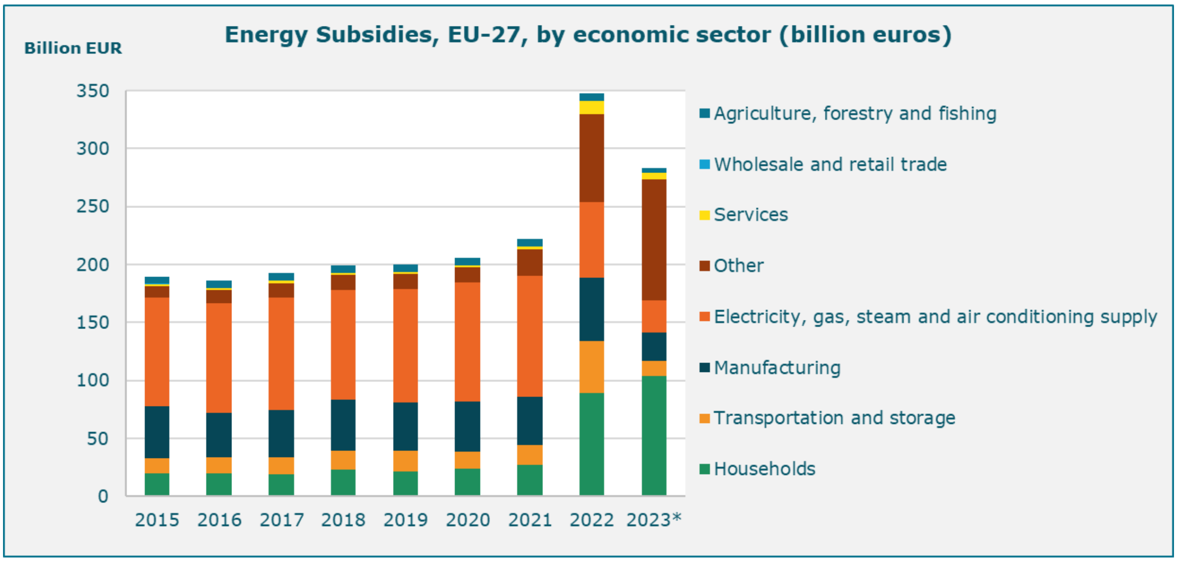

Figure 264: *Evolution of energy subsidies in the EU-27, by economic sector*[521]

Source: Authors' elaboration

Revenue remains stable from 2015 to 2021, with the notable exception of 2020, which experiences a significant decline (-48% compared to the 2015-2019 average). Conversely, subsidies show a consistent, albeit slow, increase over the same period. These divergent trends in revenues and subsidies amounts are particularly noteworthy as they are contrary to initial expectations.

The sharp rise in total subsidies observed in 2022 and 2023 does not benefit all economic sectors equally. Households are the primary beneficiaries of new support measures, followed by the Transport and storage sector, and the category labeled "Other," which encompasses non-targeted or cross-cutting measures (e.g., Cross-sectoral, Public, Mining, and Energy Infrastructures). In contrast, the energy sector experiences a substantial reduction in subsidies during these years (-38% in 2022 compared to 2021).

The years 2022 and 2023 witness significantly higher subsidy volumes than the average for 2015-2021. Regarding tax revenues, although consolidated figures for 2022 and 2023 are not yet available, it is probable that they do not increase proportionally and may even decrease due to reductions in tax rates and energy consumption over this period. This situation highlights and partially explains the increasing pressure on national budgets.

8.8.3. Contributors and recipients

Keeping this breakdown by economic sector, it is interesting to put the amounts spent through subsidies and collected through tax revenues side by side. The graph below shows this comparison for 2 distinct years: 2015 and 2021.

[521] * *Part of the amounts for 2023 are estimates*

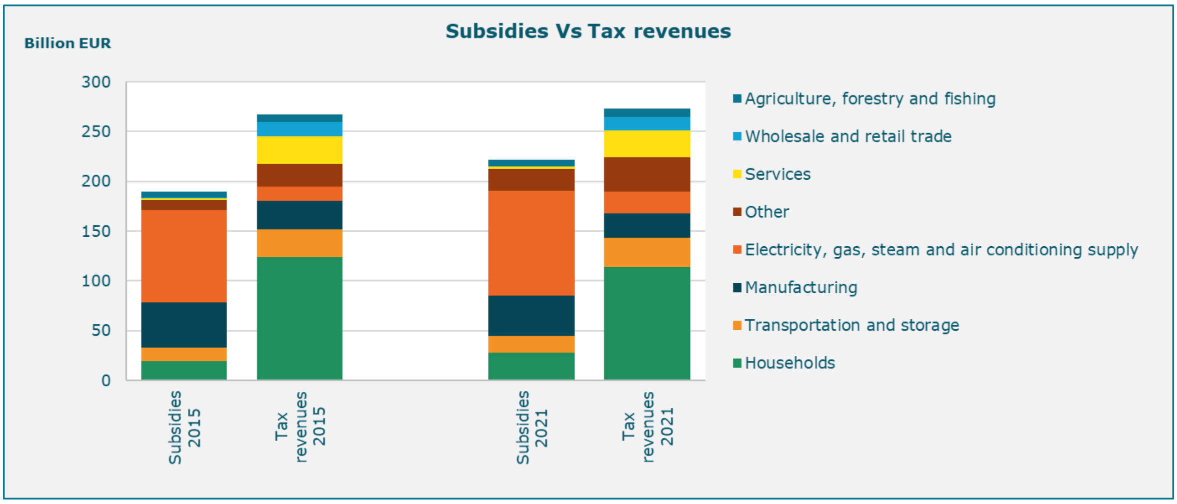

Figure 265: *Energy tax revenues and energy subsidies in the EU-27, by economic sector, in 2015 and 2021*

Source: Authors' elaboration

All sectors of activity contribute to tax revenues. In volume terms, revenues from households cover more than 40% of total revenues, with the remainder spread across the other economic sectors (from 3% for Agriculture, forestry and fishing to 13% for Other).

As for subsidies, the picture is less balanced between economic sectors. These mainly benefit the Electricity, gas, steam and air conditioning supply sector (nearly 50% of the total amount), Manufacturing (20%) and Households (12%).

9. Special chapter 1: Analysis of price surge

Key findings:

- For both electricity and natural gas prices and across EU Member States, in the period after and during the COVID pandemic the estimates show a higher speed of adjustment compared to the before covid period. This result is even more profound after and during the energy price crisis period.
- The findings support that asymmetries exist in both households and industries with respect to positive and negative changes in the wholesale retail prices and the magnitude of the pass-through to the retail prices.
- Positive changes in the wholesale electricity prices result in a higher pass-through rate compared to when there is negative change.
- Estimates for households and industries support that less competitive electricity markets have a lower pass-through rate from wholesale to household electricity prices. Additionally, the estimates shows that there is a higher speed of adjustment as the market becomes less competitive.
- Forecasting monthly electricity prices using only natural gas prices as explanatory variables provides a better fit with actual data compared to models that include additional explanatory variables. Aggregating or summarizing data over longer periods can obscure subtle but potentially significant effects of other variables, leading to an underestimation of their impact or making them appear statistically insignificant. During and after the energy crisis, a 1 €/MWh increase in natural gas prices from the previous month results in an increase of 1.6-2.4 €/MWh in electricity prices across countries.
- Net load (power generation from fossil),natural gas price and share of gas are the main drivers of electricity price throughout the day.
- An increase of 1 MWh in nuclear unavailability results in an increase in electricity prices ranging from 0 to 0.002 €/MWh.

It should be noted that complex dynamics, such as price hedging and contracts, occur during a "canonical period" (period without shocks) and have not been included in the estimations. Therefore, these estimations should be treated as indicative rather than precise figures.

9.1. Review of existing studies and reports

This section focuses to gathering the available research and reports that analyse the variables influencing energy prices (specifically electricity and natural gas) as well as the rate at which changes in wholesale prices are passed through to retail prices. Section 9.1.1. presents the literature review on the factors contributing to increases in energy prices and section 9.1.2. on the pass-through rate between wholesale and retail prices.

9.1.1. Factors contributing to increases in energy prices

- Electricity price:

Recent research has highlighted the significant impact of renewable energy sources on wholesale electricity prices. In the European Union (EU), several studies reveal a decline in wholesale electricity prices across Europe associated with the adoption of renewable energy sources. On average, for each 1 percentage point rise in the share of renewables, there is a decrease of 0.6 percent in electricity prices and the data suggests a nonlinear correlation, indicating that higher proportions of renewables lead to more substantial impacts on electricity prices[522]. The integration of renewable energy sources and sector liberalization has led to decreasing electricity prices, supporting the EU's liberalization goals[523]. A study that examines the impact of offshore and onshore wind energy on the wholesale electricity prices shows that offshore and onshore wind have different impacts on wholesale prices. Offshore wind tends to reduce both price levels and price volatility more effectively than onshore wind[524].

On the other hand, Wong, J. B., & Zhang, Q. (2021)[525] study examined the impact of carbon tax on wholesale electricity pricing and market behavior in Australia and found that carbon pricing mechanism indicate that wholesale electricity costs increase between 22.1% to 68.0% across connected regions. Additionally, Zachmann and von Hirschhausen (2008) found evidence of asymmetric cost pass-through between EUA (EU emission allowance) and electricity future prices in Germany, they found that rising prices of emission allowances have a stronger impact on wholesale electricity prices than falling prices. This could indicate the exercise of market power by German electricity generators.

Additionally, in the Iberian market, factors such as demand inputs, weather conditions, and generation capacity significantly influence electricity prices[526]. Similarly, adding an extra GW of dispatched wind and solar capacity has been found in Australia to decrease wholesale electricity prices by 11 AUD/MWh and 14 AUD/MWh, respectively[527]. Conversely, in the EU, prior to the energy price crisis, the deployment of renewable electricity production tended to increase household electricity prices due to higher associated costs[528]. In deregulated markets like Montenegro, increased electricity production slightly raises prices due to the dominance of a single major producer despite deregulation[529]. N. Foley, L. Kevany, J. Harnett, and R. Keenan (2024)[530] paper analyze the relationship between wholesale energy prices and household bills and mention that the household energy prices have experienced a significant surge which is primarily attributed to rises in wholesale gas prices.

- Natural Gas:

In the United States, there is a long run equilibrium between crude oil to natural gas prices, with a weakened impact after the 2008 financial crisis[531]. In Germany, short-term fluctuations in natural gas prices are influenced by factors such as temperature and supply shortages, while long-term trends are closely linked to crude oil and coal prices[532]. Moreover, in North American, Asian, and European markets, factors such as crude oil prices, weather, and inventories impact natural gas prices, with short-term imbalances notably affecting North American prices[533].

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[522] *Cevik, Serhan, and Keitaro Ninomiya. "Chasing the Sun and Catching the Wind: Energy Transition and Electricity Prices in Europe." November 4, 2022 (IMF Working papers).*
[523] *Da Silva, P. P., & Cerqueira, P. A. (2017). Assessing the determinants of household electricity prices in the EU: a system-GMM panel data approach. Renewable and Sustainable Energy Reviews, 73, 1131-1137.*
[524]*Emil Hosius, Johann V. Seebaß, Benjamin Wacker, Jan Chr. Schlüter, The impact of offshore wind energy on Northern European wholesale electricity prices, Applied Energy, Volume 341, 2023..*
[525] *Wong, J. B., & Zhang, Q. (2021). Impact of carbon tax on electricity prices and behaviour. Finance Research Letters, 102098. doi:10.1016/j.frl.2021.102098.*
[526] *Ferreira, Â. P., Gonçalves Ramos, J., & Odete Fernandes, P. (2019). A linear regression pattern for electricity price forecasting in the Iberian electricity market. Revista Facultad de Ingeniería Universidad de Antioquia, (93), 117-127.*
[527] *Csereklyei, Z., Qu, S., & Ancev, T. (2019). The effect of wind and solar power generation on wholesale electricity prices in Australia. Energy Policy, 131, 358-369.*
[528] *Cech, M. (2016). Panel regression analysis of electricity prices and renewable energy in the European Union.*
[529] *Dragasevic, Z., Milovic, N., Djurisic, V., & Backovic, T. (2021). Analyzing the factors influencing the formation of the price of electricity in the deregulated markets of developing countries. Energy Reports, 7, 937-949.*
[530] *Foley, N., Kevany, L., Harnett, J., & Keenan, R. (2024).* Spending Review 2023: A Review of Electricity Prices and Supports in the Context of the Energy Crisis. *Department of Public Expenditure, NDP Delivery & Reform, Climate Research Unit; Department of Environment, Climate & Communications, Economic & Evaluation Unit; Retail Energy Policy & Consumer Protection Unit. February 2024.*
[531] *Ji, Q., Zhang, H. Y., & Geng, J. B. (2018). What drives natural gas prices in the United States? – A directed acyclic graph approach. Energy Economics, 69, 79-88.*
[532] *Nick, S., & Thoenes, S. (2014). What drives natural gas prices? A structural VAR approach. Energy Economics, 45, 517-527.*
[533] *Geng, J. B., Ji, Q., & Fan, Y. (2016). The behaviour mechanism analysis of regional natural gas prices: A multi-scale perspective. Energy, 101, 266-277.*

Table 47 Literature collection overview.

#	Paper	Region	Data	Methodology / Type	Findings
1	Cech, M. (2016). Panel regression analysis of electricity prices and renewable energy in the European Union.	EU	2010 - 2013	Panel data	Household electricity prices in the studied EU Member States increase with the deployment of RES-E production
2	Csereklyei, Z., Qu, S., & Ancev, T. (2019). The effect of wind and solar power generation on wholesale electricity prices in Australia. Energy Policy, 131, 358-369.	Australia	2010-2018, Daily datasets	Autoregressive distributed lag models (ARDL)	An extra GW of dispatched wind capacity decreases the wholesale electricity price by 11 AUD/MWh at the time of generation, while solar capacity by 14 AUD/MWh
3	Da Silva, P. P., & Cerqueira, P. A. (2017). Assessing the determinants of household electricity prices in the EU: a system-GMM panel data approach. Renewable and Sustainable Energy Reviews, 73, 1131-1137.	EU (23 countries)	2000-2014	Panel data – GMM (Generalized Method of Moments)	Renewable energy sources and sector liberalization has led to decreasing electricity prices
4	Dragasevic, Z., Milovic, N., Djurisic, V., & Backovic, T. (2021). Analyzing the factors influencing the formation of the price of electricity in the deregulated markets of developing countries. Energy Reports, 7, 937-949.	Montenegro	2007–2019.	Regression model	increased electricity production slightly raises prices due to the dominance of a single major producer
5	Ferreira, Â. P., Gonçalves Ramos, J., & Odete Fernandes, P. (2019). Investigation of factors influencing electricity prices in the Iberian market.	Portugal and Spain	2017-2018	Multiple Linear Regression Model - OLS	Factors such as demand inputs, weather conditions, and generation capacity significantly influence electricity prices
6	Geng, J. B., Ji, Q., & Fan, Y. (2016). Examination of factors impacting natural gas prices across North American, Asian, and European markets from a multi-scale perspective.	North American, Asian and European markets	monthly data, for January 1992 to April 2013	The Ensemble Empirical Mode Decomposition and the cross-correlation method	Crude oil prices, weather, and inventories impact natural gas prices, with short-term imbalances notably affecting North American prices
7	Cevik, Serhan, and Keitaro Ninomiya. "Chasing the Sun and Catching the Wind: Energy Transition and Electricity Prices in Europe." November 4, 2022 (IMF Working papers).	24 European Countries	2014–2021	OLS and panel quantile regression approach	For 1 percentage point rise in the share of renewables, there is a decrease of 0.6 percent in electricity price.

#	Paper	Region	Data	Methodology / Type	Findings
8	Ji, Q., Zhang, H. Y., & Geng, J. B. (2018). Investigation of the causal relationship between crude oil and natural gas prices in the United States.	USA	1999-2017	A data-driven approach, namely the directed acyclic graph (DAG) VAR/ECM model combined with the contemporaneous causal ordering by DAG	Long run equilibrium between crude oil to natural gas prices
9	Nick, S., & Thoenes, S. (2014). Analysis of short-term and long-term determinants of natural gas prices in the German market.	Germany	Monthly data from January 2001 to March 2018	VAR (Vector autoregression model)	Short-term fluctuations in natural gas prices are influenced by factors such as temperature and supply shortages, while long-term trends are closely linked to crude oil and coal prices
10	Georg Zachmann, Christian von Hirschhausen (2008). First evidence of asymmetric cost pass-through of EU emissions allowances: Examining wholesale electricity prices in Germany. Economics Letters 99, 465–469.	Germany	2005-2006	An error correction and an autoregressive distributed lag model.	Asymmetric cost pass-through between EUA and electricity future prices in Germany. Find convincing evidence that emissions prices are passed through asymmetrically to electricity futures prices in Germany.
11	Emil Hosius, Johann V. Seebaß, Benjamin Wacker, Jan Chr. Schlüter, The impact of offshore wind energy on Northern European wholesale electricity prices, Applied Energy, Volume 341, 2023, 120910, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2023.120910.	Germany, Great Britain and Denmark	2015-2018	AR_GARCH, ARMA models.	The results indicate that offshore and onshore wind have different impacts on wholesale prices. Offshore wind tends to reduce both price levels and price volatility more effectively than onshore wind.
12	Wong, J. B., & Zhang, Q. (2021). Impact of carbon tax on electricity prices and behaviour. Finance Research Letters, 102098. doi:10.1016/j.frl.2021.102098.	Australia	1 July 2010 to 30 June 2014	OLS Regression analysis	Wholesale electricity costs increase between 22.1% to 68.0% by carbon pricing mechanism

9.1.2. Speed and magnitude of pass-through rate of wholesale to retail electricity price.

- Electricity price:

There are studies that have examined the pass-through of wholesale price to the end-user retail price in various electricity markets. For example, a study conducted in the Dutch retail electricity market found that the pass-through rate is slow and changes in the retail price are not significantly related to changes in the wholesale price[534]. Moreover, Mirza and Bergland (2012)[535] found an asymmetric pass-through from wholesale to retail electricity prices in the Norwegian market, taking nearly five weeks for a change in the wholesale price to fully manifest in the retail price.

A more recent study conducted in Victoria, Australia, revealed that the duration to pass-through changes in wholesale prices to retail prices ranging from zero to 4 months. The study found no indications of asymmetric pass-through from wholesale to retail prices, while incumbent firms do not completely pass-through wholesale price changes and new entrants do[536] .

Two additional studies in Texas and Colombia found pass-through rates from wholesale to retail electricity prices of approximately 43-47% and 113%, respectively, using panel data analysis.[537][538]

In summary, there is a broad consensus in the existing literature that the pass-through of wholesale prices to retail electricity prices varies greatly depending on the market and the specific circumstances of each case. More research is needed to understand the factors that contribute to this variability and to develop strategies to ensure a fair and efficient pricing mechanism in the electricity market.

- Natural Gas:

Studies that examine the speed and magnitude of the pass-through rate from wholesale natural gas price to retail gas prices are limited.

A study[539] mention that on average, about 13% of an increase in natural gas prices is passed on to consumer gas prices after 12 months, with only about 20% of this effect occurring within the first month. Similarly a study by the European Central Bank (ECB)[540] indicated that, on average, about 10-12% of the increase in natural gas prices is passed on to consumer gas prices in the euro area after one year.

Table 48: Literature collection overview

#	Paper:	Region:	Data:	Methodology / Type	Findings
1	Faisal Mehmood Mirza, Olvar Bergland (2012). Pass-through of wholesale price to the end user retail price in the Norwegian electricity market. Energy Economics, Norway.	Norway	2000-2010	To test the stationarity properties of the price data, the Philips–Perron and Dickey–Fuller seasonal integration tests were performed. OLS method	The study finds an asymmetric pass-through from wholesale to retail electricity prices in the Norwegian market. It takes nearly five weeks for a change in the wholesale price to fully pass through to the retail price. For an average household on a variable price contract, the cost of this asymmetric pass-through is 2.28 NOK for a one-time 2.5 Øre/kWh increase in the wholesale price. For end consumers with 5-

[534] *Mulder, M., & Willems, B. (2019). The Dutch retail electricity market. Energy policy, 127, 228-239.*
[535] *Faisal Mehmood Mirza, Olvar Bergland (2012). Pass-through of wholesale price to the end user retail price in the Norwegian electricity market. Energy Economics, Norway.*
[536] *Burns, Kelly, Mountain, Bruce (2021). Do wholesale electricity prices pass-through to consumers in contestable retail electricity markets? An examination in Victoria Australia. Working Paper. Victoria Energy Policy Centre, Victoria University, Melbourne, Australia.*
[537] *Brown, D. P., Tsai, C. H., Woo, C. K., Zarnikau, J., & Zhu, S. (2020). Residential electricity pricing in Texas's competitive retail market. Energy Economics, 92, 104953. doi:10.1016/j.eneco.2020.104953*
[538] *Correa-Giraldo, M., Garcia-Rendon, J. J., & Perez, A. (2021). Strategic behaviors and transfer of wholesale costs to retail prices in the electricity market: Evidence from Colombia. Energy Economics, 99, 105276. doi:10.1016/j.eneco.2021.105276*
[539] *European Commission. (2022). Euro Area and EU Outlook: Winter 2022 (Interim) Forecast (Institutional Paper 169). European Commission, doi: 10.2765/333044*
[540] *Kuik, F., Adolfsen, J. F., Lis, E. M., & Meyler, A. (2022). Energy price developments in and out of the COVID-19 pandemic – from commodity prices to consumer prices. ECB Economic Bulletin, Issue 4*

#	Paper:	Region:	Data:	Methodology / Type	Findings
					dominant retailers, this cost is even higher at 7.25 NOK.
2	Mulder, M., & Willems, B. (2019). The Dutch retail electricity market. Energy policy, 127, 228-239.	Netherlands	2008-2014	Data: Monthly prices for all products offered in the Dutch retail electricity.	The pass-through rate is slow. Monthly changes in the retail price are positively related with changes in the wholesale price, but this effect is not significant.
3	Burns, Kelly, Mountain, Bruce (2021). Do wholesale electricity prices pass-through to consumers in contestable retail electricity markets? An examination in Victoria Australia. Working Paper. Victoria Energy Policy Centre, Victoria University, Melbourne, Australia.	Australia	January 2019 to March 2021	ARDL model.	New entrant retailers incompletely pass-through wholesale prices (around 40 % of wholesale price variation is passed through in retail prices) when measuring cheaper offers (the 10th percentile cheapest offers). However, new entrant retailers completely pass-through wholesale prices.
4	Correa-Giraldo, M., Garcia-Rendon, J. J., & Perez, A. (2021). Strategic behaviors and transfer of wholesale costs to retail prices in the electricity market: Evidence from Colombia. Energy Economics, 99, 105276. doi:10.1016/j.eneco.2021.105276	Colombia	January 2017–March 2020	Panel data	Results show converge with the regulatory framework of the retail electricity market in Colombia. In particular, the results reveal that the cost pass-through is more than complete with a rate of 115%.
5	Brown, D. P., Tsai, C. H., Woo, C. K., Zarnikau, J., & Zhu, S. (2020). Residential electricity pricing in Texas's competitive retail market. Energy Economics, 92, 104953. doi:10.1016/j.eneco.2020.104953	Texas	January 2014 to December 2018	Panel regression analysis	Panel regression analysis finds that a retail price quote partially passes through 43% to 47% of a wholesale price forecast changes and embodies a risk premium that increases with wholesale price forecast volatility.
6	Kuik, F., Adolfsen, J. F., Lis, E. M., & Meyler, A. (2022). Energy price developments in and out of the COVID-19 pandemic – from commodity prices to consumer prices. ECB Economic Bulletin, Issue 4	Euro Area	-	BVARs and ECM models	On average about 10-12% of the increase in natural gas prices is passed on to consumer gas prices in the euro area after one year.

#	Paper:	Region:	Data:	Methodology / Type	Findings
7	European Commission. (2022). Euro Area and EU Outlook: Winter 2022 (Interim) Forecast (Institutional Paper 169). European Commission doi: 10.2765/333044	EU Member States	-	ARDL model	About 13% of an increase in natural gas prices is passed on to consumer gas prices after 12 months

9.2. Methodology

In the literature review, numerous studies have been collected. The most commonly used econometric techniques for estimating the factors contributing to changes in electricity and natural gas prices are the Error Correction Model (ECM), Auto-Regressive Distributed Lag (ARDL), and panel data analysis. The ARDL or Non-linear ARDL (NARDL) models is often used to estimate the speed and magnitude of the pass-through from wholesale to retail prices[541],[542],[543].

9.2.1. Methodology on factors contributing to increases in energy prices.

In this study, we investigate the factors driving changes in energy prices, with a specific focus on electricity and natural gas prices.

Electricity prices

For the electricity prices, we conduct two separate estimations: one utilizing hourly data and another using monthly data. In both estimations we consider two periods under examination in order to examine if there are differences of the drivers in electricity prices before and during/after the energy crisis.

Periods:

- Before energy crisis : 2018, January – 2021, April
- During/after energy crisis : 2021, May – 2024, February

Methodology on monthly estimation.

For the monthly data estimation, we focus on six countries: Austria, Belgium, France, Germany, Italy, and the Netherlands. These countries were selected due to data availability[544]. This section focuses on determining which are the key determinants that drive the electricity prices. To achieve this, a forecasting model has been developed to compare and test the alignment between estimated and actual electricity prices. The model estimation considers two periods: a) January 2018 to April 2021, and b) May 2021 to December 2022 to estimate the beta coefficients of the model. Based on this estimated model, we forecast electricity prices for the period from January 2023 to February 2024. The mean absolute percentage error (MAPE) between the actual and estimated electricity prices is calculated to evaluate the accuracy of a forecast model.

[541] *Nicholas Apergis, Grigorios Vouzavalis, Asymmetric pass through of oil prices to gasoline prices: Evidence from a new country sample, Energy Policy, Volume 114,2018, Pages 519-528,ISSN 0301-4215,https://doi.org/10.1016/j.enpol.2017.12.046.*
[542] *Burns, Kelly, Mountain, Bruce (2021). Do wholesale electricity prices pass-through to consumers in contestable retail electricity markets? An examination in Victoria Australia. Working Paper. Victoria Energy Policy Centre, Victoria University, Melbourne, Australia.*
[543] *Carabalí , Jaime & Meneses , Luis & Perez, Alex & Rodriguez, Manuel, 2022. "Retail Prices of Gasoline and Asymmetric Adjustment to Wholesale Prices in Colombia," Journal of Economic Development, The Economic Research Institute, Chung-Ang University, vol. 47(3), pages 73-105, September.*
[544] *The remaining EU-27 countries lack available data on natural gas prices.*

The mathematical formulation of the model is:

$$D\left(\left(P_{WELE_t}\right)\right) = \beta_0 + \beta_1 * D(P_{WNG_t}) + \beta_2 * \log(P_{CP_t}) + \beta_3 * \log(A_{ELE_t}) + \beta_4 * HDD^{545}{}_t + \beta_5 * SHR\_WND_t + U_t$$

Or for countries with nuclear power:

$$D\left(\left(P_{WELE_t}\right)\right) = \beta_0 + \beta_1 * D(P_{WNG_t}) + \beta_2 * \log(P_{CP_t}) + \beta_3 * \log(A_{ELE_t}) + \beta_4 * HDD_t + \beta_5 * SHR_{WND_t} + \beta_6 * SHR_{NUC_t} + U_t$$

Where:

Table 49: definition of the variables for monthly estimation of electricity prices.

Variable	Description
P_{WELE_t}	Wholesale electricity price - €/MWh
P_{WNG_t}	Wholesale natural gas price - €/MWh
P_{CP_t}	Allowance price - €/tonCO2
A_{ELE_t}	Total electricity generation - MWh
HDD	Heating degree days indicators – number
CDD	Cooling degree days indicators - number
SHR_WND_t	Share of wind to power generation - %
SHR_{NUC_t}	Share of nuclear to power generation - %
D()	Stands for the monthly difference
U_t	Error term

Methodology on hourly estimation.

For the hourly estimation, we utilized data for electricity prices and power generation by fuel type and by country from ENTSOE[546] and hourly natural gas prices and allowance prices from EEX[547]. The countries considered are EU-27 member states, excluding Cyprus, Luxembourg, and Malta.

We conducted 24 estimations for each hour of the day to capture the primary drivers influencing electricity prices more accurately throughout the day. The mathematical formulation of the model for each country is:

[545] *CDD for countries for Italy and France.*
[546] *https://www.entsoe.eu/data/power-stats/*
[547] *https://www.eex.com/en/market-data/environmentals/futures (Allowance price) and https://www.eex.com/en/market-data/natural-gas/futures#%7B%22snippetpicker%22%3A%22292%22%7D (natural gas price)*

$$P_{WELE_t} = \beta_0 + \beta_1 * Net_{load_t} + \beta_2 * P_{CP_t} + \beta_3 * P_{WNG_t} + \beta_4 * SHR_{GAS_t} + \beta_5 * SHR_{RES_t} + \beta_6 * NUC\_UAV_t + U_t$$

Where:

Table 50: Definition of the variables for hourly estimation of electricity prices.

Variable	Description
P_{WELE_t}	Wholesale electricity price[548] - €/MWh
Net_{load_t}	Power generation from fossil fuels (Coal, Oil & Gas) GWh
P_{WNG_t}	TTF (Title Transfers Front Month HHV[549] - €/MWh)
P_{CP_t}	Allowance price - €/tonCO2
SHR_RES_t	Share of renewable energy[550] to power generation - %
SHR_{GAS_t}	Share of gas to power generation - %
NUC_UAV_t	Nuclear unavailability's (planned or forced) – MWh unavailable in an hour
U_t	Error term

Natural gas prices

For the natural gas the analysis focuses on monthly data from Austria , Belgium, France, Germany, Italy and Netherlands[551]. We apply OLS regression methodology to be able to analyse the factors that contribute to changes in the wholesale natural gas prices. To examine if the drivers of the wholesale natural gas prices changed after the energy crisis, the estimations focus on two different time periods:

Periods:

- Before energy crisis : 2018, January – 2021, April
- During/after energy crisis : 2021, May – 2024, February

The mathematical formulation of the model is:

$$P_{WNG_t} = \beta_0 + \beta_1 * \log(\mathrm{P}_{\mathrm{CP}_t}) + \beta_2 * \log(\mathrm{IMP}_{\mathrm{NG}_t}) + \beta_3 * \log(\mathrm{A}_{\mathrm{NG}_t}) + \beta_4 * \log(\mathrm{NG}_{\mathrm{STRG}_t}) + \beta_5 * \log\left(\mathrm{P}_{\mathrm{CO}_{\mathrm{BRENT}_t}}\right) + \beta_6 * \mathrm{CDD}_t + \beta_7 * \mathrm{HDD}_t + U_t$$

Where:

Table 51: Definition of the variables for monthly estimation of electricity prices.

Variable	Description
P_{WNG_t}	Wholesale natural gas price - €/MWh
P_{CP_t}	Allowance price - €/tonCO2
$\mathrm{IMP}_{\mathrm{NG}_t}$	Natural gas imports - mcm
$\mathrm{A}_{\mathrm{NG}_t}$	Natural gas production - mcm

548 *The perimeter of electricity prices is on bidding zoned (BZN) – ENTSOE.*
549 *High heating value*
550 *Solar, Wind, Geothermal, Biomass & Hydro.*
551 *The remaining EU-27 countries lack available data on natural gas prices.*

Variable	Description
NG_{STRG_t}	Natural gas storage - TWh
$P_{CO_{BRENT}t}$	crude oil prices – Brent - €/bbl
CDD_t and HDD_t	cooling and heating degree days indicators - number
U_t	Error term

9.2.2. Methodology on speed and magnitude of pass-through rate of wholesale to retail electricity price

In this study, for estimating the speed and the magnitude of the pass-through rate from wholesale to retail electricity and natural gas prices the Non-linear Auto-Regressive Distributed Lag (NARDL) has been used. Shin and Yu (2014)[552] suggested a method for modelling asymmetric cointegration and dynamic multipliers in a NARDL framework. The approach introduces short- and long-run nonlinearities via positive and negative partial sum decompositions of the explanatory variables. The model is used in econometrics to capture and analyse asymmetric relationships between variables over time. This model allows for the examination of both short-term and long-term asymmetries in the relationships among the variables. For this study this means it can capture the different impacts that an increase versus a decrease in the wholesale price might have on the retail price.

Based on the data, several observations can be made regarding data unavailability for the various countries and variables. In summary, the availability of data varies between countries and variables. Some countries like Belgium, France, Germany, Italy, Netherlands, and the USA have complete data for all variables, while others like Russia, India, and China have significant gaps in data availability. The most common gaps are in the wholesale natural gas prices and, to a lesser extent, wholesale electricity prices.

Table 52:: Data availability (0 = "No", 1 = "Yes")

Country	P_{HELE_T}	P_{IELE_T}	P_{HNG_T}	P_{ING_T}	P_{WELE_T}	P_{WNG_T}
Austria	1	1	1	1	0	1
Belgium	1	1	1	1	1	1
Bulgaria	1	1	1	1	1	0
Croatia	1	1	1	1	1	0
Czechia	1	1	1	1	1	0
Denmark	1	0	1	0	1	0
Estonia	1	1	1	1	1	0
Finland	1	1	0	0	1	0
France	1	1	1	1	1	1
Germany	1	1	1	1	1	1
Greece	1	1	1	1	1	0
Hungary	1	1	1	1	1	0
Ireland	1	1	1	1	0	0
Italy	1	1	1	1	1	1
Latvia	1	1	1	1	1	0
Lithuania	1	1	1	1	1	0
Netherlands	1	1	1	1	1	1

[552] *Shin, Yongcheol and Yu, Byungchul and Greenwood-Nimmo, Matthew, Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework (October 21, 2013). Festschrift*

Country	P_{HELE_T}	P_{IELE_T}	P_{HNG_T}	P_{ING_T}	P_{WELE_T}	P_{WNG_T}
Poland	1	1	1	1	1	0
Portugal	1	1	1	1	0	0
Romania	1	1	1	1	1	0
Slovenia	1	1	1	1	1	0
Spain	1	1	1	1	1	0
Sweden	1	1	1	1	1	0
USA	1	1	1	1	1	1
Japan	1	1	1	1	1	0
Russia	0	0	0	0	1	0
South Korea	1	1	1	1	1	0
India	0	0	0	0	1	0
Cyprus	1	1	0	0	0	0
Luxembourg	1	1	1	1	0	0
Malta	1	1	0	0	0	0
Slovakia	1	1	1	1	0	0
China	0	0	0	0	0	0

The mathematical formulation for the long-run form of the NARDL (1,1) model is:

Industry electricity prices:

$$D\left(\left(P_{IELE_T}{}_t\right)\right) = \beta_0 + \rho * P_{IELE_T}{}_{t-1} + \beta_1 * P_{WELE_T}{}_{t-1}^{+} + \beta_2 * P_{WELE_T}{}_{t-1}^{-} + \beta_3 * \mathrm{D}\left(P_{WELE_T}{}_t^{+}\right) + \beta_4 * \mathrm{D}\left(P_{WELE_T}{}_t^{-}\right) + U_t$$

Household electricity prices:

$$D\left(\left(P_{HELE_T}{}_t\right)\right) = \beta_0 + \rho * \left(P_{HELE_T}{}_{t-1}\right) + \beta_1 * \left(P_{WELE_T}{}_{t-1}^{+}\right) + \beta_2 * \left(P_{WELE_T}{}_{t-1}^{-}\right) + \beta_3 * \mathrm{D}\left(P_{WELE_T}{}_t^{+}\right) + \beta_4 * \mathrm{D}\left(P_{WELE_T}{}_t^{-}\right) + U_t$$

Industry natural gas prices:

$$D\left(\left(P_{ING_T}{}_t\right)\right) = \beta_0 + \rho * \left(P_{ING}{}_{t-1}\right) + \beta_1 * \left(P_{WNG_T}{}_{t-1}^{+}\right) + \beta_2 * \left(P_{WNG}{}_{t-1}^{-}\right) + \beta_3 * \mathrm{D}\left(P_{WNG_T}{}_t^{+}\right) + \beta_4 * \mathrm{D}\left(P_{WNG_T}{}_t^{-}\right) + U_t$$

Household natural gas prices:

$$D\left(\left(P_{HNG_T}{}_t\right)\right) = \beta_0 + \rho * \left(P_{HNG}{}_{t-1}\right) + \beta_1 * \left(P_{WNG_T}{}_{t-1}^{+}\right) + \beta_2 * \left(P_{WNG}{}_{t-1}^{-}\right) + \beta_3 * \mathrm{D}\left(P_{WNG_T}{}_t^{+}\right) + \beta_4 * \mathrm{D}\left(P_{WNG_T}{}_t^{-}\right) + U_t$$

Where:

Table 53: Description of the variables used.

Variable	Description
P_{IELE_T}	Electricity price in industry (incl. taxes) - €/MWh
P_{HELE_T}	Electricity price in households (incl. taxes) - €/MWh
P_{ING_T}	Natural gas price in industry (incl. taxes) - €/MWh
P_{HNG_T}	Natural gas price in households (incl. taxes) - €/MWh
$P_{WELE_T}{}^{+} = \sum_{i=1}^{t} \max\left(D(P_{WELE_{T}}{}_{i}), 0\right)$	Partial sum processes of positive changes
$P_{WELE_T}{}^{-} = \sum_{i=1}^{t} \min\left(D(P_{WELE_{T}}{}_{i}), 0\right)$	Partial sum processes of negative changes
P_{WELE_T}	Wholesale electricity price - €/MWh
P_{WNG_T}	Wholesale natural gas price - €/MWh
D()	Stands for the monthly difference
U_t	Error term

The estimation of the parameters $-\frac{B_1}{\rho}$ (mentioned as "Coef. Positive" in the results) and $-\frac{B_2}{\rho}$ (mentioned as "Coef. Negative" in the results) are the asymmetric long run estimates (magnitude of the pass-through rate) while ρ defines the speed of adjustment.

These models have been estimated using monthly data for three different periods to determine if the speed and magnitude of the pass-through rate vary before COVID, after & during COVID, and after & during the energy crisis.

Additionally, the correlation between the concentration ratio of the largest electricity company (used as a proxy for market power) and the speed and magnitude of the pass-through rate has been examined. For the electricity price the countries examined are the EU Member States[553], Japan, Korea and United States while for the natural gas prices the analysis focus on Austria, Belgium, France, Germany, Italy, Netherlands, Spain and United States.

Table 54: monthly data used by model period.

Model	Monthly data used
Before Covid	2016 (1st month) – 2019 (12th month)
After & During Covid	2020 (1st month) – 2024 (2nd month)
After & During energy crisis	2021 (5th month) – 2024 (2nd month)

References:

Shin, Yongcheol and Yu, Byungchul and Greenwood-Nimmo, Matthew, Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework (October 21, 2013). Festschrift

[553] *Except Portugal, Cyprus, Luxembourg, Malta, Slovakia due to data unavailability.*

9.3. Results

9.3.1. Results on impact in wholesale electricity prices

Monthly data

The following graphs illustrate the alignment between actual and estimated electricity prices across two time periods: before the energy crisis (BEC) and during/after the energy crisis (AEC). The actual data is shown in grey, while the estimated values are represented by dotted lines (blue dashed line for BEC and orange dashed line for AEC).

After examination of the below graphs (from Figure 266 to Figure 271), we observe that the before and after/during energy crisis models have deviations of the real prices in different countries (except Austria). The natural gas price is statistically significant in all cases examined, whereas the other explanatory variables yield mixed results. Including variables that are not statistically significant positively affects the residuals between the actual and estimated electricity prices. Based on this observation, we re-ran the models (both before and after the energy crisis) using only one variable—the price of natural gas. This adjustment resulted in a much better fit with the real data in both models. These results are illustrated in the following graphs (from Figure 7 to Figure 12).

Full model graphs (inclusion of all variables)

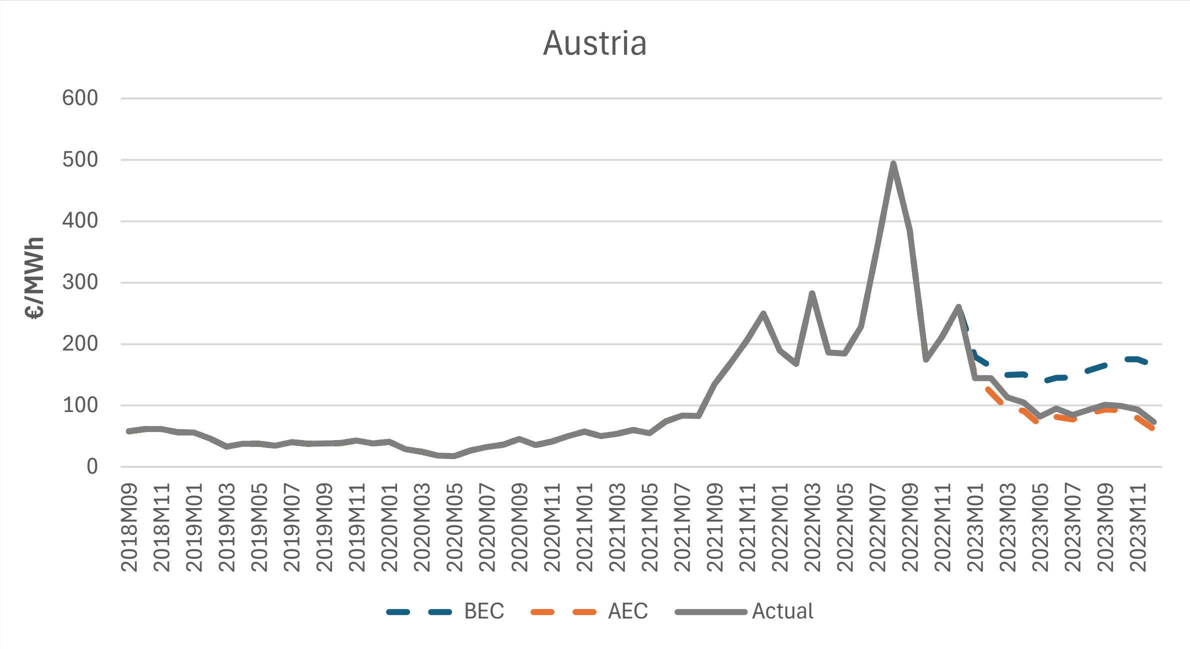

Figure 266: Estimating and actual electricity prices in Austria.

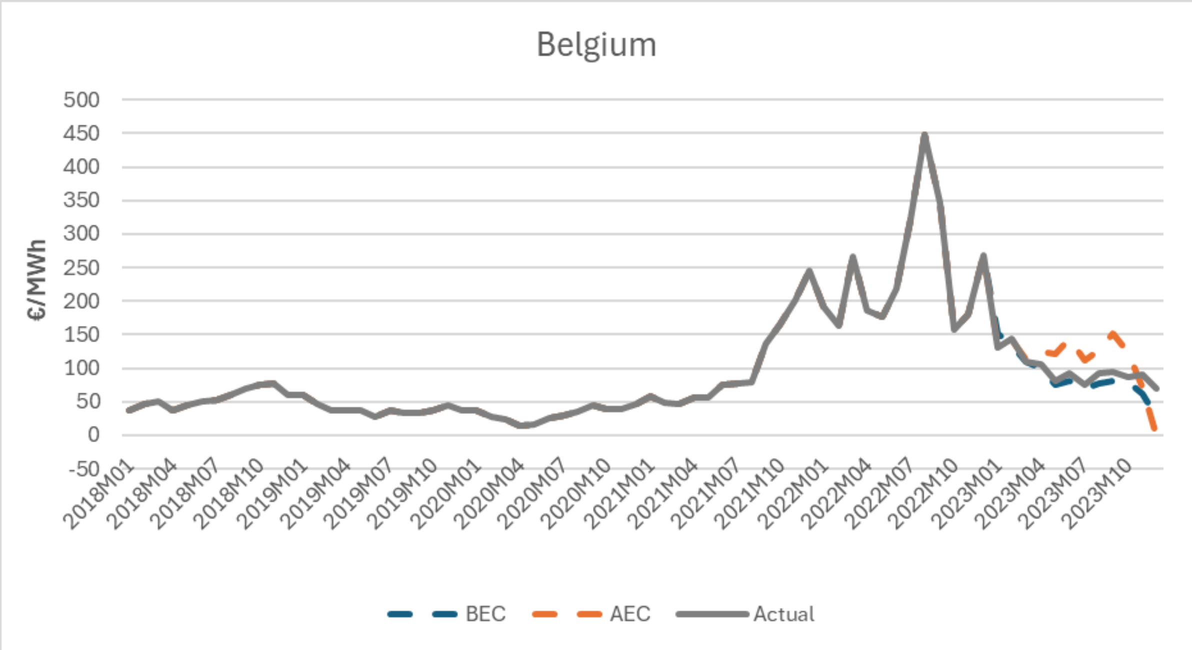

Figure 267: Estimating and actual electricity prices in Belgium.

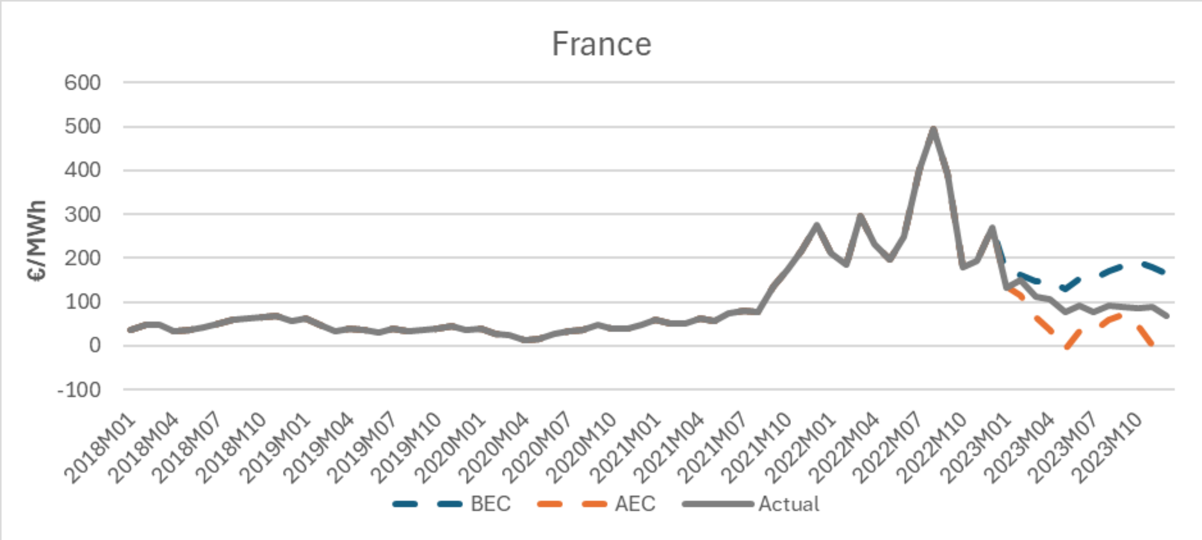

Figure 268: Estimating and actual electricity prices in France.

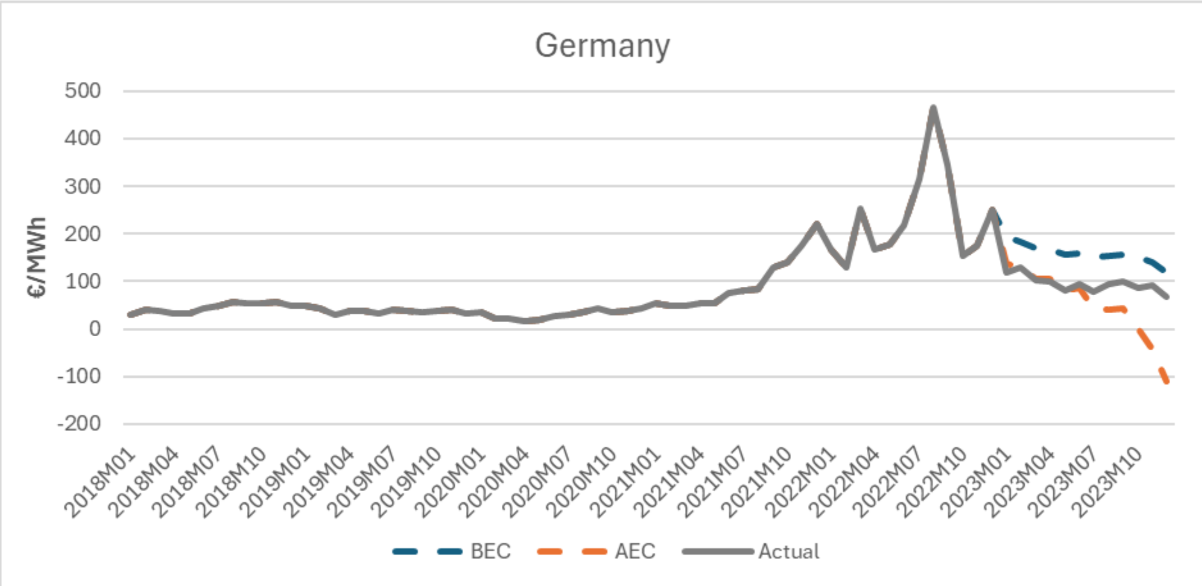

Figure 269: Estimating and actual electricity prices in Germany.

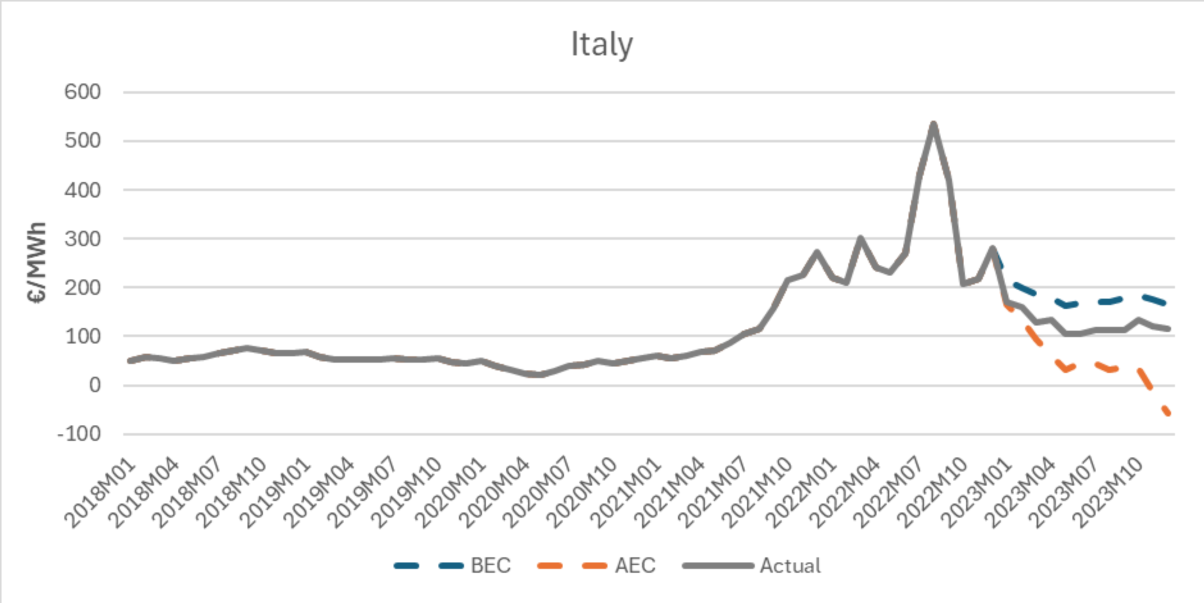

Figure 270: Estimating and actual electricity prices in Italy.

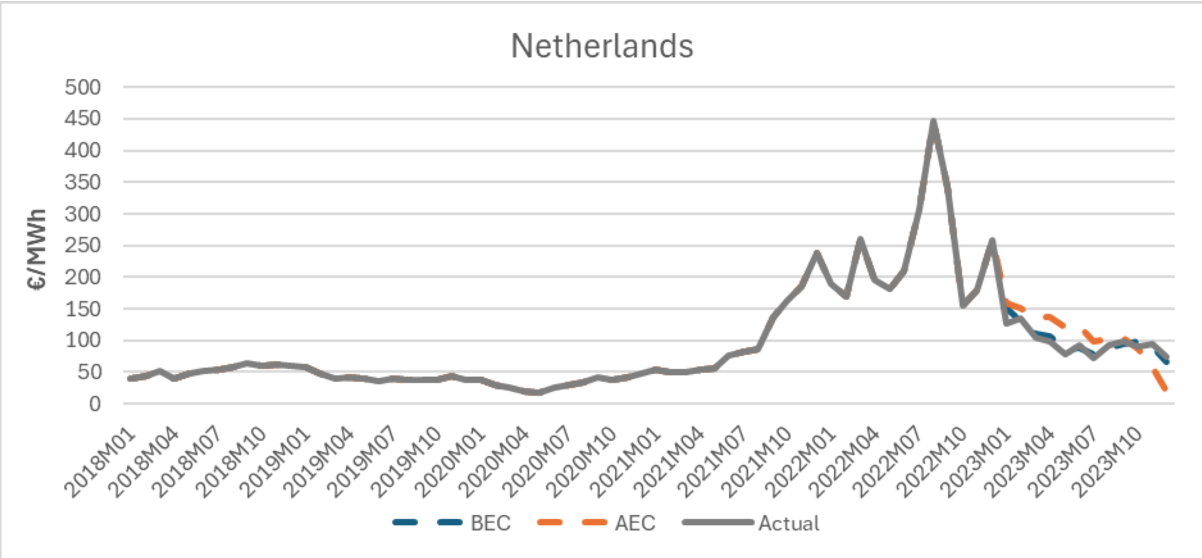

Figure 271: Estimating and actual electricity prices in Netherlands.

Model graphs (inclusion only of the natural gas price)

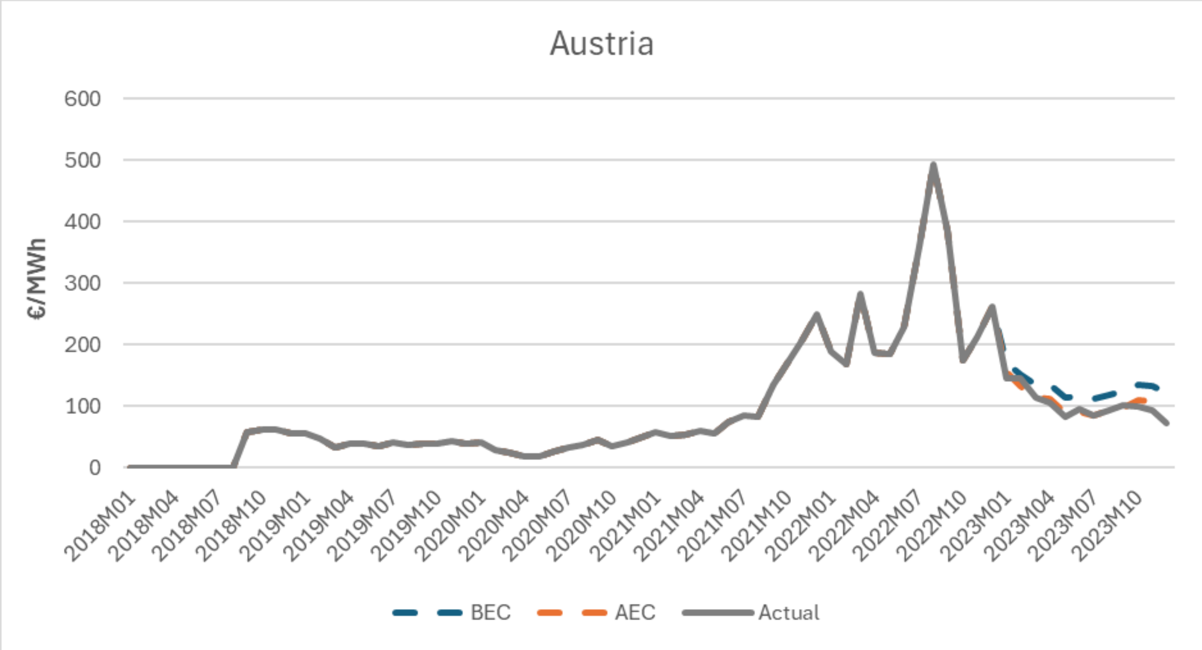

Figure 272: Estimating and actual electricity prices in Austria.

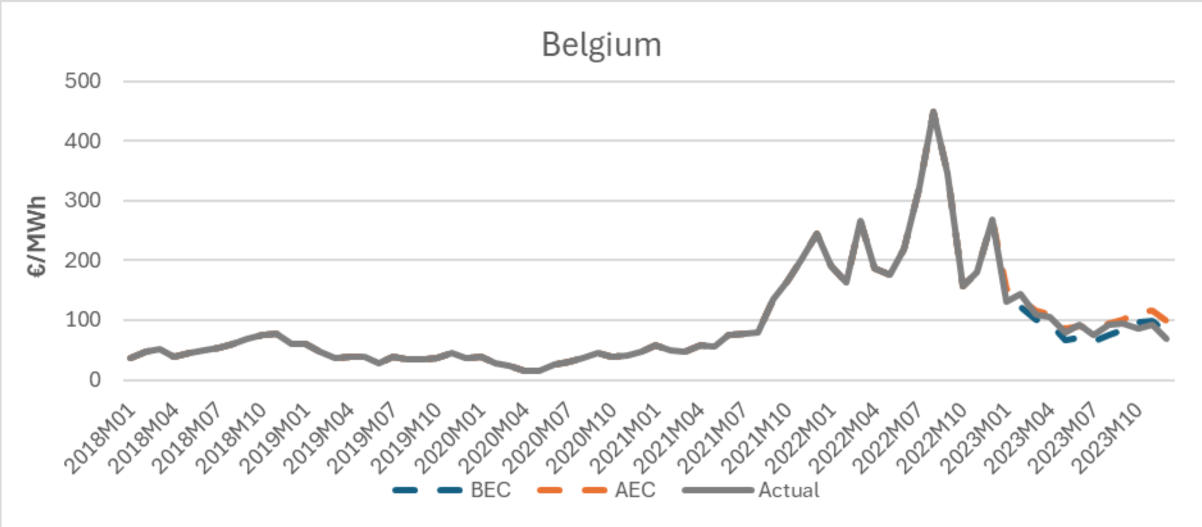

Figure 273: Estimating and actual electricity prices in Belgium.

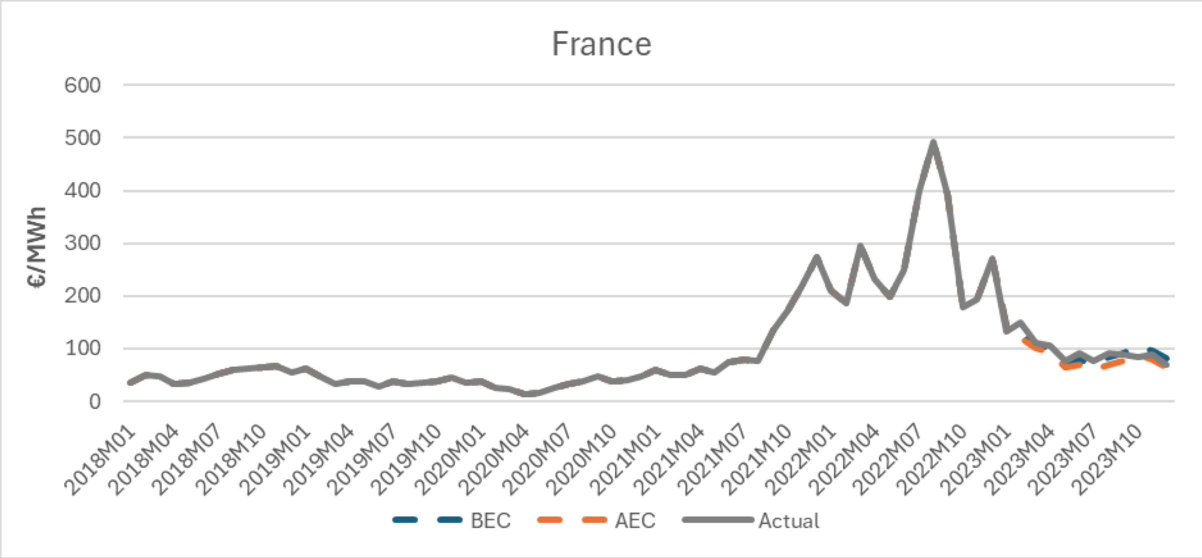

Figure 274: Estimating and actual electricity prices in France.

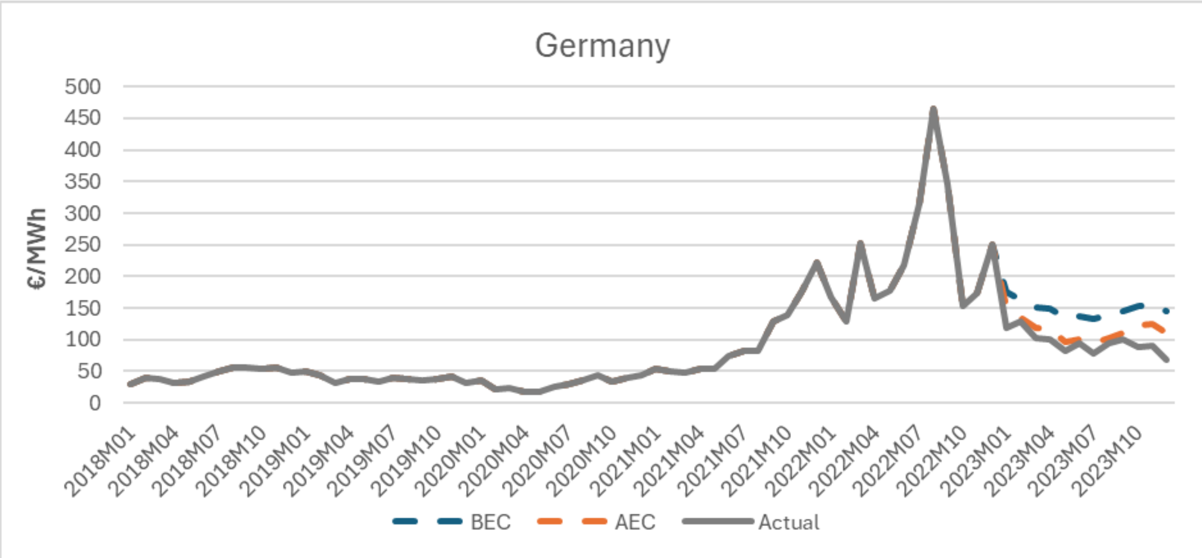

Figure 275: Estimating and actual electricity prices in Germany.

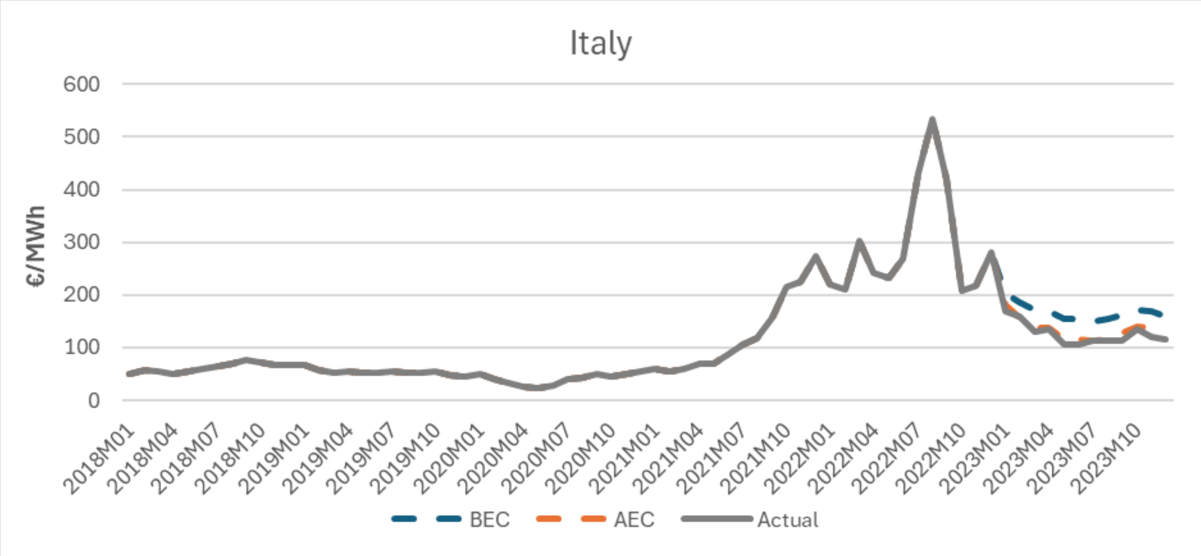

Figure 276: Estimating and actual electricity prices in Italy.

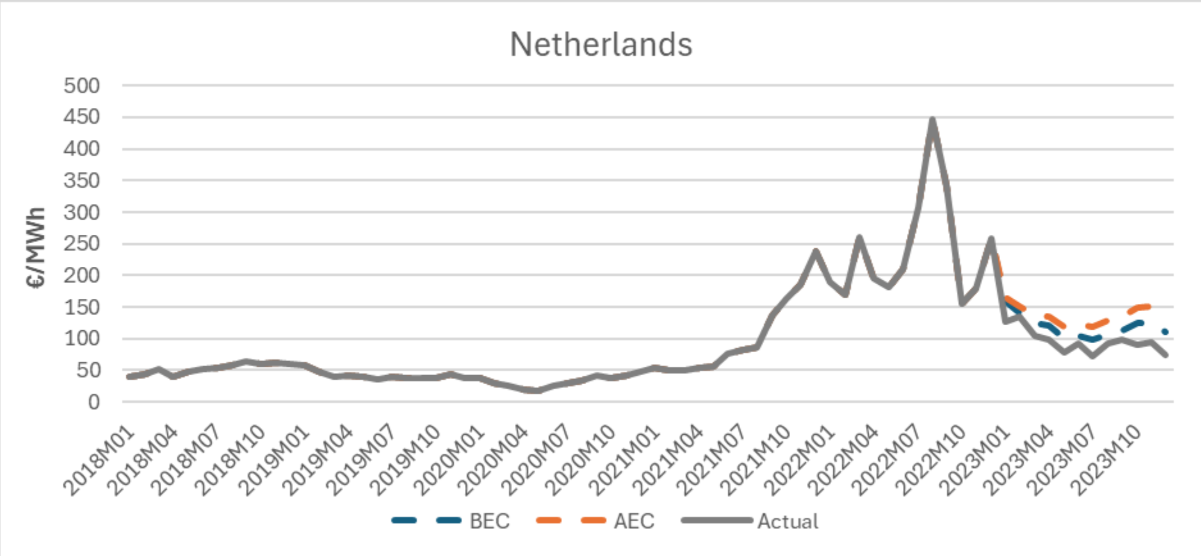

Figure 277: Estimating and actual electricity prices in Netherlands.

MAPE and estimates

Table 55 shows the mean absolute percentage error of the forecasting models by country and period examined. MAPE is defined as the average of the absolute percentage errors between the forecasted and actual values. When incorporating all variables into the model (Full model), we observe high percentage errors ranging from 7.7% to 74.7%. In contrast, including only the price of natural gas results in significantly lower mean absolute percentage errors. This suggests that the additional variables do not contribute statistically significant improvements and actually increase the mean absolute percentage error.

In Table 56 we observe a positive relationship between natural gas and electricity prices. Based on a pair-wise hypothesis testing, during and after the energy crisis, the estimated coefficient is higher compared to the period before the energy crisis in Austria, Germany and Italy while the opposite stand for Belgium and Netherlands (Table 55 – significance level of 5%). Specifically, during and after the energy crisis, a 1 €/MWh increase in natural gas prices from the previous month results is correlated with an increase of 1.6-2.4 €/MWh in electricity prices across countries.

Table 55: Mean Absolute Percentage Error (MAPE) of the forecasting models (%).

	Full model		Model only NG price	
	EC	BEC	EC	BEC
AT	11.8	60.7	8.0	32.6
BE	36.9	15.4	14.3	13.3
FR	60.1	74.7	16.5	9.8
DE	58.3	67.8	25.3	63.5
IT	63.4	44.3	8.7	37.7
NL	30.8	7.7	30.8	7.7

Table 56: Estimated coefficient of the natural gas price.

	D(P_WNG)	
	EC	BEC
AT	2.0	1.8
BE	2.2	2.5
FR	2.6	2.5
DE	1.9	1.4
IT	2.0	1.5
NL	1.7	1.8

Table 57: Hypothesis testing for the estimated coefficient [Ho: COEFaec = COEFbec, H1: COEFaec >COEFbec (column2) or H1: COEFbec >COEFaec (column3)].

	Coef. (AEC>BEC)[554]	Coef. (BEC>AEC)[555]
AT	yes	no
BE	no	yes
FR	no	no
DE	yes	no
IT	yes	no
NL	no	yes

The inclusion of additional variables may not yield statistically significant improvements and can, in fact, increase the mean absolute percentage error. Aggregating or summarizing data over longer periods can diminish the visibility of subtle yet potentially significant effects of certain variables. This can lead to an underestimation of their impact or cause them to appear statistically insignificant. Based on this, analyzing electricity prices using hourly data is crucial for understanding the detailed patterns and variations in electricity pricing.

[554] *Higher estimated coefficient in the during and after the energy crisis period compared to before energy crisis period.*
[555] *Lower estimated coefficient in the during and after the energy crisis period compared to before energy crisis period.*

Hourly data

This section presents the factors contributing to changes in electricity prices based on hourly data. The estimation has been conducted for each hour to decompose the effects by hour[556]. Figure 13 and Figure 14 show the average hourly electricity prices during and after the energy crisis and before the energy crisis, respectively. The figures indicate that the pattern between the two periods remains consistent, with electricity prices peaking between 5:00-7:00 and 17:00-19:00. However, the variability within these hours is higher during and after the energy crisis. Before the energy crisis, the range was from 20 €/MWh to 70 €/MWh, whereas during and after the energy crisis, the range increased significantly, from 50 €/MWh to 240 €/MWh, with the maximum hourly electricity prices even exceeding 800 €/MWh.

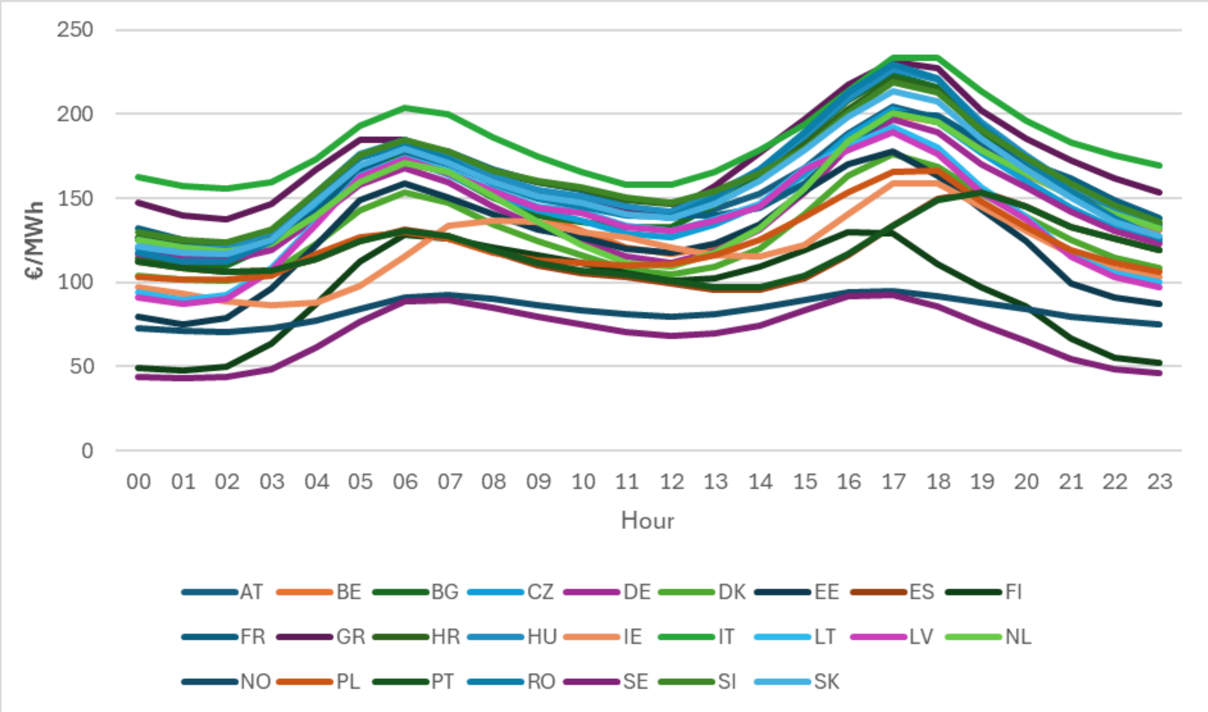

Figure 278: Wholeasale average electricity price by hour in the period 2021m05-2024m05.

[556] *The hourly estimation has been done by using data for a specific hour for each day of the period examined.*

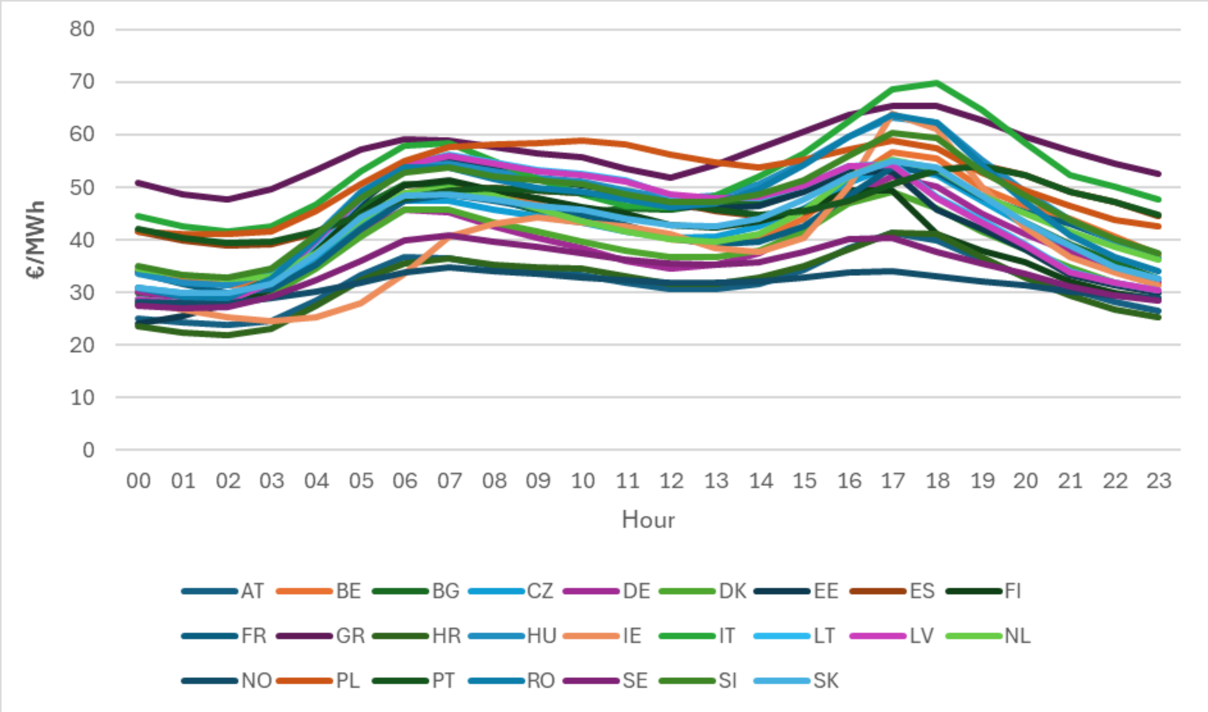

Figure 279: Wholeasale average electricity price by hour in the period 2018m01-2021m04.

The pattern of the wholesale electricity prices across hours is similar to the net load pattern. Figure 280 have the combo figure of electricity price and net load in France, Italy, Germany, Belgium, Spain and Portugal in the during and after energy crisis period, which is also similar pattern for the other EU-27 countries. We observe from the figure that the electricity prices and net load peak at the same hours and have the lowest values from 23:00 to 2:00 o'clock.

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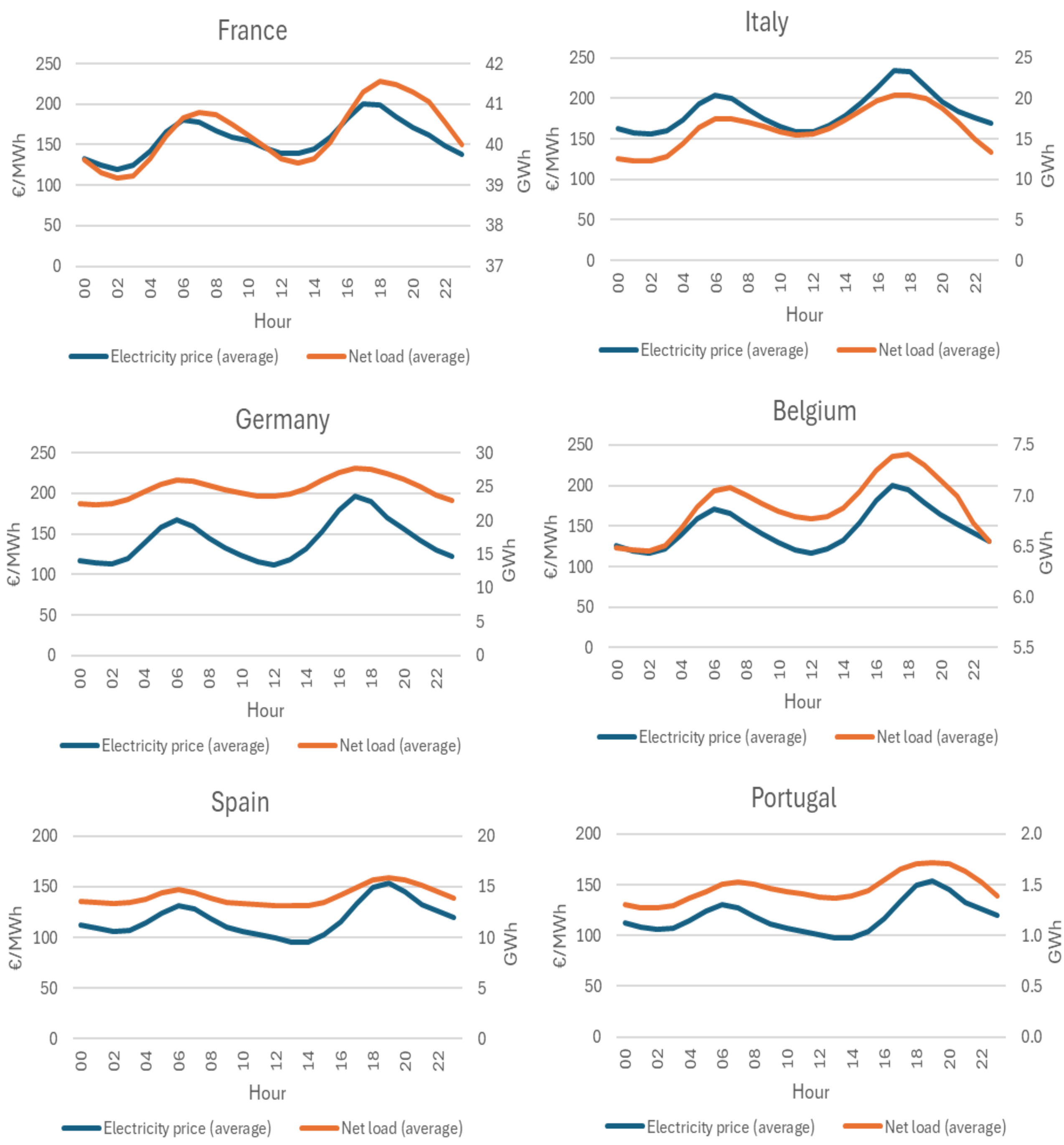

Figure 280: Average electricity price and average net load by country for each hour of the day .

Figure 16 shows the combo figure of electricity price and the share of renewable energy in France, Italy, Germany, Belgium, Spain and Portugal in the during and after energy crisis period. In general, electricity prices and the share of renewables in electricity generation exhibit opposite patterns across hours. However, this trend is not consistent across all countries, such as Portugal or other EU-27 countries. This also suggests that the share of fossil fuels follows a similar hourly pattern to electricity prices.

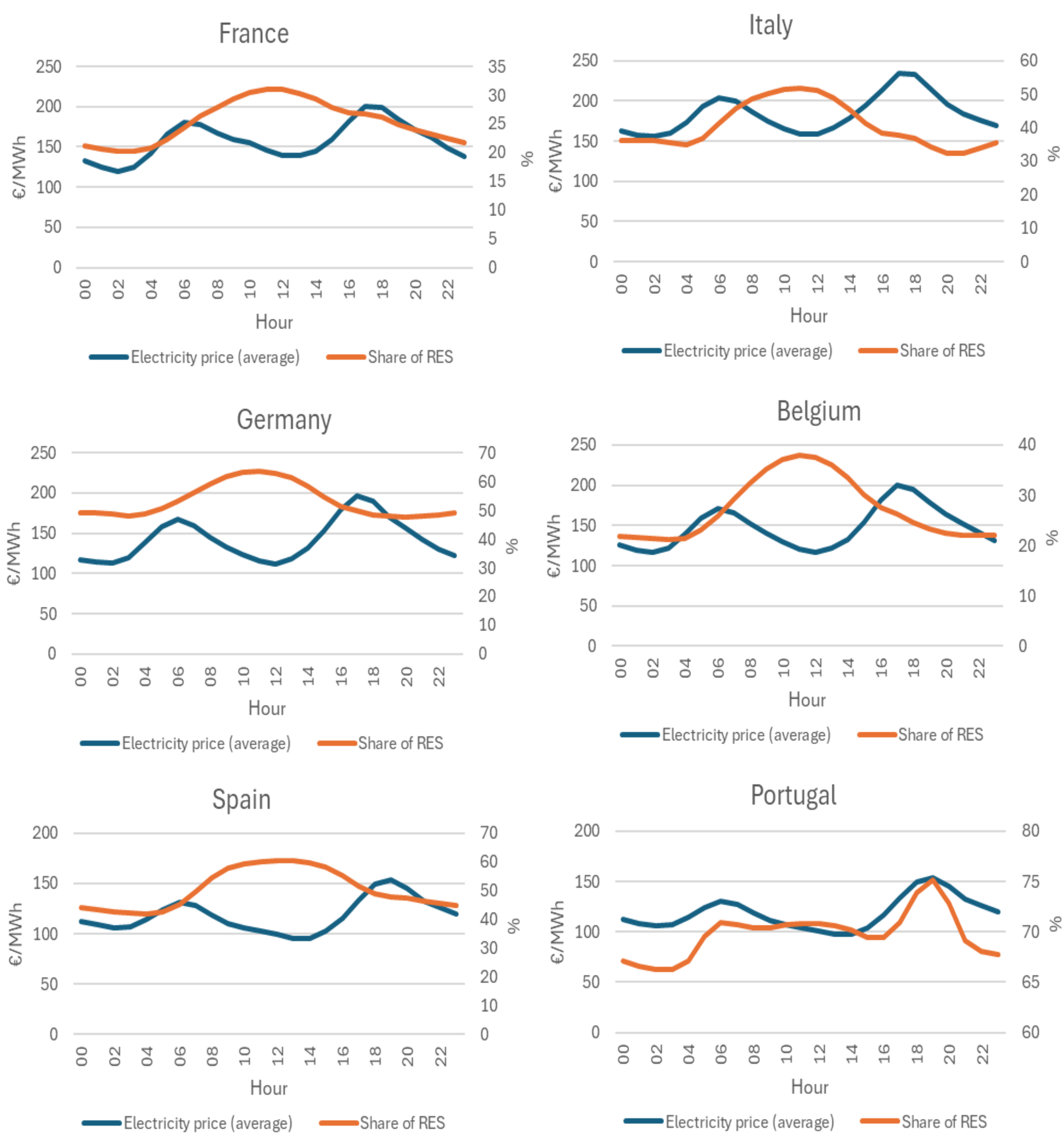

Figure 281: Average electricity price and average share of renewable energy (incl. hydro & biomass) by country for each hour of the day .

Net Load

Table 58 shows the t-statistic for the Net Load variable (to test if the variable is statistical significant). A low absolute value suggests that the coefficient is not significantly different from zero (we use significance level of 5%), and the variable may not have a meaningful impact on the dependent variable while high absolute value indicates that variable is statistical significant.

The table indicates that net load is statistically significant in most cases, with high absolute values during peak hours. This suggests that net load is an important factor contributing to changes in electricity prices. Table 59 shows the estimation of the coefficient in the during & after energy crisis period while Table 60 shows the estimation of the coefficient in the before energy crisis period. The impact of net load is higher in the during & after energy crisis period which can be explained:

- Supply Constraints due to Russia-Ukraine war.
- Higher peak demands as consumers and industries try to secure their energy needs. Meeting these peak demands often requires the use of more expensive and less efficient energy sources, increasing the net load impact on prices.

The numbers in Table 59 and Table 60 are interpret as follows:

- If the Net Load increase by 1 GWh for this country (e.g., "FR") at "x" o'clock (e.g., 01) with all the other variables of the model remaining constant the electricity price will increase by "y" €/MWh (e.g., 5.9 €/MWh).

Table 58: T-statistic in the estimation of the coefficient for the Net Load variable (Red number highlight no statistical significance estimates at significance level of 5%)

	FR	IT	DE	BE	ES	PT
00	4.4	4.5	3.9	2.0	5.8	4.8
01	5.9	3.4	3.5	2.4	5.5	3.5
02	4.2	2.8	4.1	1.7	5.4	3.0
03	1.9	2.1	4.9	1.0	5.3	2.7
04	0.8	4.3	4.1	0.8	6.6	4.2
05	3.4	9.5	0.6	0.5	9.9	8.0
06	5.5	13.1	3.5	4.5	13.2	13.1
07	11.2	11.8	4.9	7.2	12.7	17.6
08	12.0	9.4	2.2	7.4	10.6	18.3
09	9.8	7.5	0.3	6.0	8.8	15.5
10	7.9	6.4	0.2	4.5	7.8	11.6
11	7.5	6.8	0.5	3.5	7.0	9.2
12	6.5	8.0	1.3	3.8	6.5	8.4
13	7.8	8.9	1.1	4.4	6.6	7.4
14	8.0	11.1	0.9	5.3	6.9	7.5
15	8.8	13.8	0.3	5.2	6.7	8.6
16	9.6	13.8	0.8	6.5	6.7	12.1
17	7.1	8.5	4.3	3.6	8.0	14.8
18	5.2	7.3	6.8	2.0	9.3	14.6
19	3.1	9.0	7.2	1.8	9.2	10.0
20	0.2	8.5	7.6	0.2	8.4	7.8
21	0.4	8.3	4.8	2.9	8.0	8.7
22	0.9	4.9	7.7	0.3	6.9	4.9
23	4.0	7.4	4.1	2.3	6.3	6.8

Table 59: Estimation of the coefficient of the Net Load variable in the during & after energy crisis period.

	FR	IT	DE	BE	ES	PT
00	1.2	2.2	1.0	2.3	7.2	20.4
01	1.6	1.8	0.9	2.6	6.8	14.8
02	1.2	1.6	1.1	1.8	6.5	12.2
03	0.6	1.2	1.3	1.0	6.5	11.0
04	0.3	2.0	1.3	1.0	8.5	16.4
05	2.3	3.7	0.2	0.6	12.7	28.6
06	4.0	4.9	1.4	6.4	16.5	41.9
07	4.5	4.8	2.0	10.7	16.8	53.7
08	4.7	4.2	1.0	11.8	15.4	59.8
09	3.8	3.5	0.1	10.0	13.2	55.0
10	3.1	3.2	0.1	8.2	11.5	44.6
11	2.9	3.6	0.3	6.6	10.2	36.9
12	2.5	4.2	0.7	7.0	9.2	33.9
13	2.9	4.4	0.5	7.6	9.2	30.3
14	3.1	4.7	0.4	8.1	9.3	30.0
15	3.3	5.0	0.1	7.2	8.9	32.6
16	3.5	5.1	0.3	8.1	8.7	42.5
17	2.5	3.5	1.3	4.5	9.6	49.0
18	1.8	3.4	1.9	2.5	10.9	52.6
19	1.1	4.1	2.0	2.1	10.5	41.6
20	0.1	3.4	2.1	0.2	9.2	30.1
21	0.1	3.2	1.3	3.2	8.9	31.5
22	0.3	2.0	2.0	0.3	7.5	18.3
23	1.1	3.2	1.1	2.6	7.8	27.5

Table 60: Estimation of the coefficient of the Net Load variable in the before energy crisis period.

	FR	IT	DE	BE	ES	PT
00	0.8	1.6	0.5	1.7	1.3	1.4
01	1.3	1.6	0.5	1.4	1.1	0.7
02	1.4	1.7	0.5	1.1	1.5	0.8
03	1.6	1.8	0.5	1.3	1.5	1.1
04	1.8	2.1	0.5	1.0	1.8	3.4
05	2.2	2.0	0.9	2.5	2.3	5.1
06	2.6	2.1	1.2	3.7	2.7	5.8
07	1.9	1.9	1.2	4.1	2.4	5.5
08	2.2	1.5	0.9	3.6	2.1	5.3
09	2.0	1.3	0.6	2.6	1.7	4.9
10	1.7	1.0	0.5	2.0	1.5	4.4
11	1.7	1.1	0.5	1.9	1.3	4.0
12	2.0	1.4	0.7	2.6	1.3	4.0
13	2.2	1.6	0.8	3.0	1.4	4.0
14	2.0	1.6	0.8	3.0	1.5	4.2
15	1.7	1.6	0.6	2.3	1.6	4.4
16	1.4	1.6	0.6	2.8	1.6	4.6
17	1.8	1.3	0.3	2.9	1.5	4.6
18	1.4	1.1	0.2	1.7	1.3	4.1
19	0.5	1.0	0.1	0.7	1.1	3.5
20	0.0	1.1	0.0	0.7	1.3	4.0
21	0.2	1.2	0.3	0.2	1.3	3.6
22	0.3	1.4	0.2	0.6	1.0	2.7
23	0.8	1.7	0.4	1.5	1.3	3.3

Wholesale natural gas price

The Table 61 shows that the price of natural gas is statistically significant in all cases for the countries included in the table. This indicates that the price of natural gas is also an important factor that contributes to changes in the electricity prices.

Table 61: t-statistic in the estimation of the coefficient for the price of natural gas variable (Red number highlight no statistical significance estimates at significance level of 5%))

	FR	IT	DE	BE	ES	PT
00	45.8	75.1	44.9	48.4	10.9	13.9
01	43.5	70.4	43.8	47.2	10.5	13.5
02	41.3	69.1	44.1	48.2	10.7	13.9
03	41.9	73.8	47.4	51.1	10.6	13.9
04	40.9	80.2	48.1	52.8	9.7	13.2
05	24.7	88.8	47.9	54.4	8.9	13.4
06	25.0	89.1	48.6	53.0	8.8	14.1
07	45.7	79.9	46.7	48.1	8.2	14.5
08	46.1	72.1	41.7	43.7	6.9	13.7
09	46.0	71.8	37.1	39.9	6.5	12.7
10	46.3	69.6	32.8	34.1	7.1	12.5
11	42.7	62.5	30.4	31.4	8.0	13.3
12	39.3	61.7	28.5	32.6	7.7	12.7
13	38.4	64.4	31.5	36.2	7.2	11.7
14	40.6	73.6	37.2	42.9	6.7	11.3
15	47.2	85.9	48.4	53.9	7.0	11.2
16	54.1	89.7	58.8	63.5	8.5	12.4
17	57.6	93.0	61.8	66.7	10.2	15.0
18	55.0	85.5	63.6	63.3	12.7	18.4
19	50.0	79.3	60.4	62.6	14.5	19.0
20	48.5	81.9	58.3	63.8	14.2	17.6
21	47.4	83.6	54.4	58.2	12.4	15.9
22	48.0	83.0	50.5	56.6	13.4	16.2
23	48.3	83.3	47.7	50.9	11.8	14.7

Table 62: Estimation of the coefficient of the price of natural gas variable in the during & after energy crisis period.Table 63 present the estimated coefficients for natural gas prices during and after the energy crisis period, and before the energy crisis period, respectively. Generally, the impact of natural gas prices is highest during the hours when electricity prices peak (6:00 to 8:00 and 17:00 to 19:00). The coefficient of natural gas prices ranges from 0.2 to 2.4, indicating that when the price of natural gas increases by 1 €/MWh, with all other variables remaining constant, is correlated with increase in the electricity price by 0.2 to 2.4 €/MWh.

Table 62: Estimation of the coefficient of the price of natural gas variable in the during & after energy crisis period.

	FR	IT	DE	BE	ES	PT
00	1.4	1.7	1.3	1.3	0.4	0.4
01	1.4	1.7	1.3	1.2	0.4	0.4
02	1.3	1.7	1.3	1.2	0.4	0.4
03	1.4	1.7	1.4	1.3	0.4	0.4
04	1.6	1.9	1.7	1.5	0.3	0.4
05	1.8	2.0	2.0	1.7	0.3	0.4
06	2.0	2.0	2.0	1.7	0.3	0.5
07	2.1	1.9	1.8	1.6	0.3	0.5
08	2.0	1.7	1.6	1.4	0.2	0.5
09	2.0	1.7	1.5	1.3	0.2	0.4
10	2.0	1.7	1.3	1.1	0.2	0.4
11	1.9	1.6	1.2	1.1	0.3	0.4
12	1.8	1.6	1.2	1.1	0.2	0.4
13	1.8	1.7	1.3	1.2	0.2	0.4
14	1.8	1.8	1.4	1.3	0.2	0.3
15	2.0	2.0	1.8	1.6	0.2	0.3
16	2.2	2.2	2.1	1.9	0.3	0.4
17	2.4	2.4	2.3	2.1	0.3	0.5
18	2.3	2.3	2.2	2.0	0.4	0.7
19	2.1	2.3	2.0	1.8	0.5	0.7
20	1.9	2.1	1.8	1.7	0.5	0.6
21	1.8	2.0	1.6	1.5	0.4	0.5
22	1.6	1.9	1.5	1.4	0.4	0.5
23	1.5	1.8	1.4	1.3	0.4	0.5

Table 63: Estimation of the coefficient of the price of natural gas variable in before energy crisis period.

	FR	IT	DE	BE	ES	PT
00	1.4	1.3	0.3	1.6	1.5	1.4
01	1.3	1.2	0.2	1.5	1.5	1.4
02	1.2	1.2	0.3	1.5	1.5	1.4
03	1.3	1.2	0.3	1.5	1.5	1.4
04	1.5	1.3	0.4	1.6	1.6	1.4
05	1.8	1.5	0.4	1.8	1.6	1.5
06	2.0	1.7	0.5	2.0	1.6	1.6
07	2.1	1.7	0.7	2.1	1.7	1.7
08	2.0	1.7	0.8	2.2	1.8	1.7
09	1.9	1.6	0.8	2.2	1.7	1.7
10	1.9	1.5	0.8	2.2	1.7	1.6
11	1.8	1.4	0.8	2.1	1.6	1.5
12	1.7	1.4	0.8	2.1	1.6	1.5
13	1.6	1.5	0.8	2.0	1.6	1.5
14	1.7	1.6	0.8	1.9	1.6	1.5
15	1.8	1.7	0.9	1.9	1.6	1.5
16	2.1	1.8	1.2	2.1	1.6	1.6
17	2.3	1.6	1.2	2.2	1.7	1.7
18	2.2	1.3	1.1	2.2	1.8	1.8
19	2.0	1.4	0.9	1.9	1.8	1.8
20	1.8	1.4	0.7	1.8	1.6	1.6
21	1.8	1.5	0.7	1.9	1.6	1.6
22	1.7	1.2	0.5	1.8	1.6	1.5
23	1.5	1.3	0.4	1.7	1.6	1.5

Share of gas

The Table 64 shows that the share of natural gas in power generation is statistical significant in all countries included in the table except Portugal . This indicates that the share of natural gas in power generation is an important factor that contributes to changes in the electricity prices.

Table 64: t-statistic in the estimation of the coefficient for the share of natural gas in power generation variable (Red number highlight no statistical significance estimates at significance level of 5%).

	FR	IT	DE	BE	ES	PT
00	7.8	9.2	8.5	7.0	9.7	0.6
01	9.0	9.9	8.6	8.5	9.6	0.9
02	9.7	10.3	8.9	9.6	9.3	1.2
03	9.0	10.5	10.2	10.2	8.7	1.4
04	8.6	9.8	13.3	12.7	8.2	1.3
05	5.4	6.8	14.7	15.2	7.3	0.2
06	5.4	5.3	13.1	14.4	8.6	0.6
07	7.9	4.3	12.1	11.8	9.2	1.8
08	7.4	3.5	9.8	10.3	8.8	1.8
09	7.9	5.0	7.6	10.8	8.3	1.4
10	7.8	5.7	5.5	10.5	8.0	1.2
11	8.0	5.7	4.9	10.9	7.9	1.0
12	8.4	6.4	4.9	11.6	7.4	1.0
13	8.6	5.7	5.9	11.7	6.8	1.0
14	7.5	4.3	7.7	11.3	6.9	0.7
15	5.9	3.3	10.2	10.6	7.5	0.7
16	4.8	3.8	11.8	9.9	8.6	1.5
17	4.3	6.5	13.8	9.6	11.1	1.3
18	5.5	5.4	15.4	8.6	11.6	1.1
19	5.1	5.2	13.1	7.1	10.9	0.9
20	5.2	4.8	10.2	6.7	11.6	0.1
21	5.5	5.5	8.8	4.4	11.4	0.5
22	6.4	8.8	8.5	6.4	10.3	0.4
23	7.4	8.4	9.1	6.8	9.6	0.4

Table 65 and Table 66 show the estimations of the coefficients of natural gas prices during and after the energy crisis period, and before the energy crisis period, respectively. The impact of the share of gas in power generation on electricity prices is higher during and after the energy crisis, primarily due to supply constraints and elevated natural gas prices during the crisis. In the during and after energy crisis period, the impact ranges from 0.2 to 7.6. This means an increase of 1% in the share of gas in power generation, with all other variables remaining constant, is associated with increases of 0.2 to 7.6 €/MWh in the electricity price. In contrast, before the energy crisis period, the impact ranges from 0 to 1.8 €/MWh.

Table 65: Estimation of the coefficient of the share of natural gas in power generation variable in the during & after energy crisis period.

	FR	IT	DE	BE	ES	PT
00	3.4	1.9	2.6	1.4	4.9	0.9
01	3.9	2.0	2.6	1.7	4.7	1.4
02	4.2	2.2	2.7	1.9	4.4	1.9
03	4.0	2.2	3.1	1.9	4.1	2.1
04	4.7	2.3	5.0	2.7	4.1	1.9
05	5.7	1.8	6.5	3.4	4.1	0.4
06	6.2	1.6	6.2	3.5	5.3	1.1
07	5.2	1.5	5.9	3.0	6.2	2.9
08	4.8	1.3	5.2	2.7	6.5	2.6
09	5.1	1.8	4.3	3.0	6.2	1.9
10	5.1	2.2	3.3	3.1	6.0	1.7
11	5.4	2.3	2.9	3.4	5.8	1.4
12	6.1	2.6	3.0	3.6	5.4	1.4
13	6.1	2.3	3.4	3.4	4.9	1.5
14	5.0	1.6	4.0	2.9	4.8	1.0
15	3.7	1.1	4.6	2.6	5.2	1.1
16	3.0	1.3	4.6	2.3	5.9	2.4
17	2.8	2.4	5.3	2.2	7.3	2.2
18	3.6	2.1	5.4	2.0	7.6	2.1
19	3.3	2.0	4.4	1.5	7.0	1.7
20	3.0	1.5	3.2	1.3	7.1	0.2
21	3.1	1.4	2.6	0.8	6.5	0.8
22	3.1	2.0	2.6	1.2	5.4	0.7
23	3.3	1.6	2.8	1.4	5.2	0.6

Table 66: Estimation of the coefficient of the share of natural gas in power generation variable in the before energy crisis period.

	FR	IT	DE	BE	ES	PT
00	0.7	0.2	0.6	0.5	0.1	0.0
01	0.5	0.3	0.7	0.5	0.0	0.0
02	0.4	0.3	0.6	0.5	0.1	0.1
03	0.1	0.3	0.6	0.5	0.1	0.1
04	0.2	0.3	0.5	0.6	0.1	0.1
05	0.6	0.2	0.3	0.9	0.0	0.1
06	0.8	0.2	0.2	1.0	0.1	0.1
07	1.6	0.1	0.1	1.0	0.1	0.1
08	1.2	0.0	0.2	1.1	0.1	0.0
09	1.2	0.1	0.3	1.0	0.1	0.0
10	1.3	0.2	0.4	1.0	0.1	0.0
11	1.3	0.2	0.4	0.9	0.1	0.0
12	1.2	0.3	0.5	0.9	0.0	0.1
13	0.9	0.2	0.4	0.9	0.0	0.1
14	1.1	0.1	0.3	0.8	0.1	0.0
15	1.3	0.0	0.3	0.9	0.1	0.0
16	1.8	0.0	0.5	1.0	0.0	0.0
17	1.8	0.1	0.4	1.3	0.0	0.0
18	1.7	0.3	0.2	1.0	0.0	0.0
19	1.6	0.2	0.2	0.7	0.0	0.0
20	1.3	0.2	0.5	0.6	0.0	0.1
21	1.2	0.2	0.4	0.6	0.0	0.1
22	1.1	0.5	0.5	0.6	0.1	0.0
23	0.8	0.3	0.6	0.5	0.0	0.1

Nuclear unavailability

Figure 17 presents the estimated coefficients for the nuclear unavailability variable and the share of renewable energy in electricity generation in France. The figure shows that the highest impact of nuclear unavailability occurs during the hours when net load is at its peak and the share of renewable energy is not at its highest value within the day. An increase of 1 MWh in nuclear unavailability results in an increase in electricity prices ranging from 0 to 0.002 €/MWh, ceteris paribus.

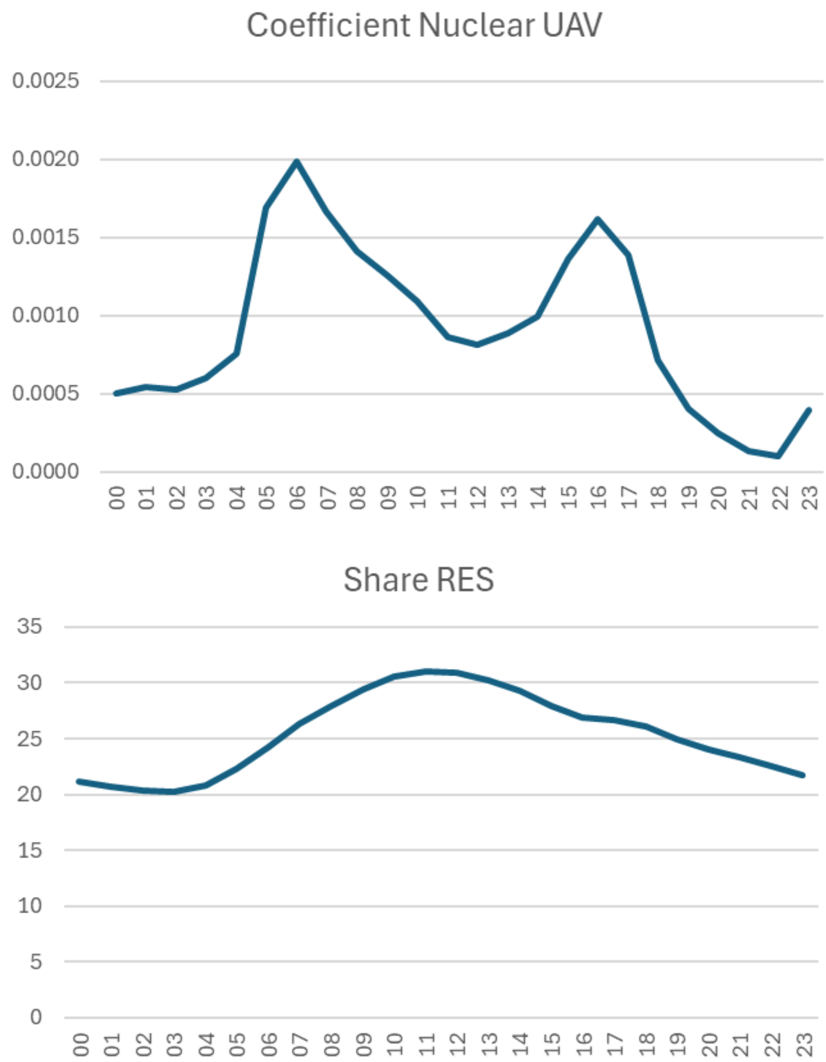

Figure 282: Share of renewable energy in electricity generation and estimated coeficient of nuclear unavailability in France.

9.3.2. Results on impact in natural gas prices

This section shows the result for the price of natural gas. The cases defined as "no stat. significance" means that there is no statistical significance in the result (level of significance a = 5%).

Table 67 shows the R-squared values for the estimated models for both the pre-crisis and during/after the energy crisis periods. For all countries, except Belgium and France, the R-squared is higher during and after the energy crisis. This indicates that the variability in natural gas prices is more effectively explained by the variability of the explanatory variables during and after the energy crisis.

Table 67: R-squared for the estimated models

	Before energy crisis	During/after energy crisis
AT	75%	84%
BE	79%	70%
FR	62%	57%
DE	73%	81%
IT	67%	79%
NL	64%	86%

Weather conditions

Seasonal variations in the weather affect natural gas consumption for heating and cooling, leading to price fluctuations. Table 68 shows the estimated coefficients of the heating and cooling degree days indicator. Cooling and heating degree days indicator shows a positive relationship with the natural gas prices however small in scale. An increase by one number in the heating or cooling degree days indicator is correlated with an increase of the natural gas price from a range of 0.003% to 0.018%.

Table 68: Estimated coefficients of the heating and cooling degree days indicator.

	CDD		HDD	
	Before energy crisis	**During/after energy crisis**	**Before energy crisis**	**During/after energy crisis**
AT	0.003	no stat. significance	0.001	0.002
BE	no stat. significance	0.018	0.002	0.003
FR	no stat. significance	0.009	0.001	0.003
DE	0.005	0.009	0.001	no stat. significance
IT	no stat. significance	no stat. significance	no stat. significance	0.001
NL	no stat. significance	0.018	0.001	0.002

Supply and Demand

The balance between natural gas production and consumption significantly impacts prices. Table 69 shows that before the energy crisis the explanatory variables are no statistical significance. In the period during/after energy crisis the results show a positive relationship between the natural gas price and natural gas imports, production and storage.

For example, in Italy,

- A 1% increase in natural gas imports (ceteris paribus) is correlated with an increase the natural gas price by 1.63%.
- A 1% increase in natural gas production (ceteris paribus) is correlated with an increase the natural gas price by 2.14%.
- A 1% increase in natural gas storage (ceteris paribus) is correlated with an increase the natural gas price by 0.46%.

Table 69: Estimated coefficients of the natural gas imports, production and storage.

	LOG(IMP_NG)		LOG(A_NG)		LOG(NG_STRG)	
	Before energy crisis	During/after energy crisis	Before energy crisis	During/after energy crisis	Before energy crisis	During/after energy crisis
AT	-0.35	-1.26	-0.87	no stat. significance	-0.210	0.623
BE	no stat. significance	no stat. significance	no stat. significance	-0.57	no stat. significance	no stat. significance
FR	no stat. significance	no stat. significance	no stat. significance	no stat. significance	no stat. significance	no stat. significance
DE	-1.30	no stat. significance	-0.75	2.14	no stat. significance	0.74
IT	no stat. significance	1.63	no stat. significance	2.95	no stat. significance	0.46
NL	no stat. significance	0.71	no stat. significance	1.22	no stat. significance	0.57

Competition with Other Fuels

The price of natural gas is also affected by the prices of alternative energy sources like oil. When alternative fuels become cheaper, natural gas demand may decrease, leading to lower prices (or the opposite).

Table 70 shows that for all countries examined the results are statistically significant and shows a positive relationship between natural gas and crude oil price. An increase of the crude oil price by 1% in the before energy crisis period will increase the natural gas price from 0.4% to 1.4%, ceteris paribus. While an increase of the crude oil price by 1% in the during/after energy crisis period will increase the natural gas price from 1.5% to 2.9%, ceteris paribus.

Table 70: Estimated coefficients of the crude oil price.

	log(P_CO_BRENT)	
	Before energy crisis	During/after energy crisis
AT	1.2	2.5
BE	0.4	2.9
FR	1.2	2.2
DE	1.0	1.5
IT	1.0	1.7
NL	1.1	1.8

9.3.3. Results on speed and magnitude of the pass-through rate for electricity prices

In the results shown in this section the cases defined as "no stat. significance" means that there is no statistical significance in the result (level of significance a = 5%) while "low R-squared" means that these cases were discarded from the results when R-squared is lower than 20%. R-squared lower than 20% characterize that the variability of the dependent variable is not sufficient explained by the independent variables.

Table 71 and Figure 283 show the speed of pass-through rate (in months) from wholesale to retail electricity prices for industries. Before covid period, estimates were characterized by low R-squared and no statistically significant estimates as a result to only few cases to be considered varying from ~1.5 months in Croatia to ~6.4 in Lithuania between the EU Member States. In the after & during covid period the cases considered have been increased and the estimates show a higher speed of adjustment compared to the before covid period. This result is even more profound in the after & during surge of energy prices period were the speed of pass-through ranged from 1.2 months in Denmark to 4.2 months in Romania across EU member states. The findings for a higher speed pass-through could denotes the fact for the following:

- Regulatory bodies implemented measures to ensure the stability of electricity markets, facilitating quicker pass-through of wholesale prices to retail prices.
- Retail electricity providers faced financial pressures due to the pandemic's economic impact, necessitating quicker adjustments in retail prices to maintain financial viability.
- Enhanced market transparency that allowing retailers to better track and respond to wholesale price changes.

Table 72 shows the pair-wise hypothesis testing for the time of adjustment across the examined periods. The tests shows if the time of adjustment for industries in the after & during covid and after & during energy crisis period is faster than the before covid period. The results show a higher speed of adjustment in the after & during Covid and after & during energy crisis period compared to the before covid period for most of the countries.

Table 71: Time of adjustment of pass-through (in months) rate for electricity prices in industry.

	Before covid	After & during Covid	After & during energy crisis
AT	no.stat.significance	3.04	2.94
BE	no.stat.significance	2.90	2.91
BG	3.92	2.03	1.41
HR	1.42	1.90	1.45
CZ	no.stat.significance	4.39	4.10
DE	no.stat.significance	1.41	1.39
DK	3.49	1.19	1.19
ES	no.stat.significance	no.stat.significance	no.stat.significance
EE	no.stat.significance	2.04	no.stat.significance
FI	3.91	3.34	1.66
FR	low R-squared	2.71	2.69
EL	no.stat.significance	3.78	2.04
HU	6.31	3.73	3.34
IE	no.stat.significance	no.stat.significance	no.stat.significance
IT	no.stat.significance	4.19	4.00
LT	6.42	2.86	2.91
LV	4.38	3.70	3.58
NL	2.93	3.58	3.75

	Before covid	After & during Covid	After & during energy crisis
PL	no.stat.significance	3.24	2.89
RO	no.stat.significance	4.37	4.25
SI	no.stat.significance	3.16	2.97
SE	no.stat.significance	3.31	3.92
JP	15.63	8.29	10.33
KR	1.43	1.57	1.41
US	6.77	4.67	no.stat.significance

Table 72: Hypothesis testing for the speed of adjustment across the examined periods in industry.

	"Acovid" faster than "Bcovid"(*)	"AENcrisis" faster than "Bcovid"(**)
AT	no	no
BE	yes	yes
BG	yes	yes
HR	no	no
CZ	no	no
DE	yes	yes
DK	yes	yes
ES	no	no
EE	yes	yes
FI	no	yes
FR	yes	yes
EL	no	yes
HU	yes	yes
IE	no	no
IT	yes	yes
LT	yes	yes
LV	yes	yes
NL	no	no
PL	yes	yes
RO	yes	yes
SI	yes	yes
SE	yes	yes
JP	yes	yes
KR	no	no
US	yes	no

(*)"Acovid" faster than "Bcovid": faster adjustment in the after/during covid period compared to the before covid period.

(**)"AENcrisis" faster than "Bcovid": faster adjustment in the after/during energy crisis period compared to the before covid period.

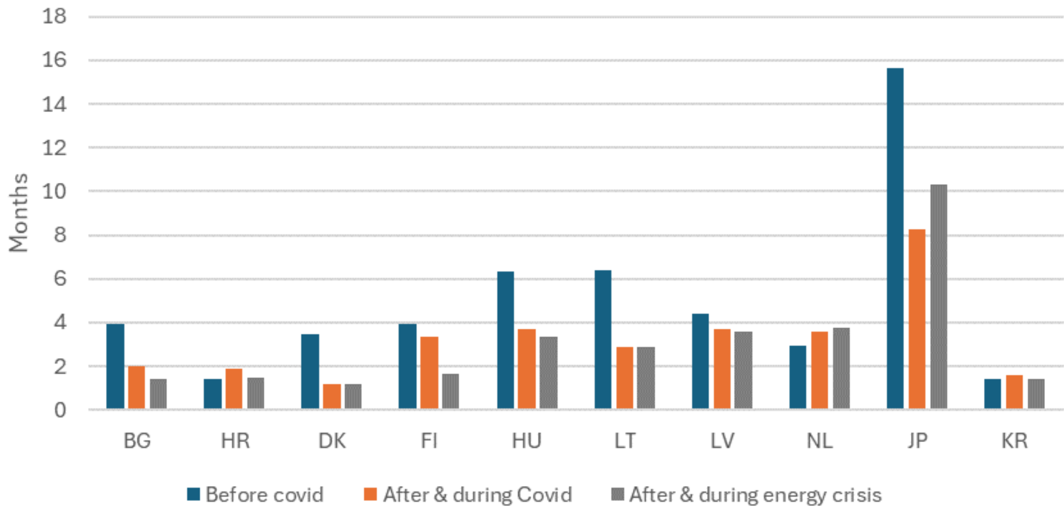

Figure 283: Time of adjustment of pass-through (in months) rate for electricity prices in industry. (only the cases with statistical significant estimates and R-squared >20%)

Table 73 and Figure 19 shows the results for the speed of pass-through rate for electricity prices in households. Similar to the industry results the speed of adjustment is statistically significant and with higher R-squared in the period after & during covid and after & during the surge on the energy prices compared to the before covid period. The range in the speed of pass-through of households in the after & during surge on energy prices period is from 1 month in Greece to approximately 4.4 months in France.

Table 74 shows the pair-wise hypothesis testing for the time of adjustment across the examined periods. The tests shows if the time of adjustment for households in the after & during covid and after & during energy crisis period is faster than the before covid period.

Table 73: Time of adjustment of pass-through (in months) rate for electricity prices in households.

	Before covid	After & during Covid	After & during energy crisis
AT	no.stat.significance	1.11	1.09
BE	2.74	2.15	2.10
BG	no.stat.significance	low R-squared	2.16
HR	1.66	2.59	2.41
CZ	low R-squared	2.25	2.18
DE	low R-squared	4.35	3.18
DK	2.16	2.86	2.67
ES	no.stat.significance	3.91	4.00
EE	no.stat.significance	2.58	2.15
FI	no.stat.significance	4.31	4.30
FR	no.stat.significance	4.50	4.37
EL	low R-squared	1.06	1.03
HU	low R-squared	no.stat.significance	no.stat.significance
IE	5.43	low R-squared	low R-squared

	Before covid	After & during Covid	After & during energy crisis
IT	low R-squared	no.stat.significance	no.stat.significance
LT	low R-squared	no.stat.significance	no.stat.significance
LV	low R-squared	2.91	2.55
NL	low R-squared	3.01	3.02
PL	low R-squared	low R-squared	low R-squared
RO	low R-squared	1.68	1.64
SI	low R-squared	2.08	2.13
SE	no.stat.significance	2.96	2.63
JP	low R-squared	no.stat.significance	1.22
KR	1.73	1.99	1.71
US	low R-squared	6.45	no.stat.significance

Table 74: Hypothesis testing for the speed of adjustment across the examined periods in households.

	"Acovid" faster than "Bcovid" ([557])	"AENcrisis" faster than "Bcovid" ([558])
AT	yes	yes
BE	yes	yes
BG	yes	yes
HR	no	no
CZ	yes	yes
DE	yes	yes
DK	no	no
ES	no	no
EE	no	no
FI	no	no
FR	yes	yes
EL	yes	yes
HU	no	no
IE	no	no
IT	yes	yes
LT	yes	yes
LV	yes	yes
NL	yes	yes
PL	yes	yes
RO	yes	yes
SI	yes	yes
SE	yes	yes

[557] *"Acovid" faster than "Bcovid": faster adjustment in the after/during covid period compared to the before covid period.*
[558] (**)"AENcrisis" faster than "Bcovid": faster adjustment in the after/during energy crisis period compared to the before covid period.

	"Acovid" faster than "Bcovid" (557)	"AENcrisis" faster than "Bcovid" (558)
JP	yes	yes
KR	no	no
US	no	no

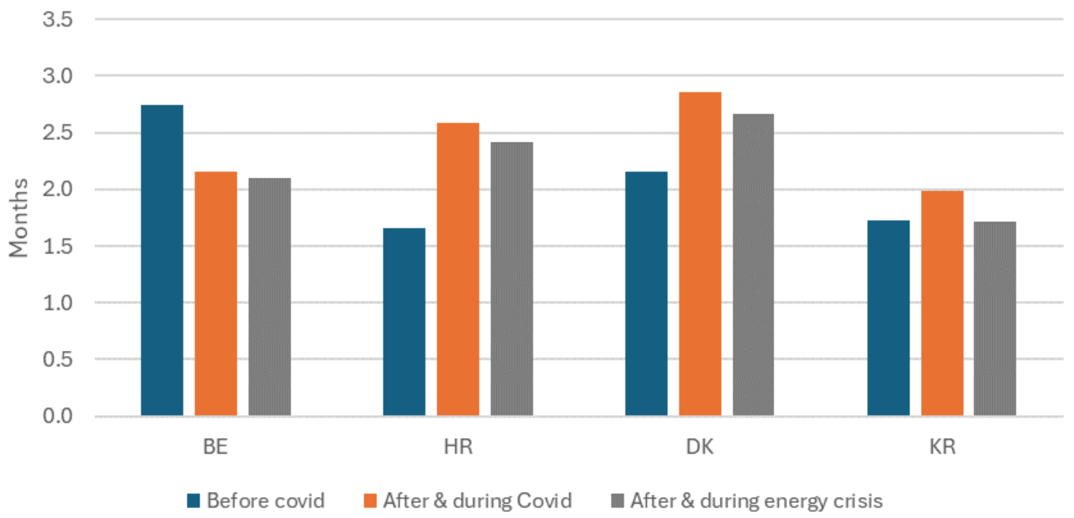

Figure 284: Time of adjustment of pass-through (in months) rate for electricity prices in households. (only the cases with statistical significant estimates and R-squared > 20%)

Table 75 shows the hypothesis test for the comparison of the time of adjustment between industries and households. There are mixed effects across countries on the comparison of the speed of pass-through and this could be related with the reasons:

a) Industrial users often have long-term contracts or agreements that lock in prices for extended periods, leading to a lag in price adjustments,
b) Household electricity prices are often subject to price caps and regulatory oversight to protect consumers from price volatility.

In Estonia and USA there is no evidence of faster time of adjustment in either industry or household.

Table 75: Hypothesis testing for the comparison of speed of adjustment between industries and households.

	Faster time of adjustment in households	Faster time of adjustment in Industry
AT	yes	no
BE	yes	no
BG	no	yes
HR	no	yes
CZ	yes	no
DE	no	yes
DK	no	yes
ES	yes	no
EE	no	no
FI	no	yes
FR	no	yes
EL	yes	no
HU	no	yes

	Faster time of adjustment in households	Faster time of adjustment in Industry
IE	yes	no
IT	no	yes
LT	no	yes
LV	yes	no
NL	yes	no
PL	no	yes
RO	yes	no
SI	yes	no
SE	yes	no
JP	yes	no
KR	no	yes
US	no	no

Table 76 and Table 77 shows the estimated magnitude for the pass-through from wholesale to retail electricity prices for industry and households accordingly. Based on the hypothesis test for symmetric or asymmetric effects, the findings support that asymmetries exist in both households and industries with respect to positive and negative changes in the wholesale retail prices and the magnitude of the pass-through to the retail prices. Most of the cases shows that when there are positive changes in the wholesale electricity prices the magnitude is higher compared when there is negative change.

The magnitude of the pass-through rate across the EU member states in the period after & during energy crisis ranges from -0.23 (-23% of the change in the wholesale electricity price will be passed through to retail prices) in Austria to 1.05 (105%) in Lithuania for industries and from -1.5 in Netherlands to ~1.4 in Denmark and Spain for households.

Cases that are above 1 and negatives should be treated as outliers and do not have a theoretical justification.

Table 76: Estimated in the magnitude of the pass-through rate in industry for electricity prices.

	Before covid		After & during Covid		After & during energy crisis		
	Coef. Positive	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Asymmetries**
AT	no.stat.significance	no.stat.significance	0.22	0.09	0.18	0.06	yes
BE	no.stat.significance	no.stat.significance	0.16	0.10	0.17	0.11	yes
BG	0.20	0.04	0.43	0.43	0.28	0.31	yes
HR	0.07	-0.10	0.09	-0.13	0.12	-0.11	yes
CZ	no.stat.significance	no.stat.significance	0.40	0.31	0.31	0.24	yes
DE	no.stat.significance	no.stat.significance	0.20	0.16	0.21	0.17	yes
DK	2.23	1.49	0.62	0.58	0.63	0.60	yes
ES	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	No
EE	no.stat.significance	no.stat.significance	0.52	0.46	no.stat.significance	no.stat.significance	yes
FI	0.31	0.34	0.42	0.40	0.42	0.37	yes

	Before covid		After & during Covid		After & during energy crisis		
FR	low R-squared	low R-squared	-0.03	-0.20	-0.06	-0.23	yes
EL	no.stat.significance	no.stat.significance	0.35	0.24	0.18	0.14	No
HU	0.52	0.45	0.32	0.10	0.38	0.14	yes
IE	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	No
IT	no.stat.significance	no.stat.significance	0.65	0.60	0.74	0.66	yes
LT	0.72	0.70	1.01	1.00	1.05	1.03	No
LV	-0.06	0.20	0.94	0.96	0.96	0.96	No
NL	0.31	0.20	0.08	-0.05	0.02	-0.11	yes
PL	no.stat.significance	no.stat.significance	0.42	0.16	0.49	0.22	yes
RO	no.stat.significance	no.stat.significance	0.88	0.74	0.85	0.72	yes
SI	no.stat.significance	no.stat.significance	0.34	0.15	0.31	0.14	yes
SE	no.stat.significance	no.stat.significance	0.59	0.56	0.39	0.39	No
JP	1.55	1.45	0.91	0.93	1.20	1.26	No
KR	-0.11	-0.10	0.06	-0.13	0.07	-0.12	yes
US	-0.29	-0.28	0.31	0.29	no.stat.significance	no.stat.significance	No

Table 77: Estimated in the magintude of the pass-through rate in Industry.

	Before covid		After & during Covid		After & during energy crisis		
	Coef. Positive	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Asymmetries**
AT	no.stat.significance	no.stat.significance	0.04	-0.05	0.03	-0.05	yes
BE	0.56	0.51	0.30	0.18	0.37	0.24	yes
BG	no.stat.significance	no.stat.significance	low R-squared	low R-squared	0.01	-0.01	yes
HR	0.00	-0.01	-0.01	-0.05	-0.01	-0.05	yes
CZ	low R-squared	low R-squared	0.37	0.21	0.30	0.16	yes
DE	low R-squared	low R-squared	-0.17	-0.31	-0.20	-0.32	yes
DK	0.88	1.12	1.39	1.30	1.46	1.36	yes
ES	no.stat.significance	no.stat.significance	0.97	1.12	1.45	1.41	No
EE	no.stat.significance	no.stat.significance	-0.33	-0.47	-0.47	-0.54	yes
FI	no.stat.significance	no.stat.significance	0.34	0.35	0.37	0.37	No
FR	no.stat.significance	no.stat.significance	0.08	0.01	0.06	0.00	yes
EL	low R-squared	low R-squared	0.20	0.10	0.21	0.10	yes
HU	low R-squared	low R-squared	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	No

	Before covid		After & during Covid		After & during energy crisis		
IE	-3.30	-2.02	low R-squared	low R-squared	low R-squared	low R-squared	low R-squared
IT	low R-squared	low R-squared	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	No
LT	low R-squared	low R-squared	no.stat.significance	no.stat.significance	no.stat.significance	no.stat.significance	yes
LV	low R-squared	low R-squared	0.09	-0.13	0.21	-0.03	yes
NL	low R-squared	low R-squared	-1.09	-1.54	-1.08	-1.53	yes
PL	low R-squared	low R-squared	low R-squared	low R-squared	low R-squared	low R-squared	low R-squared
RO	low R-squared	low R-squared	0.12	-0.36	0.13	-0.35	yes
SI	low R-squared	low R-squared	-0.05	-0.13	-0.04	-0.12	yes
SE	no.stat.significance	no.stat.significance	0.48	0.44	0.70	0.63	yes
JP	low R-squared	low R-squared	no.stat.significance	no.stat.significance	0.37	0.54	yes
KR	-0.31	-0.30	0.03	-0.15	0.03	-0.15	yes
US	low R-squared	low R-squared	0.56	0.49	no.stat.significance	no.stat.significance	No

The concentration ratio of the largest electricity producing company (CRT)[559] in 2022 has been used as a proxy for the electricity market power in each country. Table 78 shows the correlation between CRT and both the pass-through rate magnitude and the speed of adjustment. For both households and industries, the results indicate a negative correlation between CRT and the pass-through rate magnitude, meaning that less competitive electricity markets observe lower pass-through rates. In a less concentrated market, retail prices can be more responsive to wholesale price changes due to the competitive nature of the market. Additionally, there can be a higher speed of adjustment as the market becomes less competitive.

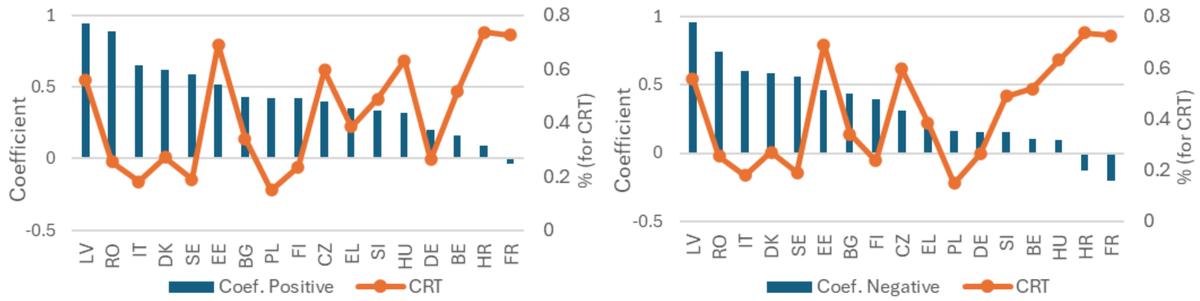

Figure 285: concentration ratio of the largest electricity generator company & magnitude of the pass-through rate.

Table 78: Correlation between concentration ratio of the largest electricity generator company and magnitude of pass-though or speed of pass-though. (max=1 , min = -1)

	Coef. Positive	Coef. Negative	Duration (months)
Industry	-0.4	-0.4	-0.1
Household	-0.5	-0.5	-0.1

559 *nrg_ind_market {Eurostat}*

9.3.4. Results on speed and magnitude of the pass-through rate for natural gas prices

In the results shown in this section the cases defined as "no stat. significance" means that there is no statistical significance (at 5% level of significance) in the result while "low R-squared" means that these cases were discarded from the results when R-squared is lower than 20%.

Table 79 and Figure 286 shows the speed of pass-through rate (in months) from wholesale to retail natural gas prices for industries. Before covid period, estimates varying from 2.2 months in Netherlands to 9.8 months in Germany between the EU Member States. In the after & during covid period the cases considered have been increased and the estimates show a higher speed of adjustment compared to the before covid period in all cases except Netherlands. This result is even more profound in the after & during surge of energy prices period were the speed of pass-through ranged from 1.7 months in Germany to 3.9 in Netherlands across EU member states. The findings for a higher speed pass-through could denotes the fact for the following:

- Governments and regulators may have implemented policies to ensure a more transparent and efficient market, facilitating quicker pass-through of wholesale prices.
- Natural gas utilities and suppliers that faced financial difficulties during the pandemic may have adjusted retail prices more aggressively post-COVID to recover costs.

Table 80 shows the pair-wise hypothesis testing for the time of adjustment across the examined periods. The tests shows if the time of adjustment for industries in the after & during covid and after & during energy crisis period is faster than the before covid period. The results show that in most of the cases examined there is no evidence of a higher speed of adjustment in the after & during Covid and after & during energy crisis period compared to the before covid period.

Table 79: Time of adjustment of pass-through (in months) rate for natural gas prices in industry.

	Before covid	After & during Covid	After & during energy crisis
AT	no.stat.significance	3.81	2.98
BE	2.86	2.63	2.63
FR	2.79	2.65	2.28
DE	9.75	1.82	1.69
IT	7.83	3.24	no.stat.significance
NL	2.22	4.19	3.87
ES	no.stat.significance	2.84	2.43
US	low R-squared	low R-squared	4.12

Table 80: Hypothesis testing for the speed of adjustment across the examined periods in industry.

	"Acovid" faster than "Bcovid"(*)	"AENcrisis" faster than "Bcovid" (**)
AT	no	yes
BE	no	no
FR	no	no
DE	yes	yes
IT	yes	yes
NL	no	no
ES	no	no
US	no	no

(*)"Acovid" faster than "Bcovid": faster adjustment in the after/during covid period compared to the before covid period.

(**)"AENcrisis" faster than "Bcovid": faster adjustment in the after/during energy crisis period compared to the before covid period.

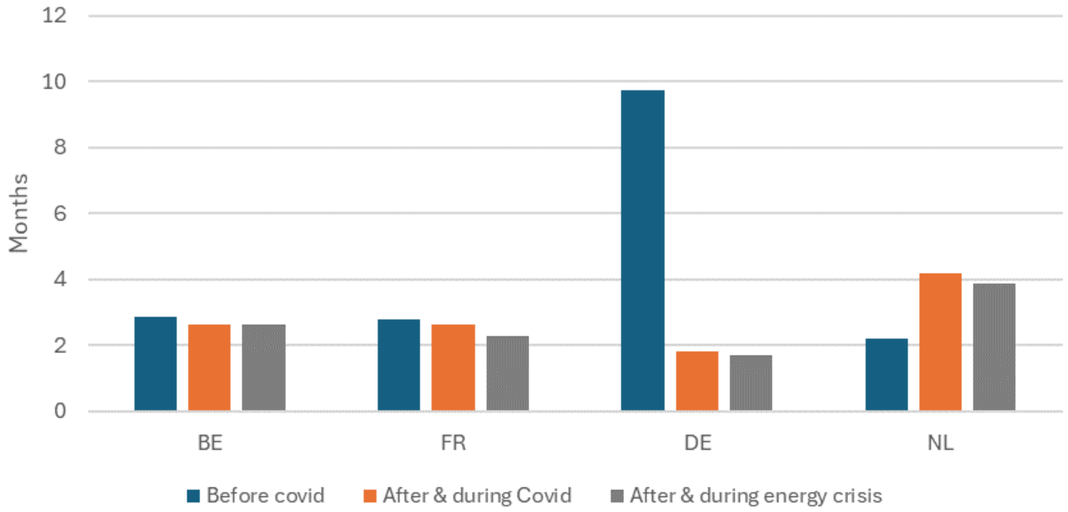

Figure 286: Time of adjustment of pass-through (in months) rate for natural gas prices in industry. (only the cases with statistical significant estimates and R-squared >20%).

Table 81 and Figure 287 show the results for the speed of pass-through rate for natural gas prices in households. The speed of adjustment is statistically significant and with higher R-squared in the period after & during covid and after & during the surge on the energy prices compared to the before covid period. The range in the speed of pass-through of households in the after & during surge on energy prices period is from 1.2 month in Netherlands to 3.2 months in Italy. The period after & during covid show a higher speed of pass-through rate compared to before covid period.

Table 82 shows the pair-wise hypothesis testing for the time of adjustment across the examined periods. The tests shows if the time of adjustment for households in the after & during covid and after & during energy crisis period is faster than the before covid period. The results show that in the cases considered there are mixed results for the speed of adjustment in the after & during Covid and after & during energy crisis period compared to the before covid period across countries..

Table 81: Time of adjustment of pass-through (in months) rate for natural gas prices in households.

	Before covid	After & during Covid	After & during energy crisis
AT	2.98	2.43	2.21
BE	3.32	2.16	2.10
FR	2.90	2.72	3.05
DE	low R-squared	1.39	1.25
IT	no.stat.significance	3.23	3.23
NL	no.stat.significance	1.24	1.21
ES	no.stat.significance	2.64	2.44
US	low R-squared	low R-squared	4.12

Table 82: Hypothesis testing for the speed of adjustment across the examined periods in households.

	"Acovid" faster than "Bcovid"(*)	"AENcrisis" faster than "Bcovid"(**)
AT	yes	yes
BE	yes	yes
FR	yes	no
DE	yes	yes
IT	no	no
NL	yes	yes
ES	no	no
US	no	no

(*)"Acovid" faster than "Bcovid": faster adjustment in the after/during covid period compared to the before covid period.

(**)"AENcrisis" faster than "Bcovid": faster adjustment in the after/during energy crisis period compared to the before covid period.

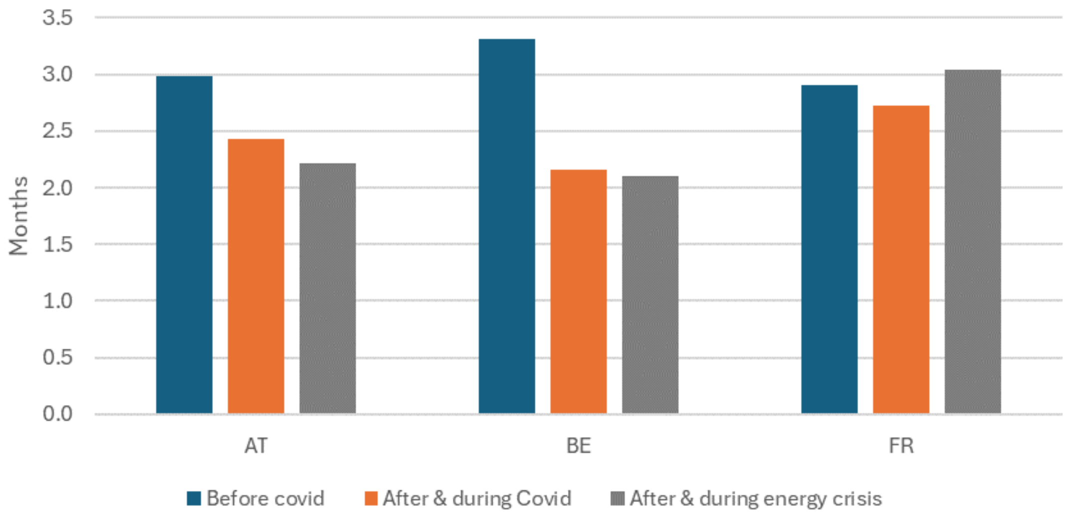

Figure 287: Time of adjustment of pass-through (in months) rate for natural gas prices in households. (only the cases with statistical significant estimates and R-squared >20%).

Table 83 and

Table 84 shows the estimated magnitude for the pass-through from wholesale to retail natural gas prices for industry and households accordingly. Based on the hypothesis test for symmetric or asymmetric effects, the findings support that asymmetries exist in both households and industries with respect to positive and negative changes in the wholesale retail prices and the magnitude of the pass-through to the retail prices. In all the cases considered, when there are positive changes in the wholesale natural gas prices the magnitude is higher compared when there is negative change (except Italy for household).

The magnitude of the pass-through rate across the EU member states in the period after & during energy crisis ranges from 0.10 (10% of the change in the wholesale natural gas price will be pass-through to the retail prices) in Netherlands to 0.70 in Spain across EU Member States for industries. In the case of households, the maximum pass-through rate is observed in Belgium and Spain (~36%).

Cases that are above 1 and negatives should be treated as outliers and cannot be explained from the econometric analysis.

Table 83: Estimated in the magintude of the pass-through rate in industry for natural gas prices.

	Before covid		After & during Covid		After & during energy crisis		
	Coef. Positive	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Asymmetries**
AT	no.stat.significance	no.stat.significance	0.36	0.29	0.26	0.21	yes
BE	0.21	0.23	0.29	0.24	0.27	0.22	yes
FR	0.34	0.28	0.43	0.33	0.32	0.24	yes
DE	0.24	0.28	0.27	0.16	0.25	0.14	yes
IT	0.69	0.66	0.55	0.46	no.stat.significance	no.stat.significance	yes
NL	0.30	0.36	0.24	0.15	0.17	0.10	yes
ES	no.stat.significance	no.stat.significance	0.57	0.47	0.70	0.55	yes
US	low R-squared	low R-squared	low R-squared	low R-squared	1.78	1.50	No

Table 84: Estimated in the magintude of the pass-through rate in households for natural gas prices.

	Before covid		After & during Covid		After & during energy crisis		
	Coef. Positive	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Coef. Positive**	**Coef. Negative**	**Asymmetries**
AT	0.11	0.12	0.16	-0.16	0.20	-0.13	yes
BE	0.57	0.37	0.28	0.17	0.36	0.24	yes
FR	0.09	-0.53	0.05	-0.05	0.01	-0.08	yes
DE	low R-squared	low R-squared	0.06	-0.12	0.02	-0.14	yes
IT	no.stat.significance	no.stat.significance	0.07	0.08	-0.01	0.02	No
NL	no.stat.significance	no.stat.significance	0.21	-0.24	0.32	-0.17	yes
ES	no.stat.significance	no.stat.significance	0.25	0.20	0.37	0.28	No
US	low R-squared	low R-squared	low R-squared	low R-squared	1.78	1.50	No

10. Special chapter 2: Impact of increased renewable energy generation on electricity price formation

Introduction

One of the largest changes in the energy system in recent history has been the gradual replacement of electricity generation from fossil fuel sources to generation from clean energy sources. The speed of this change increases also due to geopolitical factors (such as the ambitions developed within the REPowerEU plan) and updated ambitions to combat climate change and pollution (such as those developed within the Fit-for-55 package). While some sources of clean energy experience slower growth or stagnation (such as hydropower) or could decline (such as nuclear fission), renewable electricity produced from solar and wind energy (variable renewable electricity, VRE) is growing rapidly across Europe.

This rapid growth has been especially pronounced in the last two decades (see Figure 288). Initially, some growth was seen in countries such as Italy (for solar PV), Denmark (for wind), and Germany (for both). More recently, growth in VRE has been very rapid in many other European countries, such as Netherlands, Ireland, France, and Spain. As of 2024, almost 30% of total power generation in the EU-27 comes from solar and wind – with shares up to 50% in the Netherlands and Germany. This growth is expected to continue, if not accelerate. While the growth of VRE has been delayed by project permitting and grid connection issues in many countries (such as the Netherlands and Ireland), further growth is still expected in most projections.

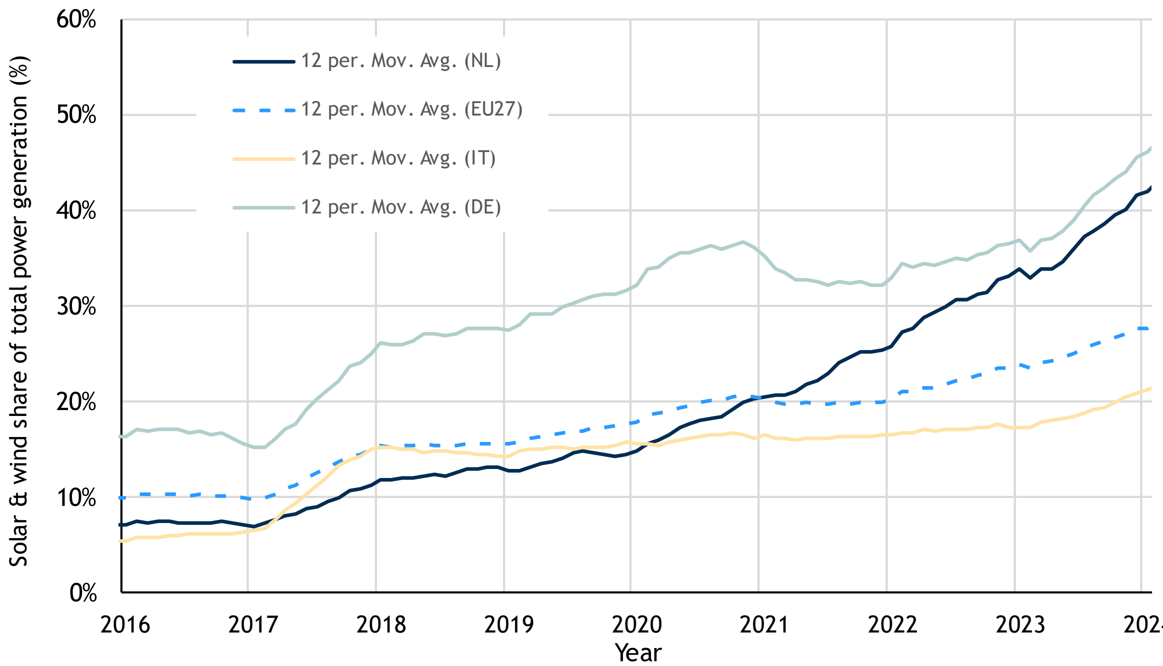

Figure 288: Share of VRES in total power generation, 12 month moving average.

Source: ENTSO-E

This growth has been boosted by market factors. VRE has becoming more easily marketable and its costs have been rapidly decreasing. These developments have for example led to a growing and dynamic renewable Power Purchase Agreements (RPPA) market for VRE projects. The amount of electricity being traded via these RPPAs has grown exponentially throughout Europe, fueled primarily by demand from the ICT sector (Amazon, Google, Microsoft, etc.) and heavy industry (Alcoa, Lyonell Basell). In 2023, about 36.2 GW of total capacity was announced within the European corporate PPA market (Figure 289). With recent decreases in costs of solar panels, it appears likely that this growth rate will maintain in the coming years.

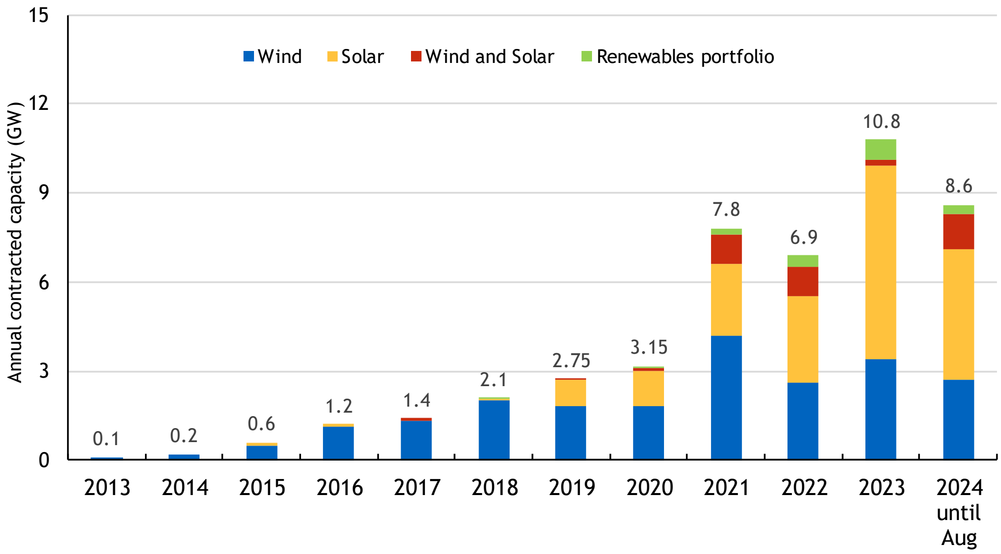

Figure 289: Corporate renewable PPA annual contracted capacity in GW from 2013-2014 Aug in Europe.

Source: RE-Source PPA deal tracker[560]

In addition to market factors, renewable energy support schemes continue to boost the growth of VRE. Countries have used various support types for VRE, with 2-sided contracts-for-difference (CfDs) or equivalent schemes being more popular in recent years. This support is usually decided based on a market mechanism, such as an auction, to determine the most economically efficient projects to support. With the adoption of the Electricity Market Design Reform[561] at the European level, which promotes the use of CfDs (and CfD-like instruments) for renewables support, we expect that these support schemes will continue to be used extensively well into the future.

[560] *Note: that it is possible that PPA trackers do not cover 100% of contracted capacity in the EU.*

[561] *European Council (2024). Electricity market reform: Council signs off on updated rules*

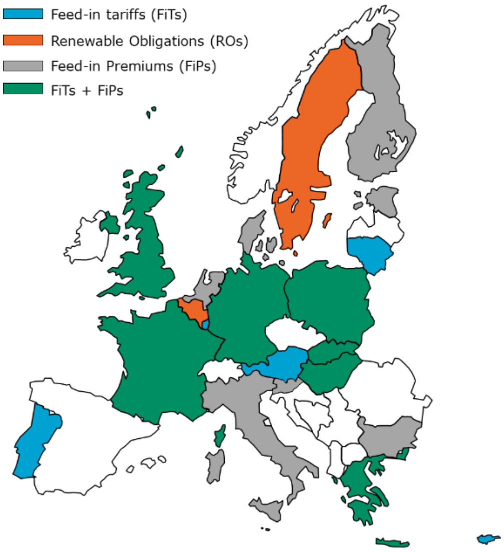

Figure 290: Renewable support schemes across Europe.

Source: CEER

VRE units are safer and cleaner than other generation units based on fossil fuel and fissile material. However, they can only generate electricity intermittently – when the sun is shining or the wind is blowing. Unlike prior generation units, which could ramp up and down thermal cycles to match needs, these sources cannot directly control their electricity production and are weather-dependent. Hence, as these sources appear on the grid more and more, the electricity system requires more flexibility in other areas to continuously balance supply and demand.

This flexibility remains elusive on the demand side. Electricity demand has been slowly decreasing in Europe, partially due to energy efficiency measures, while the ongoing electrification of heating, industrial processes, and transport, has been counteracting this drop. Theoretically, many new and conventional devices are or have become capable of providing flexibility. In practice, however, technical (missing digital components), regulatory (discriminatory legal frameworks), market (high entry and participation barriers), and other (low value from providing flexibility for end-users) barriers prevent this flexibility from being activated. Thus, while intermittent RES continues to grow, flexibility on the demand side is far from keeping pace.

The outcome of this high intermittency on the supply side with low flexibility on the demand side plays out in both grid operation and energy markets. With low demand side flexibility, these other parts of the energy system are required to make up and provide flexibility where and when it is needed.

The larger outcome may be in energy markets. We discuss here the impact of these VRE, and their growth, on wholesale markets for electricity. These markets are where they are most impactful. We first discuss the impact on short-term markets (wholesale day-ahead markets), and then on long-term markets, mainly electricity forward products.

Grid operation will also be impacted by growing VRE. Ancillary services and congestion management needs are growing rapidly, while adequacy concerns are increasingly creating issues for security of electricity supply. In many areas, the high capacity needs of VRE installations have led to highly congested grids (such as in the Netherlands), delaying the connection of both generation and consumption assets. The impact of VRE on grid operation remains out of scope, and we focus here on electricity wholesale market impacts.

10.1. Impact on short-term markets

The impact of VRE growth on short-term markets can be seen in day-ahead market price formation. These prices are formed on an hourly basis based on the "merit-order" curve: bids for power delivery are sorted based on price ("merit"), and all bids up to the required power demand are accepted (with the final bid accepted only up to the amount of demand still necessary). All bids are paid based on cleared price, rather than the bid price. Power generators submit bids based on their marginal costs, i.e. in any case where fulfilling a bid is more profitable than marginal costs.

VRE generally has close to zero marginal cost. Thus, the inclusion of these sources on the merit order curve pushes prices towards zero at times when VRE can produce the most: during windy and sunny hours. Increasing VRE can push prices towards zero in even more timeslots, as VRE generation becomes significant in even more hours of the year.

Prices can sometimes be pushed to negative values, in cases where:

- Many thermal units (i.e. burning fossil fuels or splitting atoms for electricity generation) on the margin face significant costs to ramping down production, and/or
- Returns on VRE generation are too disconnected from market prices. The most common causes of this case are renewable energy support schemes and power purchase agreements that diminish the relationship between market prices and the returns received per MWh for VRE. For example: a solar plant that receives a fixed feed-in premium per produced unit can still generate revenue at negative market prices if the premium is higher than the negative price. Luckily, new subsidy schemes distort market signals

The occurrence of negative prices also highlights an issue on the demand side. If prices (excluding other components) were negative, demand would have a direct incentive to increase, causing the market prices to increase until at least a non-negative clearing price is reached. The fact that this doesn't happen also indicates that demand is not adequately responsive, for various reasons including technology (devices without sufficient automated responsiveness to prices), consumer behavior (consumers are unaware or unwilling to make changes in consumption patterns), and price regulations (wholesale market prices are not adequately reflected in the retail prices passed on to consumers).

The unique role of storage, as both on the supply and the demand side in an energy market, should also be emphasized. Negative price events provide, in theory, an excellent opportunity for large storage assets (and aggregators of small assets) to arbitrage on wholesale markets (and possibly stack value with other markets). In reality, various regulatory barriers still hinder the development of storage in various EU markets.[562,563]

At the EU level, negative price events have generally been growing significantly in recent years. In regions where renewables have been growing, we observe significantly more incidence of negative price events. From an aggregated perspective, at the regional level, negative price events have grown especially in the Northern Europe and CWE regions (Figure 291; note that data for 2024 covers only first 4 months).

[562] *ACER (2023). Market monitoring report: Demand response and other distributed energy resources: what barriers are holding them back?*

[563] *Energy Transition Expertise Centre (2023). Study on Energy Storage*

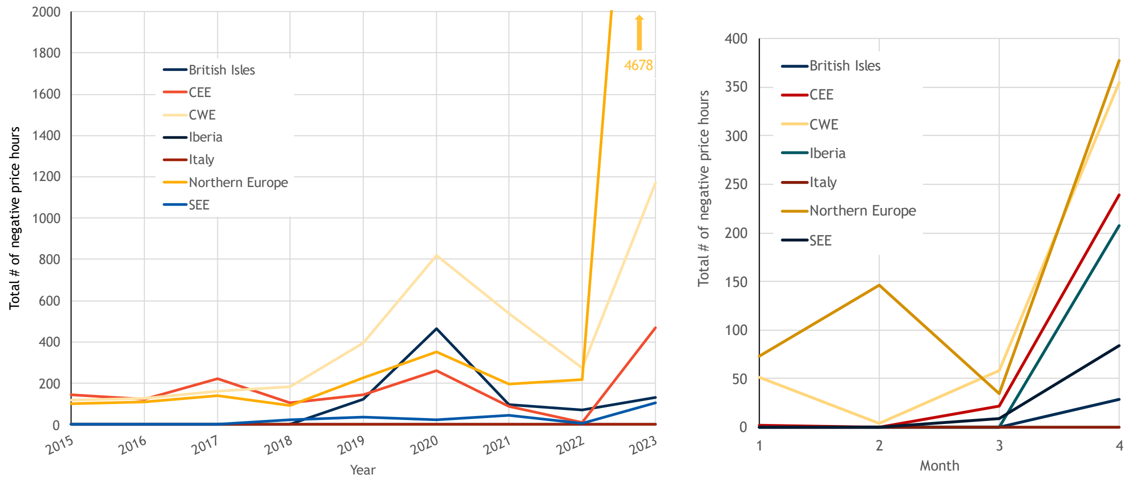

Figure 291: Number of negative price events per region per year (left) and same value for first 4 months of 2024 (right). Negative price hours for 2023 reached 4678 hours for Northern Europe, which is not displayed due to truncation of the y axis.

Source: ENTSO-E

The number of negative price events in some countries is significantly noticeable. These countries include the Netherlands, Germany, Sweden, and Ireland.

In the Netherlands, negative price events were rare prior to 2020. However, net metering schemes designed to promote household/SME uptake of VRE led to significant downward pressure on market prices. In this context, households/SMEs installed far more generation units than expected, which were mostly shielded from market prices (and were exposed instead to retail prices). Thus, demand in wholesale markets plummeted and caused significant negative price events, which continue to grow to this day. The net metering scheme is planned to be scrapped by 2027, but its effects are likely to be felt for many years after.

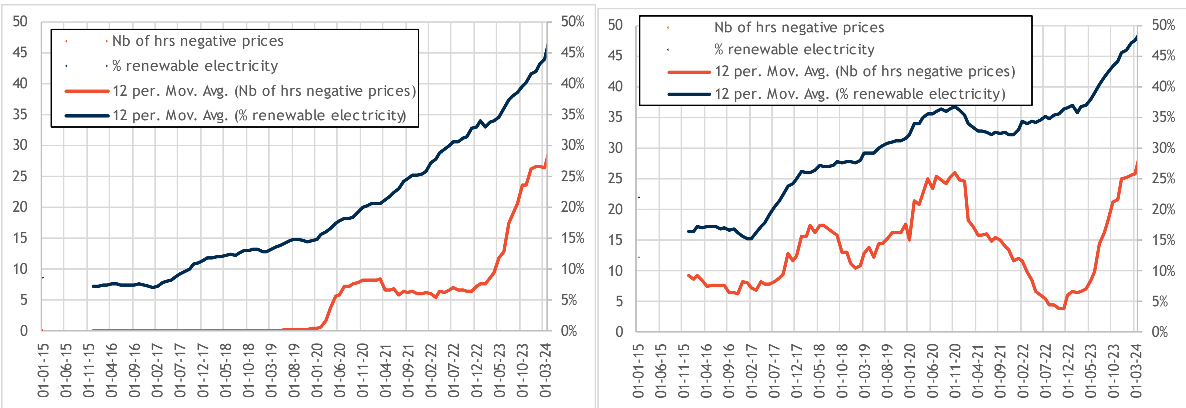

Figure 292: Dutch (left) and German (right) negative price events versus % renewable electricity in generation mix. Solid lines indicate a 12-month moving average.

Source: ENTSO-E

Germany had faced for some time increasing numbers of negative prices on the day-ahead market. However, in 2021 and 2022 negative price events were significantly reduced, due to two developments. First, thermal units with more flexibility became available on the market. Second, and possibly more impactful, was a tightening of supply coupled with significant rises in gas prices leading to generally higher market prices.[564] With the continuously increasing trend of VRE, and stabilisation of market prices, however, negative price events have once again risen to their multi-year trend.

Sweden has experienced a massive growth in negative prices in 2023 and early 2024. The absolute value of negative prices is, however, lower than that of Netherlands and Germany. In Sweden, node prices on average reached about -9 to -10 EUR/MWh in 2023, while in Germany the average was -35 EUR/MWh, and in the Netherlands it was -55.4 EUR/MWh.[565] Generally, the heavy oversupply of hydropower during 2023 was the main cause for this, which allowed some producers to bid below zero. However, their bids were generally limited by the minimum Guarantee of Origin price, which tend to vary around 4-7 EUR/MWh.[566]

Irish negative electricity price events were also frequent but reduced in size compared to Germany and the Netherlands. Over 2020, the average price for 374 negative price events was -8.56 EUR/MWh. These prices were driven by nights (and a few days) with low demand but high wind generation. In recent years, the number of negative price events has dropped to far lower numbers.

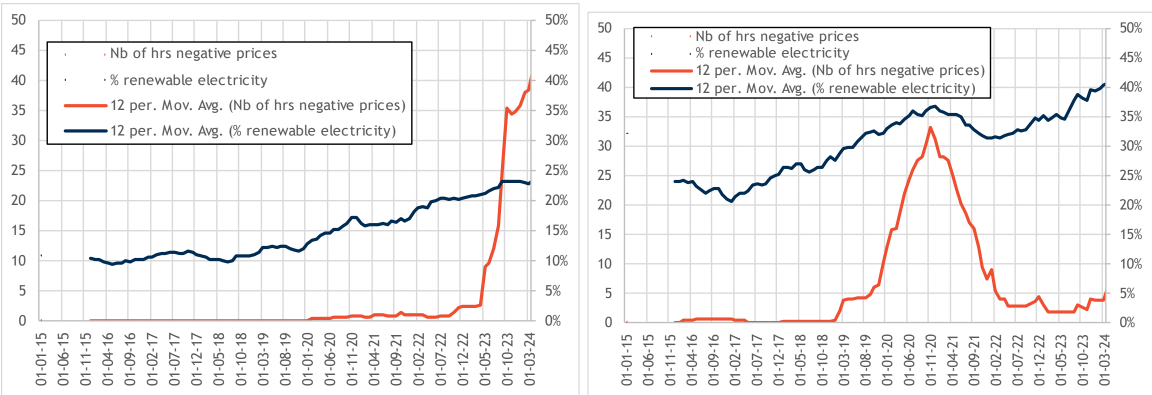

Figure 293: Swedish (left) and Irish (right) negative price events versus % renewable electricity in generation mix. Solid lines indicate a 12-month moving average.

Source: ENTSO-E

Low market prices tend to occur during hours when demand is low and VRES production is high. Demand tends to be lowest during the mid-day and night-time hours, and solar production is highest during sunny daytime hours in the early afternoon. Thus, negative price events can happen on sunny low-demand days during the mid-day, as is shown for one day in the Netherlands in Figure 294. In some cases, negative price events can happen during the evening, when demand is also low and wind generation tends to be higher. In general, it is well-known that in hours with high VRES production, negative price events happen quite frequently. [567,568]

[564] *IEA (2023). Electricity Market Report.*
[565] Volt Power Analytics (2024). Negative Prices in the Nordics: The New Normal?
[566] Forrs (2024). Insights from GoO Price Trends
[567] Biber et al (2022). Negative price spiral caused by renewables? Electricity price prediction on the German market for 2030
[568] Prokhorov et al (2022). The impact of renewables on the incidents of negative prices in the energy spot markets

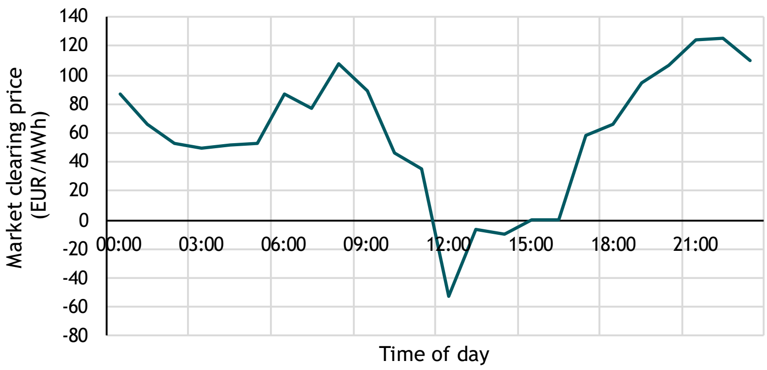

Figure 294: Day-ahead market clearing price for 17 July 2023 in the Netherlands.

Source: ENTSO-E

The sharply increasing (now multi-year, as already observed in both 2023 and 2024) occurrence of negative electricity prices on European power markets indicate an increasing need for either a more flexible supply combined with increased storage capacity, or demand-side response and further integration of the electricity markets, i.e. by establishing and increasing (cross-border) interconnection capacities. Where appropriate, the revision of support schemes for VRE generation might also be necessary.[569,568]

10.2. Impact on long-term markets

The increase in VRES in recent years may also have impacts on long-term markets. By long-term, we refer to 1-month to 3-year hedging products sold on energy exchanges and similar bilateral contracts. These products provide electricity for suppliers and consumers with a guarantee for delivery at a specific time and price, giving these entities better hedging against price fluctuations than short-term day-ahead markets. The analysis here is focused on 1-year hedging products, as they constitute the vast majority of products on EU markets.[570]

Forward markets in the EU are less integrated than day-ahead markets. Thus, it can be expected that the individual trajectories of each country, with regard to VRES increases, would have a larger impact on these markets. However, the change in VRES does not appear to impact long-term markets, beyond its impact on short-term markets Figure 296 shows the monthly average prices (with monthly standard error bars) for the French, German, and Spanish year-ahead base contracts. Next to this, the growing rate of VRES in these markets can be observed in Figure 295. The data shows little relationship between the share of total power generation from VRES and the prices and volatility in these markets. Generally, in addition to the clear impact of other factors, such as commodity prices for natural gas and oil, forward market prices and volatility seem to be heavily driven by country fixed effects, i.e. specific factors related to each country.

[569] IEA (2023) Electricity market report update: outlook for 2023 and 2024.
[570] ACER (2023). Progress of EU electricity wholesale market integration, 2023 Market Monitoring Report.

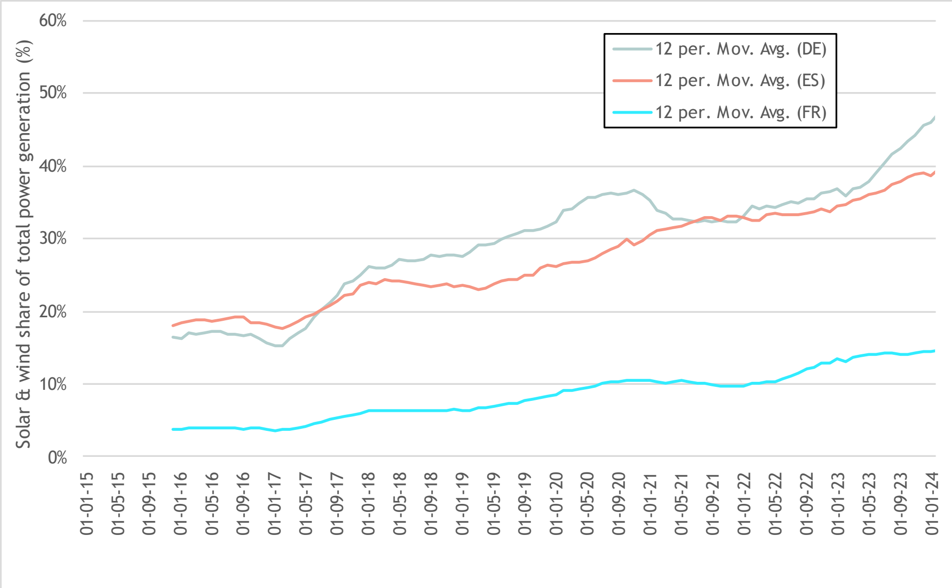

Figure 295: Share of VRES in power generation mix, 12-month moving averages.

Source: ENTSO-E

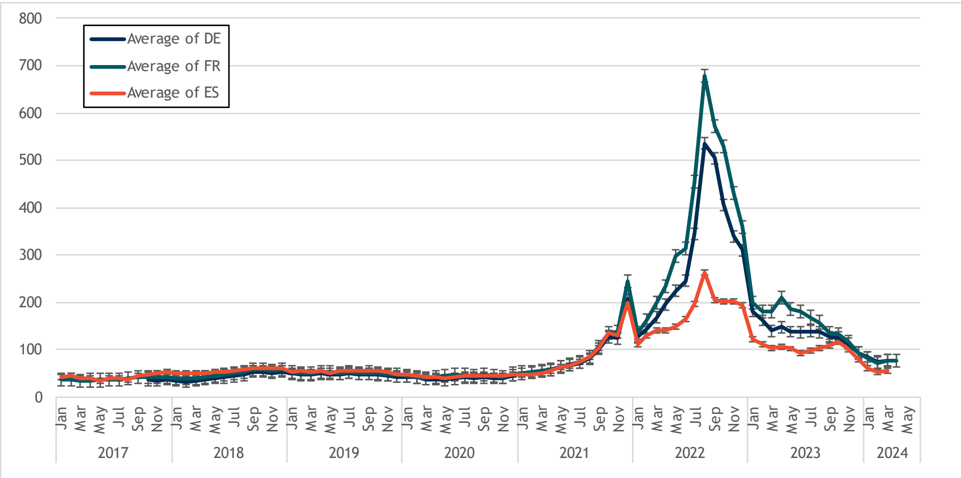

Figure 296: Average monthly price of three main markets for forward products in the EU, for year-ahead base products. Error bars represent standard error over daily prices in a given month.

Source: Platts

Overall, forward markets in the EU are known to have little activity in the past 2-3 years in comparison to (short-term) spot markets. With low market liquidity and demand, forward markets are less impacted by VRES than short-term markets, and the price impact from higher RES production on forward markets appears to be of lower impact than on short-term markets.

Annex A

Submitted in a separate document.

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