Structural changes in energy markets and price implications: effects of the recent energy crisis and perspectives of the green transition

By Miguel Gil Tertre[1]

Abstract

Over the last year and a half, the weaponisation of natural gas supplies by Russia led to concerns over security of supply, in Europe and globally. Significant gas price spikes contributed to high electricity prices. This analytical piece focuses on three points: (1) the necessary distinction between short-term spikes driven by fossil fuel supply and demand mismatches versus the long-term effects of the transition, (2) the different lessons that could be learned regarding energy price components and market expectations from the 2021-2022 crisis and (3) the implications of the on-going structural change in the energy and electricity mixes on prices. It finally argues that the key question might not only be if the green transition has an overall upward/downward impact on prices but also the impact of its different dimensions and how these can be better managed through policy decisions and the pace of the transition itself.

1 What happened last year? The necessary distinction between short-term spikes and volatility versus long-term effects of the structural change in energy markets

The 2021-2022 energy crisis was not related to the green transition, but a (Russian) fossil fuel / gas crisis.

Setting aside the global dynamics of post pandemic economic recovery observed in 2021, the reduction in supply of natural gas from Russia and the fear of gas shortages in 2022 have been at the epicentre of the recent energy crisis. The unprecedented rise to all-time high wholesale gas prices translated also into wholesale electricity prices putting a very significant upward pressure on retail electricity prices which steadily rose until autumn 2022. Climatic conditions led to low

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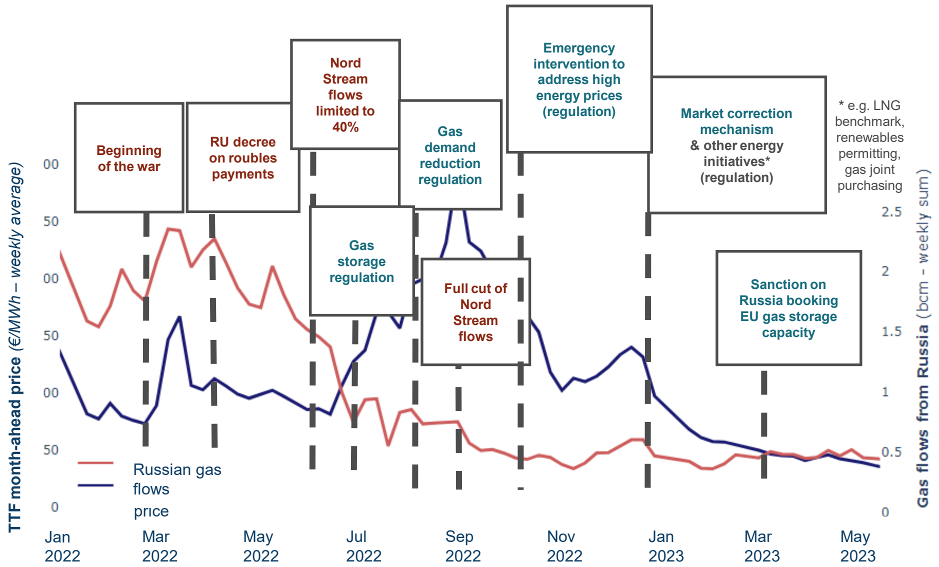
supply from the nuclear fleet and hydropower in summer 2022, and exacerbated the stress on gas and electricity markets pushing prices further up.

Chart 1

Russian weaponisation of gas supply & EU energy policies



Sources: DG ENER Chief Economist Team based on S&P Global Platts and ENTSO-G Transparency PlatformENER

There is a need to differentiate between short-term price spikes and volatility (which would result from regular and sudden mismatches between fossil fuels supply and demand) and the medium- to long-term effects of the Green Transition on prices. Increased price volatility can also be expected in the upcoming years if the global trends in fossil fuel demand are not well synchronised with flexible solutions (like available storage or flexible demand[2]) and any possible decrease in fossil fuels' global supply. During the transition when demand of fossil fuel is still high while not matched by supply, volatility might increase in the absence of flexible solutions, given the potential for stronger miss-matches.

Energy prices increased in 2021-2022 due to the following reasons[3]:

(a) Reduction in the supply of pipeline gas from Russia

(b) Uncertainty and fears of shortages that ensued

[2] Volatility in electricity markets results mainly from the steepness of the supply curve i.e. the price differential between peak and baseload generation (including renewables). While the carbon free and low-carbon electricity sources (renewables, nuclear, lignite to a degree) did not contribute to the price hike caused by gas, the peak producers suddenly became more expensive by a certain order or magnitude. A "sudden mismatch" would exacerbate this situation by requiring either: a)a particularly inefficient gas peaking plant to run, or b) a consumer to sell back electricity already bought on the forward market at a price derived from opportunity costs of the use (loss of income from sales of goods).

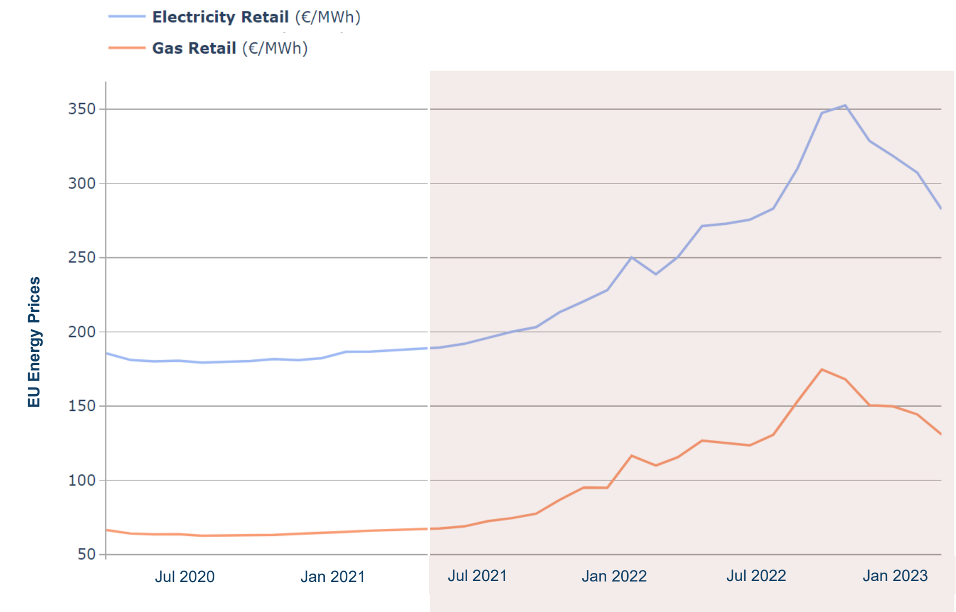
[3] At the start of 2021, a stronger Asian demand post COVID in the global LNG market started to put pressure on markets, although not to the extent of the price increases in 2022.

(c) Lower than usual hydro and nuclear output for electricity in the summer, that pushed gas consumption for electricity and wholesale electricity prices up

The decrease in supply from Russia led wholesale gas and electricity prices to increase steeply since the summer of 2021. During 2022, natural gas prices in the EU reached ten times the average prices seen over the last decade as Russia supplied to the EU 70 billion cubic meters (bcm) less than in 2021 (from a total of 155bcm in 2021). According to the REPowerEU plan[4], the EU had to structurally change the origin of 40% of its imports of natural gas[5] that were in their majority by pipeline under long-term contracts.

Chart 2

Households' retail prices for gas and electricity (EU average)



Sources: European Commission based on VaasaETT

However, supply and demand fundamentals might not fully explain the increase of prices in natural gas markets that the EU experienced in the summer of 2022, and the extreme volatility that ensued. While the tight supply-demand balance linked to storage refilling and the reduction of pipeline flows explain most of the increase in 2021-2022, the abnormally high natural gas prices in the summer 2022 were the result of political uncertainty and expectations of further supply disruptions by Russia (that did not materialise), and underestimation of the potential of demand-side elasticity. For security reasons, some market operators became price-insensitive buyers.

4 European Commission (2022a). "REPowerEU Plan" COM/2022/230 finalCOM

5 While natural gas (mainly via pipeline) from Russia represented 40% of the imports into the EU at the start of 2022, in March 2023 Russian gas imports by pipeline and LNG represented 8% and 7% of the total EU gas imports respectively.

EU prices paid in wholesale market were dislocated from global prices in August 2022. The difference between the prices of the Dutch Title Transfer Facility (TTF)[6] and global prices like the JKM[7] amounted to around EUR 35 €/MWh on average between June and August 2022. Dutch Title Transfer Facility (TTF) Gas Futures (3-month/quarterly products) traded on the ICE Endex[8] exchange have been traded at levels slightly below EUR 350/MWh, the TTF day-ahead gas traded on European Energy Exchange (EEX) hit EUR 316/MWh. During the late Spring and Summer of 2022, the TTF became also detached from prices at other hubs and trading places in Europe, as well as from the price assessments made for LNG imports by price reporting agencies[9] . Historically the TTF had been a good proxy for gas prices in the EU due to its geographical location and connections. With the supply cuts from Russia, prices reflected more and more the infrastructure bottlenecks in North-western Europe and the congestion when bringing gas from other locations. This brought questions on the representativeness of the TTF which is the traditional index used across Europe.

Higher gas prices than global prices were instrumental in attracting additional LNG in 2021 and 2022. However, extremely high prices between July and August 2022 were not necessary to increase European imports. While beneficial in incentivising demand reduction and fuel switching, these extremely high gas prices did not attract higher import volumes of LNG due to network congestion[10]. The high gas prices can be attributed to intra-EU competition. The higher demand could not be met via LNG due to infrastructure constraints. Higher demand during the summer of 2022 was temporarily constrained by infrastructure bottlenecks and highly inelastic supply. Essentially, the price signal at the ports did not have an impact on increasing supplies in the short run which could not be accommodated by the infrastructure. Instead, the spike in gas prices were due to intra-EU competition for gas by market operators in the face of fears of limited supply, with a supply constrained by infrastructure bottlenecks.

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6 The Title Transfer Facility, more commonly known as TTF, is a virtual trading point for natural gas in the Netherlands. This trading point provides facility for a number of traders in Netherlands to trade futures, physical and exchange trades.

7 Platts JKM is the Liquefied Natural Gas (LNG) benchmark price assessment for spot physical cargoes. It is referenced in spot deals, tenders and short-, medium- and long-term contracts both in Northeast Asia and globally. JKM reflects the spot market value of cargoes delivered ex-ship (DES) into Japan, South Korea, China and Taiwan. Deliveries into these locations equate to the majority of global LNG demand.

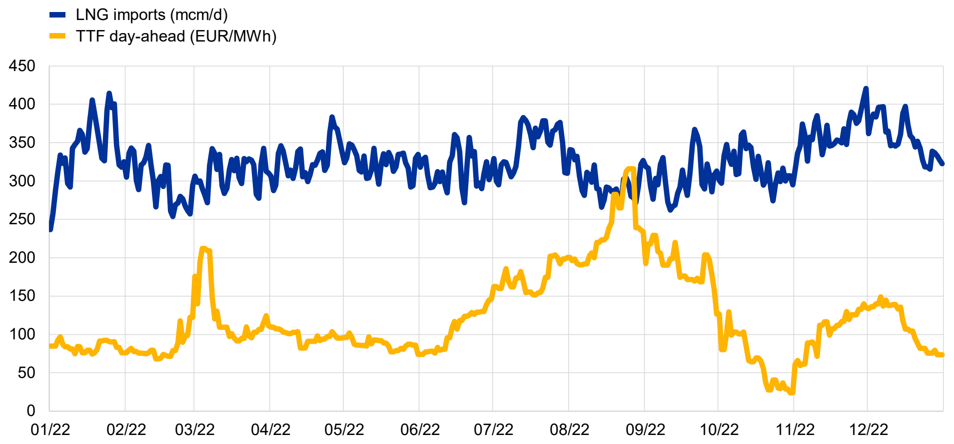
8 ICE ENDEX is one of the main energy exchanges in Europe. For gas, it provides regulated futures and options trading for the Dutch Title Transfer Facility (TTF) trading hub.

9 This is largely because the gas system of North-Western Europe presented particular infrastructural limitations to address the shortages of Russian gas both in terms of pipeline transmission (West-East) and in terms of LNG regasification capacity. Such limitations were partly responsible for the general increase of gas prices since the beginning of the crisis in Europe following Russia's weaponisation of energy. The abnormal spread between the TTF and other regional hubs in August 2022 indicated that, until bottlenecks were resolved, the TTF may not always be an accurate proxy for the EU outside North-Western Europe.

10 European Commission (2023a). "Commission Staff working document on coordinated gas demand reduction measures, Commission Staff working document on coordinated gas demand reduction measures" COM/2023/173

Chart 3

Daily day-ahead prices and LNG imports



Sources: DG ENER Chief Economist Team based on ENTSO-G and Platts Notes: After stabilising in Spring 2022, TTF natural gas spot and futures prices raised steeply and continuously from June 2022 to their peak in late August 2022. The rise in European gas prices has been fuelled by (i) the incident in June at Freeport LNG terminal (freezing around 20 bcm/y of capacity until partial restart in February 2023) and more considerably by (ii) the drop of Russian supplies over the summer with a significant uncertainty on when or if these supplies will come back to the EU market and on if further drop on Russian flows were to be anticipated (North Stream cut froze 58 bcm/year of flows in June 2022, before partially restarting in July 2022 and indefinitely interrupting in August 2022).

Ultimately, higher prices benefited those trading the assets and represented a significant wealth transfer. Natural gas traders had very significant profits (sometimes even 10 times above the historical range as per their financial statements). In this context, it is worth mentioning that according to ESMA (European Securities and Markets Authority), there is a significant concentration in EU financial energy commodities markets, at both clearing and trading levels[11].

The crisis in the gas markets was exacerbated by the lower than usual hydro[12] and nuclear[13] output for electricity generation in the summer of 2022 which put upward pressure on electricity prices. Reduced nuclear and hydro-based electricity generation resulted in fossil fired power stations filling this gap during the summer of 2022, despite high prices for gas and coal. Gas-fired generation was up by 19% (+16 TWh), between July and September 2022 compared with the same period in 2021.

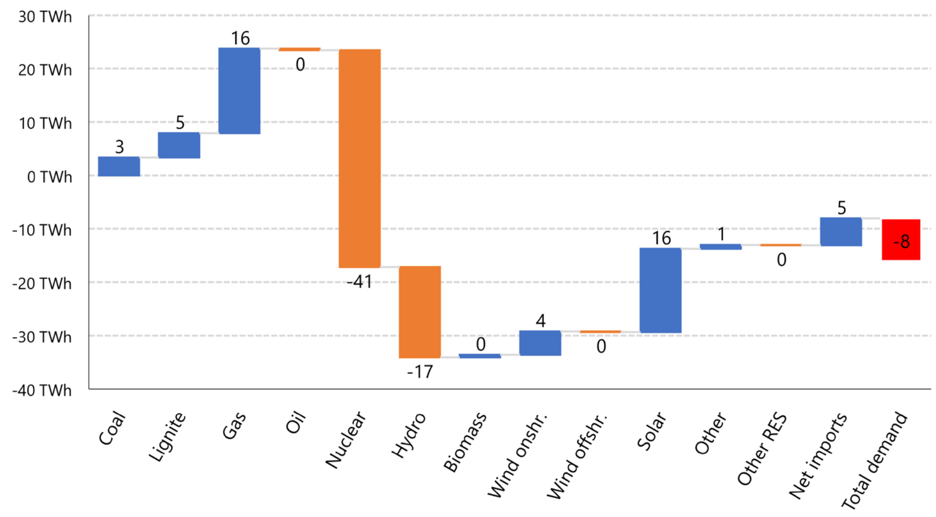
11 ESMA, TRV Risk Analysis - EU natural gas derivatives markets: risks and trends, May 2023

12 Weak hydroelectric production due to droughts in Europe, exerted additional pressure on the already tight European wholesale electricity market. Hydropower generation was down by 20% (-17 TWh), during July and September 2022 compared with the same period in 2021. Hydro generation during summer 2022 remained at the lower bound of the 2017-2021 range.

13 The French nuclear fleet (around 6% of the total EU installed capacity according to Eurostat) was down by 36% (-31 TWh), between July and September 2022, compared to the same period in 2021. Nuclear generation drastically decreased, from 4.6 TWh in the first week of July 2022 to a new low during the last week of August (3.8 TWh) and then bounced back to around 4.5 TWh in the last week of September 2022. Subdued nuclear generation continued well into the last months of 2022, registering an increase in its output to 6.3 TWh during the second week of December. However, the output remained below historical levels.

Chart 4

Changes in power generation in the EU between July-September 2021 and July-September 2022



Sources: DG ENER Chief Economist Team based on Eurostat and ENTSO-E
Notes: Data represent net generation

Decisive EU policy as outlined by the REPowerEU plan contributed to reducing the concerns over natural gas shortages in 2023-2024 bringing prices back to supply-demand fundamentals. The European Union and its Member States have adopted and implemented in record time successful measures to strengthen security of supply by setting gas storage and demand reduction targets, by accelerating gas supply diversification, accelerating the deployment of renewables and energy efficiency, by upgrading targeted infrastructures and by adopting costly fiscal measures to contain price rises.

Since the summer of 2022, the improvement of market fundamentals encouraged and/or enabled by EU policy initiatives have resulted in a steep downward trend bringing back prices and price market expectations close to the pre-crisis historical range. The market situation improved thanks to steadily high (in historical terms) levels of gas stocks, constant high import of LNG during 2022 and some pipeline imports from non-Russian suppliers and substantial efforts to contain gas consumption across the EU, in a context of mild weather.

There are a few reasons that make similar spikes as those experienced in the summer of 2022 less probable this year all things being equal:

1. Ending the winter season with high storage levels (68.6% at 1st of June 2023 versus 49.0% on average on the same day during the reference years 2016-2021) means less demand for gas imports next year (lower volumes needed to fill the storage facilities for the next winter season).

2. The EU did a huge effort done in reducing demand for natural gas. Part of the demand reduced last year is structural[14]. It has not only affected gas, but also other energy commodities[15]. If the current natural gas demand reduction is maintained (18% demand reduction from August 2022 to March 2023 in comparison to the past five year average) and with stable global LNG volumes, no shortages of natural gas would be expected in the EU during the winter 2023/2024.

3. The weaponisation of energy by Russia last year cannot impact the market in the same way anymore: with the current trend, only about 20 bcm/y are coming via pipeline from Russia per year vs. 155 bcm/y in the 5 years before 2022. The EU has diversified its supply thanks to LNG and different suppliers (e.g. the US has become the main number supplier of LNG).

4. More infrastructure added to remove bottlenecks (especially in North Western Europe) and therefore less congestion and lower prices in this European region. New LNG importing terminal projects with a total capacity of around 30 bcm/year are helping the EU to secure alternative supply and bring prices down[16]. Significant efforts were done to avoid countries to remain isolated (e.g. inter connectors, terminals and pipelines).

5. Less uncertainty compared to 2022 regarding shortages after the efforts EU made last year. Market players do not need to buy gas at whatever the price to ensure security of supply (as the rest of the world is not competing above certain prices). EU Member States decided to enact bidding limits for futures and forward trading over natural gas with the market correction mechanism[17], which might have contributed to a disciplinary effect on the market and anchored expectations regarding natural gas prices in the future as volatility has almost disappeared since January 2023 while prices have gone down. Market participants also learnt that demand-elasticities are higher than expected. Letting the market demand to adjust to supply was key in the European success.

[14] Weather was responsible of only 20% of the demand reduction according to International Energy Agency estimates. Heating Degree Days – a measure of how much energy is required to heat a building due to colder weather – across the European Union were 12% lower on average in 2022 than in 2021, lowering space heating requirements. However, weather was not very different from the average of the past five years. It is also important to note that while prices have considerably decreased compared to the peak in summer 2022, they are still materially higher than the historical/pre-crisis level. In June 2022, TTF is traded around 35-40 €/MWh pre-crisis gas prices had been around 20 €/MWh on average. So, the crisis impact on gas prices, and therefore on the cost structure of gas-intensive industries, is still there.

[15] The demand for electricity in the EU fell by 7% for the period November 2022 - March 2023 (reference period is average electricity consumption from 1 November to 31 March in the five consecutive previous years). EU oil products demand fell by 3% in the period November 2022-January 2023 compared to the same period the previous year. Coal demand fell by 7% in the period November 2022-December 2022 compared to the same period the previous year as the increase of use for electricity and heat generation were more than offset by a drop of consumption from industry, especially from energy intensive industry like iron and steel.

[16] Total added capacity via FSRU and LNG: 20.6 bcm/y in operation and 49.8 bcm/y to be commissioned

[17] European Commission (2022b), “COUNCIL REGULATION - Establishing a market correction mechanism to protect citizens and the economy against excessively high price”, COM(2022) 668 final

However, important challenges remain. Several issues must be monitored (e.g., continuation of demand reduction, global LNG supply/demand balances[18], weather…) but spikes are less probable for the reasons above. Global LNG markets remain tight, and we can expect increased volatility in the upcoming years if supply and demand reduction from coal and gas do not move in parallel. By 2026 significant new natural gas supply should ease the situation in global gas markets.

2 Different lessons to be learned regarding energy prices and price expectations during the 2021-2022 crisis

The 2021-2022 crisis also allows to draw some conclusions regarding the behaviour and complexity of energy prices.

The evolution of the price setting technologies in electricity has a major impact on the prices paid by consumers. During the events in 2021 and 2022, the increases in natural gas prices had a disproportionate effect in the overall economy given its role during the crisis as the marginal price setting technology for electricity. Despite only representing about 20% of EU electricity generation, the increase in the natural gas price is the overwhelming driver for the electricity price increase. Increasing the uptake of renewables and reducing demand for natural gas in electricity generation can have a very significant impact on lowering electricity prices, the main channel for energy inflation as reverberating in the whole economy. The Chief Economist Team in DG ENER and the Joint Research Centre (JRC) at the European Commission applied the METIS[19] power system model to simulate the hourly dispatch of the European power system for the years 2022 and 2030. The results show that of all fossil fuels, natural gas was the most significant price setter for electricity in 2022. Results are explained below.

Adding more renewable energy sources to the electricity mix and limiting the role of gas in electricity generation will moderate this effect. By 2030, renewable energy sources are expected to provide around two thirds of the EU's electricity but gas-fired generation will still be needed to set the price during significant numbers of hours. Therefore, accelerating the uptake of renewable sources and demand response solutions will be important in order to reduce peak load[20] and, thus, the role of gas in setting the price in the power sector. Furthermore, the development of

[18] While the post-COVID rebound of Chinese demand is an element to monitor, China's gas demand for power generation is more price-sensitive than elsewhere as it can switch relatively easily to other energy sources (e.g. coal) when gas prices rise (and it is investing in expanding its coal generation capacity). Therefore, even if demand from China were to rebound, this is not necessarily going to have a destabilising impact on the EU. Chinese gas demand is also highly linked to industrial activity, while Chinese economic recovery has been highly service driven and not industry driven implying less of a rebound in Chinese gas demand.

[19] METIS is the European Commissions' model for the European energy system for power, gas, hydrogen and heat. The Chief Economist Team in DG ENER used the METIS power system model to determine the utilisation (dispatch) of the current European electricity system. We used this model to analyse the impacts of high energy prices in the short and long-term. In this analysis, the counterfactual of the high-price scenario is the Commission's central MIX scenario, which was prepared in the framework of various initiatives of the European Green Deal policy package presented in July 2021.

[20] Peaking power plants are power stations constructed for providing power to electrical grids for periods of high demand. Natural gas power stations are often utilised during peak demand times since they can be switched-on rapidly.

storage capacity will help to keep prices at check. Our analysis shows that an increase in the installed renewable energy capacity would have partially lowered electricity prices[21]. Additional renewable capacity corresponding to about half of the additional capacity foreseen in the 2020-25 period in the European Commission's central MIX scenario would reduce wholesale power prices between 1.5% and 9% depending on the Member State.

Secondly, the crisis has made more visible that the pass-through mechanisms to end-consumers vary greatly across EU Member States with contract indexation, public support and taxation among others playing a critical role. The steep increase in wholesale prices has progressively and only partially translated into retail prices. Retail prices increased in a much more contained magnitude than they would have in the hypothetical case of a full and immediate pass-through[22].

Pass-through effects depend on market characteristics (power mix, competitive structure, etc.) and on the regulatory and contractual environment, which differ significantly across countries (and over time).

Several government interventions have alleviated the bill for consumers and decreased or delayed the pass-through rate. Given that roughly one-third of the final retail prices are driven by wholesale prices[23], the rise could have been much higher without the multiple measures (taxation reduction, caps at retail level, regulated tariffs) taken by Member States to contain prices and mitigate the impact on consumers' bills. An analysis from VaasaETT[24] concluded that without measures on energy prices introduced by governments in selected markets, across the EU retail electricity prices would have increased by a further 70 €/MWh (+22%) and gas prices by further 25 €/MWh (+21%). The costs were often carried by suppliers or governments, rather than consumers. The EU governments' budgetary cost of support measures was estimated at 1.5% of GDP for 2022[25], with a net cost of 1.2% taking into account levies on windfall profits.

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21 Analysis from the European Commission Joint Research Center for DG Energy with the METIS model.

22 The pass-through effect refers to the impact on total retail prices (energy component + taxes + network tariffs). The increase of the energy component was progressively and only partially translated due to many factors (e.g. contractual lags, hedging, and competition) and also due to the application of tax reductions and policies to avoid partial or full increase of final prices by Member States governments. For example, in the Spanish electricity market, the total retail price increased by 175.3 27€/MWh during the crisis period, from April 2021 to the peak. Meanwhile, the wholesale price showed an increase of 218.4 37€/MWh. As a result, approximately 80% of the total increase in the wholesale price was reflected in the total retail electricity price. Similarly, in the Spanish gas market, using the same methodology, it was found that 94.7% of the wholesale price increase was translated into the total retail price.

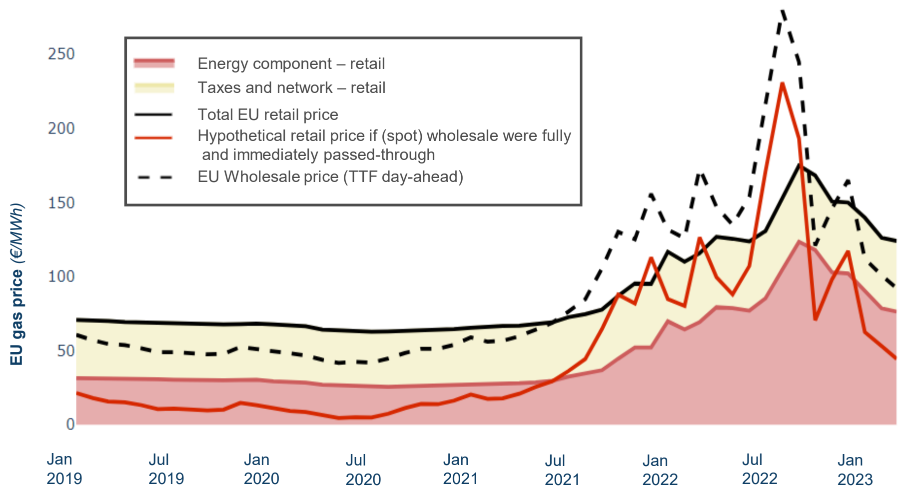
23 Historical EUROSTAT data (2017-2022) indicates that the energy component represents roughly 33% of the final electricity retail price for medium consumption. However, the latest report from VAASAETT (May 2023) indicates that that on average, the energy component represents 60% of the end-user price of electricity bill. This is a direct effect of the energy crisis.

24 VAASAETT (2022) Provision of Retail Energy Market Data and Analysis for ACER

25 European Commission estimates

Chart 5

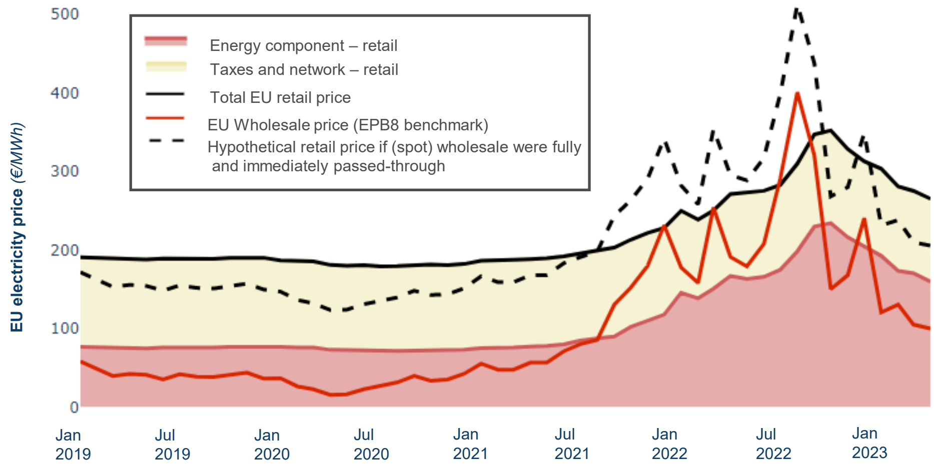
Gas prices: Monthly wholesale vs retail



Sources: DG ENER Chief Economist Team based on S&P Global Platts and VaasaETT
Notes: Graphs use aggregated data for MS. In the case of gas, the analysis uses TTF for wholesale and for electricity, the Electricity Power Benchmark for the 8 most important markets in the EU. The retail prices is the average of EU27. The energy component of the retail prices includes energy production costs (wholesale price) and other costs stemming from the commercialisation of energy by suppliers to the end consumers (e.g. billing, advertisement, other costs, and margins).

Chart 6

Electricity prices: Monthly wholesale vs retail



Sources: ENER Chief Economist Team based on and ENTSO-E, European power exchanges, S&P Global Platts and VaasaETT
Notes: Graphs use aggregated data for MS. In the case of gas, the analysis uses TTF for wholesale and for electricity, the Electricity Power Benchmark for the 8 most important markets in the EU. The retail prices is the average of EU27. The energy component of the retail prices includes energy production costs (wholesale price) and other costs stemming from the commercialisation of energy by suppliers to the end consumers (e.g. billing, advertisement, other costs, and margins).

Finally, long-term contracts, secured by some retailers, were trading at discount to wholesale market spot prices, therefore also contributing to limiting the pass-through to retail prices in the short-term. Around two thirds of EU gas consumption is covered by long term retail contracts[26].

Given the different usages for energy and the specific role of marginal sources on electricity generation, it is critical to assess thoroughly the representativeness of any sample used to measure retail prices. In the calculation of inflation, only specific retail electricity tariffs are usually included. Both in Spain[27] and the Netherlands[28], the statistical offices have revised the basket used to calculate electricity prices given the perceived lack of representativeness of the basket used[29].

Thirdly, market expectations as measured by natural gas futures have proven not to be, in the context of a turbulent market, an accurate predictor of future price developments. While expectations of shortages (rather than real shortages) drove future prices up, they ultimately fell in line with the supply/demand fundamentals supported by the policy response and the reduction of uncertainty. The analysis based on futures needs to be qualified with a qualitative analysis assessing fundamentals. While futures might not always offer an accurate picture on the long-term future developments of energy prices, due to market illiquidity and high risk premiums, they are an important indicator for market expectations in the liquid time horizon, i.e. 1-3 years, reflecting market sentiment and risk preferences. That said, price forecasts using fundamental models usually complement this picture and a qualitative analysis on supply (e.g. new LNG terminals coming online, probability of droughts, price elasticity in other regions of the world, fuel-switching …) and demand conditions (e.g. lower demand due to the installation of heat-pumps) can offer a more comprehensive assessment of possible price behaviour in the future.

26 This refers to contracts between gas wholesalers and retailers. Long-term contract usually refers to a contract of at least one year of duration. Price-setting formulas translate only a part of the increase in spot wholesale prices into the price paid by retailers under long-term contracts. As an example, the formula reflecting the basket of ENGIE long-term contracts used by the Commission de régulation de l'énergie to calculate the evolution of gas retail prices is Δm = Δ(TTF QA+1)€/MWh*0,04044 + Δ(TTF MA+2)€/MWh*0,23303 + Δ(TTF YA)€/MWh*0,07222 + Δ(PEG MA+2)€/MWh*0,59172 + Δ(PEG QA+1)€/MWh*0,06066; For more information: https://www.cre.fr/content/download/25695/file/220622_2022-164_Avis_arrete_tarifaire_ENGIE.pdf

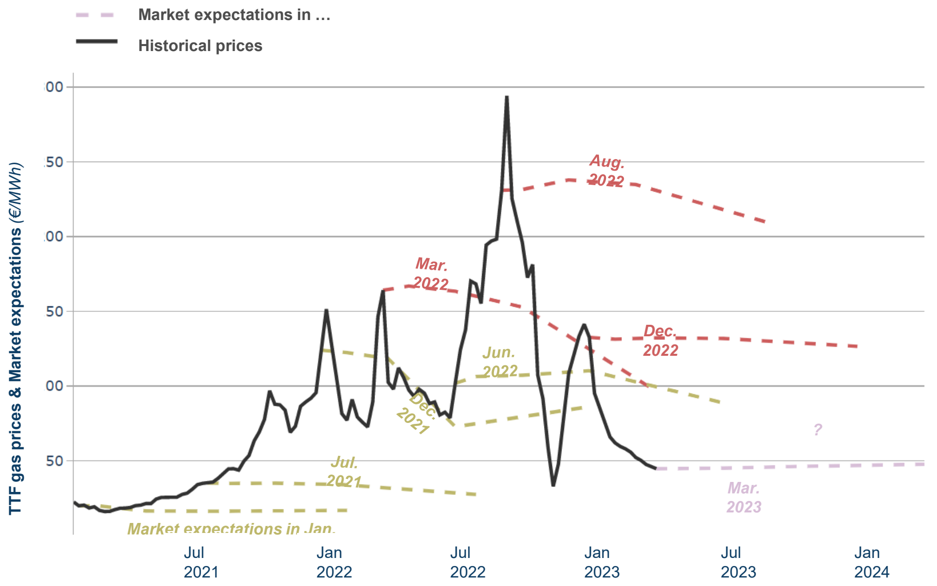
27 Instituto Nacional de Estadistica (2023), "Novedades metodológicas en el IPC", Notas de prensa

28 Statistics Netherlands (2023), "CBS introduces new energy price measurement method"

29 For example, Statistics Netherlands (2023) focusses on new contracts as obtained from the suppliers, which, however, do not take into account already signed fixed contracts. Therefore, many households remained unaffected when wholesale prices increased from 2021 onwards while the method of calculating inflation overestimated the increase in prices.

Chart 7

Historical and futures TTF natural gas prices



Sources: DG ENER Chief Economist Team based on BNEF

3 The medium to long-term perspectives of the green transition on prices: analysing the implications of the on-going structural change in the energy mix

Given the large number of different effects, in analysing price impacts, there is a need to differentiate both:

(a) the impacts during the transition and (b) those once the transition has been achieved.

(b) the short-term contribution of energy to inflation (business cycle issue mainly driven by supply factors like the events in 2021-2022) and (b) the structural changes in relative prices for energy and relevant goods brought by the transition (long-run secular issue).

In the future, the central assumption is that prices paid by the EU on both fossil fuels and critical and raw materials necessary for the green transition will be set in international markets. The EU will be able to reduce vulnerabilities mainly by lowering demand and promote diversification. Greater efficiency and electrification will be critical to insulate consumers from future shocks. There could be price pressures on clean technologies, esp. if supply chains are disrupted (e.g. by geopolitics) or if critical minerals supply fails to keep pace with demand.

In this context, residual price-setting effect of peak sources of energy on electricity markets (e.g. natural gas), is crucial and will be affected by both the market design and innovation on flexibility and storage.

A crucial issue for prices is about how fast transitions proceed in internationally, especially in developing economies, and the internal sequencing of supply and demand changes. Poorly-sequenced or erratic change during the green transition (in EU and internationally) will be accompanied by very volatile prices. Some effects intrinsic to transitions could make volatility more likely, especially in electricity where variability on both supply and demand sides is likely to increase significantly[30]. The EU might only be able to influence international balances via financing for structural change abroad affecting its pace.

3.1 Future Energy Mix: REPowerEU scenarios

The energy sector is undergoing a massive structural change with the green transition. When analysing prices, it is important to consider the changes in the energy mix in the past decades, the specific application of the different energy sources and the role of the underlying commodities. For example, oil made sense as a proxy for measuring all energy prices from the 1970s until the first decade of the 2000s. However, the lesser use of oil in the EU beyond the transport sector, its decoupling with natural gas for indexation since the 2010s and the increasing importance of other sources for electricity generation (e.g. renewables) have made the analysis on price implications progressively more complex. Any analysis of future energy prices has to build on energy scenarios and global trends, in particular related to the energy mix, global supply/demand balances and the development and deployment of new technologies..

The European Commission updated its scenarios in the aftermath of Russia's invasion of Ukraine[31]. The analysis suggests that higher fossil fuel prices[32] and the policy measures as part of the REPowerEU plan to phase-out Russian fossil fuels imports will accelerate the pace of the green transition.

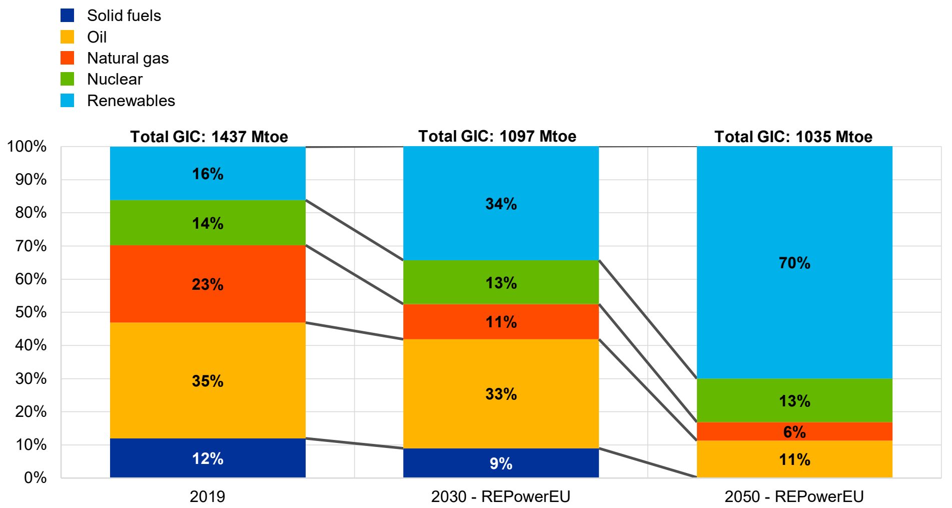
[30] On the supply side, weather variability on wind/solar. On the demand side, increased electrification will make demand more temperature- sensitive (e.g. use of electric heat pumps), while Electric Vehicles could potentially increase the risk of rapid variations in demand caused by charging if not managed.

[31] Communication from the Commission on the REPowerEU Plan, SWD(2022) 230 final.

[32] Market consensus expects higher natural gas prices than those experienced over the past 15 years, but the peak will rebalance in the short to medium term.

Chart 8

A changing energy mix: total Gross Inland Consumption (GIC) and shares by energy in 2019 and in 2030 in the REPowerEU scenario



Sources: DG ENER Chief Economist Team based on Eurostat and PRIMES model
Notes: Includes uses beyond the energy sector: e.g. feedstock

According to the REPowerEU modelling, with all policy and legal measures systematically implemented total energy consumption will decrease by one-third in the EU by 2050. While Gross Inland Consumption in 2019 was 1437 Million Tonnes of Oil Equivalent (Mtoe), it is expected to reduce to 1097 Mtoe by 2030, and 1035 Mtoe by 2050. Driven by higher prices, dedicated policies and consumer awareness, energy efficiency measures will also help to accelerate this process.

The replacement of fossil fuels by renewables in the energy mix would accelerate as well: from 70% of the energy mix in 2019 to an expected 53% by 2030, and 17% by 2050. The demand for oil and coal is projected to decrease by 34% (2030 vs 2020) and 36% (2030 vs 2020), respectively. An increased role of renewables in the electricity generation system will progressively crowd-out more expensive sources of electricity generation such as coal and gas.

As a result of the impact of Russia's invasion of Ukraine, natural gas demand will decrease faster[33]. Gross electricity generated from gas power plants is expected to be238.7 TWh lower (-67%) in 2030. The use of natural gas decreases significantly in the residential and services sectors too. By 2030, gas use in buildings decreases by 27 Mtoe (equivalent to approximately 32 bcm of gas). Natural gas is replaced mainly by electrification, heat pumps and bio-methane transported in the existing gas network.

[33] The REPowerEU modelling states that the full implementation of the Commission's Fit for 55 proposals would lower EU gas consumption by 30%, equivalent to 100 billion cubic meters (bcm), by 2030. The higher long-term gas and oil price paths reduce the natural gas demand further by about 40 bcm until 2030, whereas the implementation of the RePowerEU measures completes it with an additional 110 bcm reduction by 2030. Together with additional gas diversification and renewable gases, frontloaded energy savings and electrification have the potential to jointly deliver at least the equivalent of the 155 bcm imports of Russian gas by 2027.

With the electrification of the economy, the share of electricity in final energy consumption increases from 23% in 2018 to 33% in 2030 and 59% in 2050. The lower fossil fuel consumption has major impacts on the EU's trade balance. The Commission estimates that with the Fit-for-55 and REPowerEU measures combined, the EU can save €80 bn on gas import expenditures (0.5% of the 2022's GDP), €12 bn on oil import expenditures (0.07% of the 2022's GDP) and €1.7 bn (0.01% of the 2022's GDP) on coal import expenditures per year .

3.2 Green transition channels impacting prices

Different aspects of the transition will have opposite impacts on prices. The analysis needs to be granular and isolate the different effects one-by-one. The shift required for the green transition will affect prices through a variety of channels, in particular:

- Changes in commodities and the energy mix
- Replacement of the capital stock and infrastructure
- Changes in overall demand and consumption patterns
- Lower costs of electricity driven by renewables
- Carbon prices and taxation
- Uncertainty and higher risk premiums

3.2.1 Changes in commodities and the energy mix

Increasing need of raw materials and minerals for the decarbonisation

The green transition requires clean technologies that are very mineral-intensive. Most green technologies require significant amounts of metals and minerals, such as copper, lithium and cobalt, especially during the transition period[34]. According to the International Energy Agency, as demand rises, supply is constrained in the short and medium term. The EU depends heavily on a few countries for critical raw materials. The EU gets 98% of its rare earth supply and 93% of its magnesium from China[35]. While demand for critical raw materials is projected to increase drastically, Europe heavily relies on imports, often from quasi-monopolistic third country suppliers. Competition with other world regions that have investment heavily in the global value chain of metals and minerals remains a challenge.

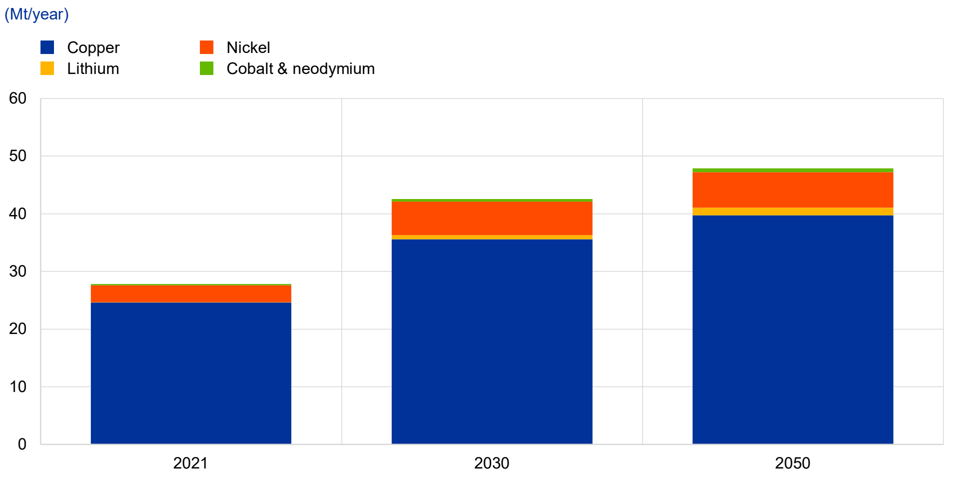
34 The current value of imports of critical raw materials and minerals remains modest compared to the value of imports of fossil fuels.

35 RMIS - Raw Materials Information System (europa.eu) - https://rmis.jrc.ec.europa.eu/

All initiatives to ensure stable and cheap access to these materials for the EU would be critical for the success of the transition. Depending on the pace of the expansion of mineral mining on the global market and the investment made into manufacturing capacity, the overall increase in demand for clean technologies might inflict upward pressure on prices[36]. The recent Critical Raw Materials Act adopted by the European Commission[37] proposes a comprehensive set of actions to ensure stable and cheap access to these materialsthat, including through identification of sources, diversification, stocks and external actions.

Chart 9

Total global demand for critical materials by type in the Net Zero Emissions Scenario of the International Energy Agency



Sources: International Energy Agency (2023): Energy Technology Perspectives 2023.

Decreasing marginal volumes of fossil fuels needed in the system

At the same time, the EU will continue to need diminishing volumes of fossil fuels during the whole transition. As shown by the recent crisis, this diminishing volumes can have a significant impact on the overall inflation, for instance if they continue to set the price of electricity. According to the International Energy Agency natural gas prices in Europe and Asia are "likely to remain increasingly volatile and in relatively high ranges over the next few years", Russian reduced supply will keep global gas markets tight with rebalancing expected from the start of new LNG supply in the mid-2020s.

In order to keep prices stable, it will be critical to reduce demand at a pace that is commensurate to the decrease in global oil and gas supply. Otherwise, sudden mismatches would result sharp increases in oil and gas prices, the later reverberating on electricity production. The European Union is very dependent on

36 It is worth pointing out, however, that raw materials are only a portion of the overall cost of installation/final product.

37 European Commission (2023b), “Proposal for a regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials”, COM(2023) 160

fossil fuel imports. The import dependency rate is particularly high for oil and petroleum products (97%) and for natural gas (94%)[38]. Therefore, the majority of fossil fuel investment decisions will be taken outside the EU, by countries and companies that may not share the transition ambitions. In this sense, the best signals we could send is phasing out fossil fuel subsidies, decreasing fossil fuel consumption and pushing ahead with the electrification of our economy and households in Europe. Clear market signals for both decarbonised investments (avoid boom-bust circles due to periodic over- or under subsidising) as well as for carbon fuel maintenance investments (ensuring security of supply for oil and gas) could help.

3.2.2 Replacement of the capital stock and infrastructure

The increase in demand for green goods could push the prices up. Moving before other regions of the world can moderate the price tensions, unless there would be massive learning curves that create late-mover-advantages. Achieving the climate and energy policy objectives requires significant investments in the energy system and transport sector (e.g. charging infrastructure for electric vehicles). It will be crucial to manage carefully its development to avoid any mismatch during the phase-out of fossil fuel and the uptake of renewables.

The Commission estimated that meeting the objectives of the Fit-for-55 package would require annual investments of about EUR 487 billion in the energy system and EUR 754 billion for transport[39] over the 2021-2030 period[40]. In particular, annual investments in the energy system are estimated to be EUR 272 billion higher in 2021-2030 compared to the 2011-2020 period. Similarly, investments in the transport sector will have to reach EUR 205 billion per year more than in the previous decade (see Table 1).

By 2030, the EU will need to invest around EUR 55 billion per year in power grids. The increasing market share of intermittent renewable energy sources for electricity directly affects the requirement for flexibility in the system, namely storages (e.g. batteries, pumped storage hydropower), dispatchable power plants (e.g., gas- and coal-fired power plants), expansion of interconnection and demand-side response.

The investment in new assets goes along with the decommissioning and lower utilisation of existing assets. Price pressures could develop if costs of stranded assets would be compensated in the form of higher tariffs. Another risk is given by regulated assets, e.g. gas grids, who could pass on their costs to a lower base of users, increasing overall costs.

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38 European Commission (2022), “Energy prices and costs in Europe” - COM/2020/951 final

39 Transport investments include the full cost of the new vehicles and the charging infrastructure.

40 European Commission (2021), “Commission Staff working document Impact assessment” Accompanying the Proposal for a Directive of the European Parliament and the Council amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, SWD(2021)621

Table 1

Average annual investment needs in the energy system and for transport, historical trend 2011-2020, and Fit-for-55 policy scenario 2021-2030

(bn EUR 2022, annual)

Sector	2011-2020 (annual)	Fit-for-55 policy scenario 2021-30 (annual)	Difference (annual)
Supply side	55	148	+93
Power grid	15	55	+40
Power plants, incl. boilers and new	40	93	+53
Demand side	160	339	+178
Industrial sector	12	34	+22
Residential	102	202	+100
Tertiary	46	103	+56
Total (Energy System)	215	487	+272
Transport sector	549	754	+205
Total (energy and transport)	**764**	**1,241**	**+477**

Sources: European Commission (2023c), "'Investment needs assessment and funding availabilities to strengthen EU's Net-Zero technology manufacturing capacity', Commission Staff Working Document SWD(2023)68 final
Notes 'Investment needs assessment and funding availabilities to strengthen EU's Net-Zero technology manufacturing capacity', Commission Staff Working Document SWD(2023)68 final:, 23 March 2023. -: The investment needs for the fit-for-55 package have been derived from a variant scenario from the MIX and MIX-H2 scenarios published in SWD(2021) 621 final. They are reported in EUR2022 while for SWD(2021) 621 final, they were in EUR 2015. They are reported in EUR2022 with deflator 1.1588.

A skilled workforce will be required in the development and deployment of energy technologies[41]. The significant increase in demand for construction will create some pressure on markets, also in the future demographic context. Shortages in the skilled labour force might create upward pressures on wages and thereby on the cost of production. The green transition happens alongside the ageing of the population, and skilled labour is increasingly in short supply across the EU.

Production of 'green' goods in the EU such as solar panels and electrolysers, as shown by the assessment of the investment needs accompanying the Net Zero Industrial Act is more expensive than in other parts of the world (e.g. China). Reshoring part of the production to the EU would need to be managed in order not to increase the costs significantly and slow-down the transition.

3.2.3 Changes in overall demand and consumption patterns

Several changes in demand and consumption patterns can already be identified, beyond the decrease in overall consumption and the acceleration of energy efficiency.

Demand-response and self-consumption

A protracted digitalisation allows empowering consumers and enhancing demand-response, hence contributing to reducing energy bills by better synchronising

[41] International Energy Agency (2023): Energy Technology Pperspectives 2023

consumption and generation of cheap electricity. This would have in principle a downward effect on prices. In particular, the green transition leads to a further decentralisation of energy generation (in particular, renewable energy sources for electricity like rooftop solar panels). However, self-consumption will need to be well managed in order to avoid that some system costs will have to be distributed to a reduced base of users, possibly offsetting the saving of self-consumers.

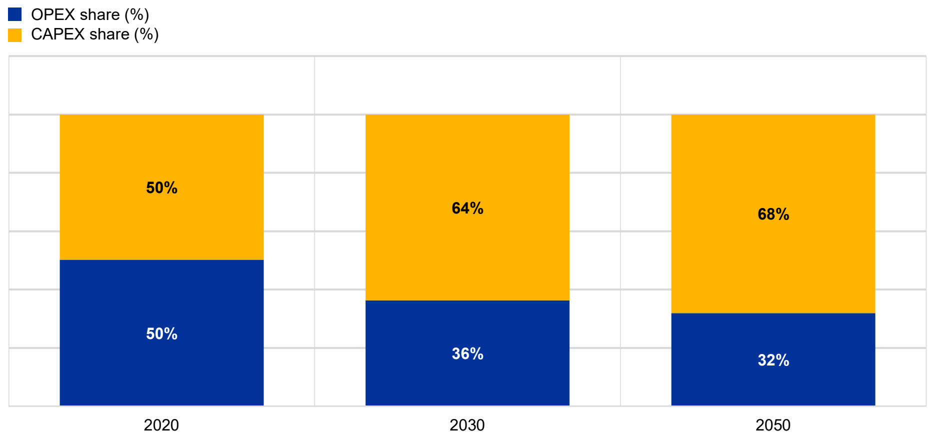
The consumers will become increasingly also producers. Currently, about 30% of the rooftop solar panels are used for self-consumption[42]. This gives small consumers direct access to low-cost electricity generated from solar energy and reduces their exposure to wholesale market volatility. These volumes are outside the consumption basket used to measure inflation.

A higher capital expenditure with lower operating costs

The green transition implies not just the substitution of carbon-intensive energy carriers with low carbon ones, but also a change in cost/price development in energy markets. Traditionally, coal, gas and oil prices are driven by supply and demand on global commodity markets. Fuel prices translate to operational expenses for the off taker (e.g. a power station) who can hedge against fluctuations only on a limited time horizon. Electricity from wind and solar and energy storages incur the dominant part of their lifetime costs upfront, at the construction stage, not during the operating phase in domestic markets. This implies a new focus on capital expenditure of projects and increases the importance of the interest rate for the overall cost of the green transition, as opposed to a focus on fuel costs for the operation.

Chart 10

Share of CAPEX and OPEX in total costs of electricity generation, transport and distribution



Sources: DG ENER Chief Economist Team based on PRIMES model

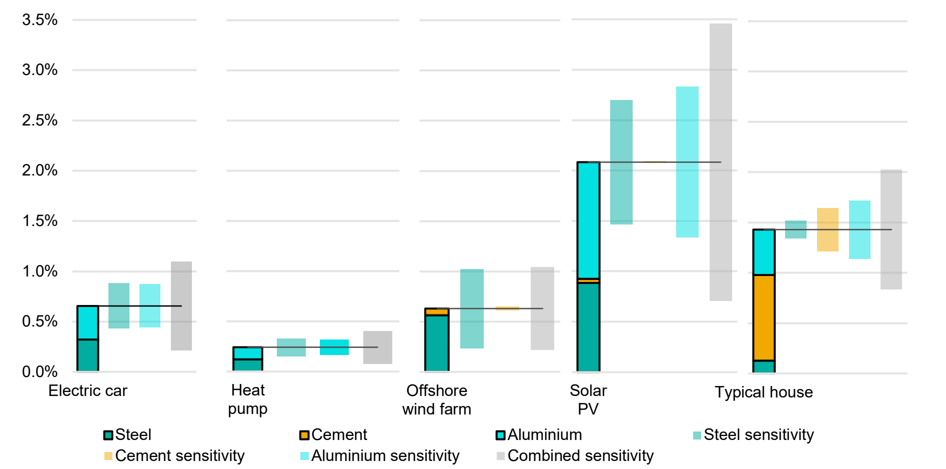
[42] Self-consumption of renewable energy sources for electricity is the direct consumption of electricity generated by an installation associated with the same meter.

Some of the technologies such as electric vehicles and heat pumps are more expensive than its fossil equivalents, although prices are lowering over time[43]. At the same time, their operating costs are usually cheaper. A critical aspect for the success of the green transition would be to ensure that the electricity on which these green solutions operate is cheaper than the fossil alternatives. This could be achieved by an accelerated increase share of renewables in the energy mix and through progressive efficiency gains.

The production of goods using low-emission technologies is more expensive than using conventional technologies with higher emissions rate. However, the effect on final prices of products is limited as green goods represent only a relatively small portion of total production costs. According to the International Energy Agency[44], the low carbon construction might increase by 0.3% (heat pump) to 2% (solar PV). The construction of a typical house would increase by around 1.4%.

Chart 11

Increase in the global average prices of selected clean energy products from switching to low-emission bulk material production



Sources: International Energy Agency (2023): Energy Technology Perspectives 2023

The assumption that the prices of green technologies will continue to go down over time would have to be monitored and might have to be revised. So far the price of the green technologies has gone down (e.g. wind turbines or solar panels) over time, therefore supporting a quicker deployment. However, due to supply chain constraints and higher global demand, recently the price of wind turbines has gone up for the first time[45].

43 Tesla Goes After America's Top-Selling SUVs - Bloomberg -

44 International Energy Agency (2023): Energy Technology Perspectives 2023

45 S&P Global

Lower costs on electricity driven by renewables

The share of electricity in final energy consumption will increase due to the electrification of the economy. This shows the growing importance of ensuring lower electricity prices in order to make the transition successful.

As explained in section 2, renewables can help bring down the price paid by final users if they manage to set prices in proportion to their greater deployment. A European Commission analysis[46] shows that in 2022, natural gas was still the most significant price setter for electricity in 2022. The share of hours in which fossil fuels set the price exceeded largely the share that these technologies have in electricity generation. Adding more renewable generation to the mix will progressively moderate this effect but it will take time.

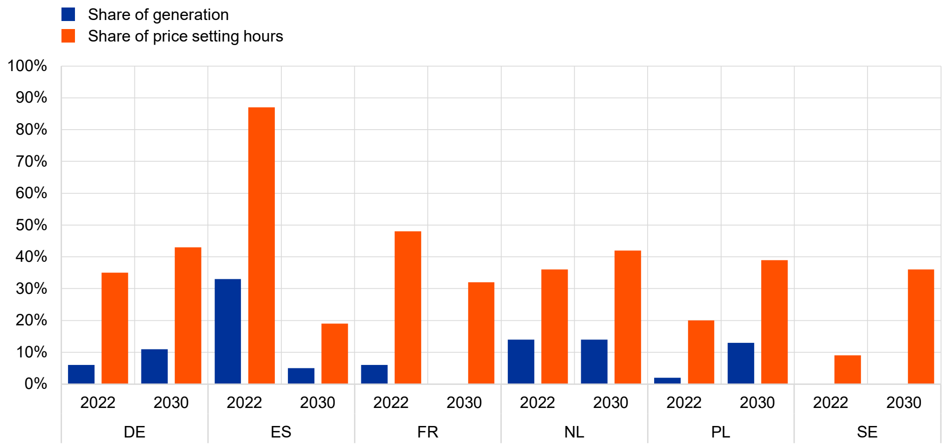
By 2030, while renewables are expected to provide more than two thirds of the EU's electricity, fossil fuels are expected to still set electricity prices during a significant number of hours and even increasing in some Member States. This is why the timing of the transition is critical. The sooner the transition is achieved the sooner the benefits would reach the overall economy limiting the competition from other parts of the world. Unlike oil or gas, electricity has very different prices depending on time and location. Instruments to arbitrage over time (e.g. storage, demand shifting) and location (e.g. transmission) might reduce the hours when gas is setting the price and levelise prices. But such a rollout of storage solutions is expected to come only after 2030 in a significant scale in the EU. As shown by the METIS model, until then, gas fired generation would take care of much of the flexibility requirements, still setting the price 50% of the time.

For 2022, our model-based assessment suggests gas setting the price between 9% in Sweden and 87 % of the time in Spain. The development by 2030 is mixed with the impact of gas on power prices diminishing in Spain (to 19%) and France (from 48% to 32%) but increasing in the other four selected Member States: from 35% to 43% in Germany, from 36% to 42% in the Netherlands, from 20% to 39% in Poland and from 9% to 36% in Sweden.

46 European Commission's JRC

Chart 12

Natural gas share of price setting-hours in electricity



Sources: DG ENER Chief Economist Team based on METIS model
Notes: Results based on PRIMES model and Fit-For-55 scenarios. Not necessarily taking into account all recent Member States announcements.

Carbon Pricing and taxation

Increasing the cost of carbon or energy, in the form of a carbon or energy tax or a cap-and-trade scheme (such as the ETS), will impact productivity as the marginal cost of production increases which might have an upward pressure on prices. However, this effect is limited to relative prices so that the impact depends on the price rigidities in other sectors of the economy. When the desired absolute price increase in the carbon-intensive sector is accompanied by reduced marginal costs and wages in the rest of the economy, the increase in prices in the fossil sector is counterbalanced by reduced output and employment in the other sectors. In a working paper from Banco de España, Santabárbara and Suárez-Varela (2022) find evidence that cap and-trade schemes are associated with larger volatility in CPI headline inflation, while no significant effect is found in the case of carbon taxes. This effect seems to feed only through the energy component, and does not seem to affect the volatility of core inflation.

The redistribution of the revenues of carbon pricing changes the transmission of the shock, and can impact prices either positively or negatively. Direct transfers to households lead to an increase in household income, which can reduce the economic burden but increase prices as a result. Using the revenues for public investment in clean technologies could lead to a positive supply shock. EU Member States are able to use the revenues of emissions trading and the new Social Climate Fund for both purposes. Overall, the private and public investment as well as targeted fiscal policy to support vulnerable households will be crucial to limit the macroeconomic costs of the green transition[47]. Recycling revenues to reduce other taxes could have a downward effect on the inflation by lowering the overall price as the overall prices go down.

47 Banque de France (2023): Transition vers la neutralité carbone: quels effets sur la stabilité des prix ?

Current taxation systems in Member States will have to be adapted to support the energy transition. Currently, while fossil fuels are heavily subsidised in several Member States, electrification does not always benefit from significant incentives. Should taxation on electricity decrease in the future, this could have a downward impact on prices.

Approximately two thirds of energy tax revenues derive from taxes on transport fuel. In Lithuania and Luxembourg, transport fuel tax represents more than 95% of total energy tax revenues. However, fossil fuels are also one of the most prevalent harmful subsidies in the EU. Overall energy tax revenue is the highest in Greece (2.9% GDP) and Bulgaria (2.7% GDP), and the lowest in Spain, Germany, Luxembourg, Austria, Malta and Ireland, with total energy revenues below 1.5% GDP[48].

Uncertainty and higher risk premiums

Changes in the cost of capital will have an increasing impact on prices given the high level of debt financing of investments where revenues can be secured such as for renewable energy sources with guaranteed remuneration[49]. Rising interest rates have driven up costs of renewable energy during the second half of 2022. Investors will closely watch policymakers as risk premiums or higher equity shares might further drive up costs of financing in case off perceived or real uncertainty.

[48] European Commission (2022c), "Taxation trends report 2022" (based on Eurostat data)

[49] According to Bloomberg, the current level of debt finance for offshore wind projects is between 70% and 80%.

Table 2
Summary table

Possible upward effects	Description
Increase in the cost of raw materials and minerals for the decarbonisation	A higher price of critical raw materials would impact both the final energy prices and the value of green goods, slowing the transition down. If all the regions in the world would engage in the transition at the same time, this could result in a large demand shock. To be noted, that the EU is very much reliant on critical minerals and raw materials, imported for their vast majority. A negative trade shock could result in upward pressures on prices. It would be critical to ensure a stable and diversified supply of critical and raw materials and accelerate the green transition in the EU ahead of other regions in the world.
Increase in the price of the marginal volumes of fossil fuels needed in the system	During the green transition, fossil fuels will decrease their role on the whole energy mix. This would be especially true for electricity generation. However, fossil fuels would still set the spot electricity prices for a significant number of hours at least until the mid-end of the next decade. Even smaller volumes, if the price of fossil fuels increases due to scarcity , might push electricity prices up. It would be important to ensure stable and diversified supply of diminishing fossil fuel supply during the transition.

Possible downward effects	Description
Changes in overall demand and consumption patterns	With the green transition, less energy is needed for a growing economy. This would be coupled with the acceleration of energy efficiency solutions and the development of more flexible demand solutions and self-consumption. While the cost of the new “Green” goods could be more expensive (CAPEX), the price of operating them could be lower (OPEX). For instance, while electric cars are more expensive today, if they access cheap electricity, they might have a deflationary effect overall for the consumer.
In a context of greater electrification, increase in the share of renewables in the electricity generation coupled with demand response, storage and higher level of interconnections	An increased role of renewables in the electricity generation system will progressively crowd-out marginal sources such as coal and gas and bring prices down. A higher level of demand response and storage solutions can limit the recourse to gas to provide electricity. A higher number of interconnections could help mitigating any risk on other sources in specific locations (e.g. hydro). The extension of long –term contracts in the electricity market would be helpful to deal with volatility and spikes and ensure that consumers benefit from the cheaper price of renewables.

Other effects	Description
Replacement of the capital stock and infrastructure	In the initial stages, the green transition will increase the demand of specific “green” goods which could bring prices up, as being more expensive that the traditional alternatives. While the prices of “green” goods have fallen over time, there is anecdotal evidence of a reversal in several goods lately (e.g. wind turbines, solar panels,…) that would have to be monitored. Underutilisation of legacy assets, e.g. gas grids could drive unit prices up. Shortages in the skilled labour force might create upward pressures on prices. Improving adjustment speed in the massive transition is crucial to avoid supply/demand mismatches at the core of inflationary pressures (e.g. re-skilling, regional transformation …).
Carbon prices and taxation	Increasing the cost of carbon or energy, can have an adverse effect on productivity which might put an upward pressure on prices. However, this effect should be limited to relative prices so that the impact on inflation depends on the price rigidities in other sectors of the economy. Using the revenues for public investment in clean technologies could leads to a positive supply shock.
Uncertainty and higher risk premiums	Market and policy uncertainties could increase the cost of capital

4 Concluding remarks

The 2022 energy crisis was driven by political instability and a related temporary supply shock in natural gas markets, where expectations and fear of shortages (beyond supply and demand fundamentals) played a major role.

Although the situation remains challenging for the upcoming years regarding global demand and supply balance, as long as diversification and demand reduction efforts continue, concerns about future shortages will be contained. This will help in avoiding extreme price spikes, like those seen in August 2022.

In the perspective of transitioning towards greener and climate neutral economy, the energy sector is in constant evolution both in terms of the sources of energy and their use. The measurement of inflation driven by energy will have to evolve accordingly.

There is a need to differentiate the short-term contribution of energy to inflation (driven by supply factors like the events in 2021-2022) and the structural changes in relative prices for energy and relevant goods brought by the transition.

Going forward, maybe the key question might not only be if the green transition has an overall upward/downward impact on prices but also the impact of its different dimensions and how these can be better managed through policy decisions and the pace of the transition.

Several trends should exert a downward pressure on prices: an increase in energy efficiency, a lower energy consumption, a higher the share of renewables in electricity generation and a lower exposure to (imported) fossil fuels.

At the same time, the EU would have to be careful to ensure in the upcoming years that it has sufficiently available cheap supply to perform the transition (both in the decreasing need of fossil fuels and increasing volumes of new materials concentrated in a limited number of countries outside the EU). Fossil fuels are traded on a global market dominated by cartels, and increasingly concentrated in a few producing countries at ever increasing marginal producing costs (in particular for oil). Policy uncertainty can also play a role making future payoffs uncertain and compressing investment.

The green transition requires significant investments to arrive to a new steady state. If properly managed, a high initial capital expenditure during the transition would meet a progressively lower expenditure. Should the rest of the world embark in the Green Transition at the same pace as the EU, this would increase global demand and certainly push prices up, despite generating more economies of scale. The sustained high demand for minerals, construction and skilled labour is likely to cause an upward pressure on the prices and up-front costs.

Given the role electrification will play in cleaning our energy systems, ensuring cheaper electricity would be crucial. A higher share of renewables in the market will contribute to greater affordability of power for end-users. At some point it will push fossil fuels out of the electricity generation merit order but it will take in the EU until the mid of next decade. During the transition, developing Power Purchase Agreements and Contract for differences in the electricity market can help in shielding consumers from price swings while providing a much-needed price signal.

But achieving the benefits of the transition might not be easy. If not well timed and managed, the marginal fossil fuels volumes to keep the system alive might become very expensive and translate into higher electricity prices (increasingly important due to electrification). The phasing out of fossil fuels should be in tune with the ramping up of the renewables and their supporting infrastructure, in order to avoid supply shocks.

Political steering will play a key role in providing visibility and predictability and ensuring that policy measures can deliver on the ambition, including by facilitating permitting for renewables, reinforcing manufacturing capacity for net-zero technologies, supporting infrastructure development, labour force skilling, and ensuring secure supplies of critical raw materials. Policy guidance and choices will be critical to avoid a double effect: more expensive fossil fuels reverberating into the economy via electricity system during the transition and more expensive raw materials. At the end of this structural change, prices for electricity generation and heating might be lower but arriving to the steady state might be challenging if not properly managed. There would be a need to ensure competition and increase elasticities.

The sooner (and the more managed) the green transition would be implemented, the smaller the costs would be.

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