EU REGULAR ECONOMIC REPORT 9

WORLD BANK REPORT
ON THE EUROPEAN UNION

Energizing Europe

PART 2

Rising to the Challenge

WORLD BANK GROUP

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Rising to the Challenge

1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org

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Piotr Ruczynski, London, United Kingdom

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Abbreviations

CAPP Clean Air Priority Program
CGE Computable General Equilibrium
CO_2 Carbon dioxide
CPA Classification of Products by Activity
EC European Commission
ESCO Energy service company
ESPC Energy Savings Performance Contracting
ETS Emission Trading System
ETS Emissions Trading System
EU European Union
EU27 European Union
FE Fixed effects
FIRST Foster. Innovate. Reduce. Savings. Targeting.
FSRU Floating storage and regasification unit
GBS Gravity Based Structure
GDP Gross Domestic Product
GHG Green House Gas
GJ Gigajoule
GM Green management
GMI Guaranteed minimum income
GTAP Global Trade Analysis Project
HBS Household Budget Surveys
HEI High Energy Intensity
IGB Interconnector Greece–Bulgaria
KWh Kilowatt-hour
LEI Low energy intensive
LNG Liquified Natural Gas
M&E Machinery and equipment
MWh Megawatt hour
NACE The Statistical Classification of Economic Activities in the European Community
PMT Proxy means testing
RER Regular Economic Report
SME Small and medium-sized enterprise
SOE State Owned Enterprise
TAP Trans Adriatic Pipeline
TTF Title Transfer Facility
US United States
VAT Value Added Tax
WBG World Bank Group
Yoy Year-over-year

Regional Groupings

Central and Southeast Europe (CEE):
Bulgaria (BG), Croatia (HR), Czech Republic (CZ), Hungary (HU), Poland (PL), Romania (RO), Slovak Republic (SK), Slovenia (SI)

Northern Europe (NE):
Denmark (DK), Estonia (EE), Finland (FI), Latvia (LV), Lithuania (LT), Sweden (SE)

Southern Europe (SE):
Cyprus (CY), Greece (EL), Italy (IT), Malta (MT), Portugal (PT), Spain (ES)

Western Europe (WE):
Austria (AT), Belgium (BE), France (FR), Germany (DE), Ireland (IE), Luxembourg (LU), Netherlands (NL)

Executive Summary

The spillovers from the Russian Federation's invasion of Ukraine have been widespread, particularly for European Union countries. The key channels of impact included higher energy and food prices, disruptions in trade and financial flows and increased geopolitical tensions and uncertainty. With persistent inflation, monetary policy has been tightened. The impact on the energy sector in the EU has been particularly severe and is likely to be sustained.

This report focuses on the impact of the war in Ukraine on the energy sector in 2022 and early 2023 and its implications at the macro and micro level in the EU. The EU is a net importer of energy and is highly dependent on fossil fuels. In 2021, almost 70 percent of the EU's energy needs were met from fossil fuels, mostly imported from Russia. This has led to legitimate concerns on the security of energy supply and has also made the EU susceptible to fluctuations in fossil fuel prices. Russia's invasion of Ukraine in February 2022 led to disruptions in the supply of fossil fuels, especially natural gas, to the EU and a spiraling of energy prices. The macro level effects of the war in Ukraine as evidenced by higher inflation and tighter monetary policy as well as lower growth are relatively well-known but the impacts on firms and households have been very heterogenous with significant policy implications.

The findings in this report are drawn from data sources including Eurostat, GTAP, IEA, World Bank Enterprise Survey, and other publicly available datasets, and based on analysis completed in April 2023.

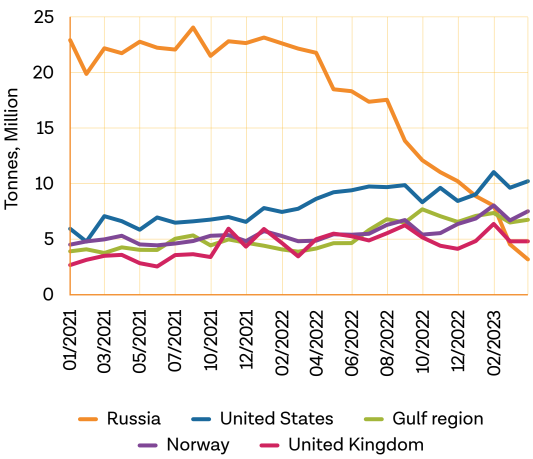
How have populations fared?

EU Governments stepped in again, after massive COVID-19 support, to shield firms and households from the spillovers of the war in Ukraine and to shore up energy security — these measures have helped but have come at a significant cost. In Bulgaria, Croatia, Poland and Romania, the total fiscal cost of policy measures (either spent resources or revenue foregone) amounted to EUR 52.1 billion as of April 2023. Support measures to firms and households have included tax relief and non-tax measures like subsidies and price caps, with the latter accounting for nearly 80 percent of the support in the four countries. In Croatia, an assessment of the distributional impacts of the VAT reduction shows a small increase in household income and a modest decline in the at-risk-of-poverty rate. An analysis of the indirect subsidies and transfers in Bulgaria suggests that they are less progressive than direct transfers. Nevertheless, many of the support measures have distorted energy prices, thereby encouraging the use of fossil fuels and reducing efforts aimed at energy efficiency. On the energy front, the EU embargoed oil and coal imports from Russia to varying degrees while Russia reduced natural gas supplies to the EU. To ensure short- to medium-term energy security, EU countries ramped up imports of liquified natural gas (LNG), primarily from the United States, and are scaling up their LNG capacity of terminals, storage, and regasification units (Figures ES.1 and ES.2). In addition, the EU announced the REPOWEREU program, setting the pillars for the EU's energy independence from Russian fossil fuels by 2027. Governments also undertook measures to delink the electricity and gas markets, but price caps and non-cost reflective tariffs could impact the financial sustainability of energy companies, thereby affecting future green investments.

Nevertheless, certain aspects of the EU's green transition saw an acceleration in 2022, particularly noteworthy were the strides made on energy efficiency and the scale-up of renewable energy. Energy demand reduction was a key feature of 2022, with various efforts by countries yielding a reduction in EU electricity demand of 3 percent in 2022, year-on-year, and a reduction in natural gas demand of 12 percent compared to the 2019 – 21 average. The decline in natural gas demand in Bulgaria, Croatia, Poland,

FIGURE ES.1 EU Mineral Fuel Imports by Partner

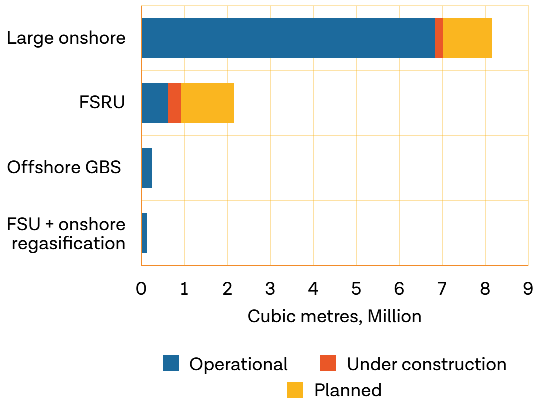
01/2021 – 03/2023



Source: Eurostat Comtext.

FIGURE ES.2 EU LNG capacity

As of November 2022



Source: Gas Infrastructure Europe.

Note: * FSRU — floating storage and regasification unit; GBS — Gravity Based Structure.

and Romania was close to or exceeded the reduction at the EU level, attributable in part to increased energy efficiency. This was the result of efficiency retrofits, boiler replacements, installation of heat pumps, efficiency gains in industry, and progress on the renovation wave to improve the energy efficiency of buildings (some of these efforts pre-date Russia's invasion of Ukraine). Meanwhile, wind and solar generated 22 percent of EU electricity in 2022, for the first-time overtaking gas (20 percent) and remaining above coal power (16 percent). Moreover, coal generation fell by 6 percent in Q4 2022 compared to Q4 2021 because of falling electricity demand.

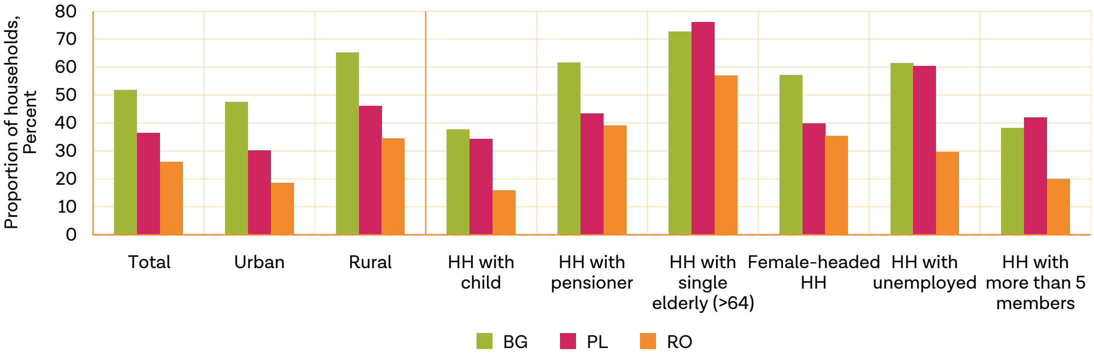
In the industrial sector, firms proved to be far more resilient to energy price hikes than was earlier anticipated. Industrial lobbies voiced their concerns about the severe repercussions of sanctions on Russian fossil fuel imports to the EU. Nevertheless, these bans were put in place and firms proved to be far more resilient than expected. They responded to high energy prices by lowering energy consumption and through product price increases. For example, in October 2022, German industry reduced energy consumption by 23 percent due to a 540 percent gas price hike for industrial consumers relative to pre-crisis levels. These results were corroborated by a World Bank qualitative survey in Bulgaria, Croatia, and Poland, which found that the key channel of response for firms included price pass throughs and a reduction in profits rather than a cut in output or employment.[1] At the firm level and for certain industries highly reliant on gas (like fertilizers), there was considerable heterogeneity in terms of impact, but at the aggregate industrial level, there was significant resilience. Government support measures were also instrumental in softening the impact on firms.

However, amongst households, the energy price hike has had a disproportionate impact on the poor and vulnerable, with implications for increased inequality. Single elderly households and rural residents have higher energy poverty rates, with significant variation across countries. The share of household income spent on energy is higher among the bottom income quintiles in Bulgaria, Croatia, Poland, and Romania, while such households also have lower buffers and fewer means to cope with shocks. In addition, they live in low-quality housing with poor insulation, which raises their energy needs. They also have less access to cheaper renewable energy sources and energy efficient appliances. Therefore, the energy price

1. The survey included 28 firms and was undertaken in Bulgaria, Croatia and Poland. Further details in Chapter 3.

shock has made households in the bottom income quintiles worse off than those in higher income quintiles, likely exacerbating inequality in the four countries. Government support measures have certainly helped offset some of the negative impacts, but the poverty and inequality effects are still perceptible.

FIGURE ES.3 **Energy poverty rate by groups, 2021**



Source: Romania HBS and Bulgaria HBS, 2021, Poland HBS 2018.

Note: The spending shares are constructed using the energy spending over the observed household monthly income from the budget surveys. Energy poverty is defined as the share of households spending more than 10 percent of income on energy. The income and energy spending information across countries are not fully comparable.

Opportunities ahead

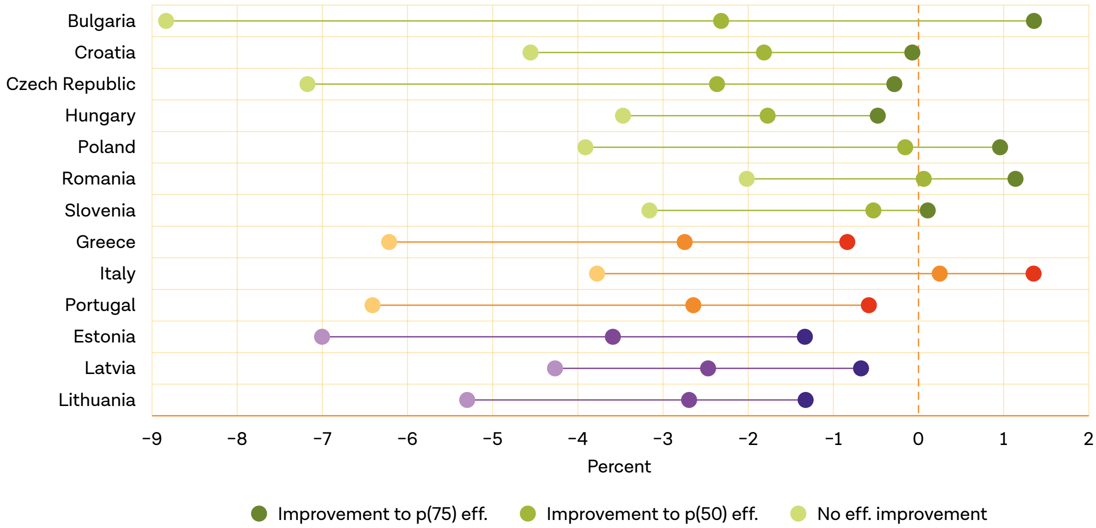
At the macro level, the impact on growth of a full cessation of gas supplies from Russia to the EU (from already reduced levels seen in 2022), is expected to be relatively muted, implying that energy decoupling from Russia is achievable without large disruptions to the aggregate macroeconomy. Simulations of a cessation in natural gas trade between Russia and the EU show that the impact on growth varies amongst the four countries — Bulgaria, Croatia, Poland, and Romania — but is low and ranges between +0.11 to -3.48 percentage points.[2] The heterogenous impact is a result of differences in gas availability and energy structures in the four countries, which impact prices and hence aggregate demand differently. Government support measures, which are not considered in the simulation exercise, could further reduce the impact on growth. These simulations show that the four countries have already achieved significant decoupling from Russian gas and if supplies are disrupted further, the growth impact on these economies is not likely to be large.

At the micro level, firm level energy efficiency measures have the potential to offset the decline in profits as a result of higher energy prices. A microsimulation exercise shows that an increase in the energy efficiency of firms can significantly reduce the impact of higher energy prices on firms' costs and profits and can also help them retain their workforce.[3] Increasing energy efficiency would in turn require upgrading capital for firms that have outdated or polluting equipment and machinery. For other firms that have modern capital, the adoption of green management practices would have a big impact on energy efficiency. In Bulgaria, Croatia, Poland, and Romania, more than 80 percent of the inefficient firms have a level of capital that is below the average capital endowment of the firm at the median of the energy efficiency distribution. Therefore, most of the firms in these four countries will require capital upgrades to improve energy efficiency.

2. These simulations were done using a CGE model and the details are mentioned in Chapter 2.

3. The details of this microsimulation exercise using the World Bank Enterprise Survey data are presented in Chapter 3.

FIGURE ES.4 Scope of energy efficiency improvements in offsetting the negative impact of higher energy prices on profits



Source: World Bank elaboration based on WBES and Eurostat.

Notes: No efficiency improvements considered the impact of energy price shocks on average firm-level profits assuming the price increase is the average EU27 electricity and gas price changes. Improvement to the 50th percentile — p(50) — efficiency means that efficiency of firms below median of the industry-by-size efficiency threshold are improved to the threshold value. The equivalent exercise if performed for the 75th percentile -p(75). Baseline costs are those under no efficiency improvements.

Meanwhile, the data so far do not corroborate a loss of trade competitiveness in the EU, but lagged effects are yet to be seen. Prior to the pandemic, the EU's exports of energy-intensive goods were predominantly standardized heavy products, whereas low energy-intensive exports were characterized by greater differentiation and higher unit prices. In 2022, there was a decline in the volumes of both low and high energy-intensive exports and imports. However, the decline was more pronounced in high energy-intensive sectors, particularly during the latter half of the year. The limited impact on competitiveness can partly be explained by the fact that energy prices had global repercussions, with most countries negatively impacted and many emerging economies also bearing the brunt of currency depreciations. Another possibility is that EU firms demonstrated remarkable resilience to price increases and have adapted well to the changed energy landscape. Meanwhile, the recent decline in trade for both high and low energy intensity products could be more indicative of a decline in global trade rather than an impact on competitiveness. It is also conceivable that the loss of competitiveness may be apparent with a delay.

However, at the household level, the poverty impacts of an increase in prices could be substantial. According to microsimulation results,[4] food and energy inflation are expected to increase poverty rates by 0.3 to 1.8 percentage points in Bulgaria, Croatia, Poland, and Romania. The poorest households experience the highest relative welfare losses. Indirect effects of higher food and energy prices explain most of the increase in poverty as they ripple through core inflation. While income support measures could potentially mitigate some of these losses, poorer households are more vulnerable due to their consumption patterns.

4. Based on household budget surveys, poverty defined at US$ 6.85 per day in 2017 PPP. For details, refer to Chapter 4.

What can governments do differently?

Going forward, there is room to strengthen and finetune government support to firms and households to help them adapt to the evolving energy landscape. It is important for governments to target support to viable firms and vulnerable households so that scarce fiscal resources are well utilized and so that fiscal policy supports macroeconomic stabilization. For viable firms, government support should incentivize and be contingent on energy efficiency improvements. These could be in the form of accelerated depreciation for relevant investment or grants and vouchers for investment to support smaller and younger firms. In addition, support should be tied to specific energy price levels so that it is needs based. Meanwhile green management practices could be encouraged by developing markets for energy audits and consultants and providing blended finance schemes. For vulnerable households, effective social safety nets are critical for providing support in the short term, while subsidies to upgrade the energy efficiency of housing and appliances are needed in the medium term.

In addition, governments can also undertake measures to accelerate the transition to net zero emissions while strengthening energy security. The downside risks to the EU energy sector can potentially emanate from adverse meteorological events and increased global demand for existing LNG and other fuel supplies. Therefore, EU governments need to prioritize strategies that increase energy security, accelerate the energy transition, and reduce greenhouse gas emissions. These strategies include diversifying the energy (and geographical) mix, increasing electrification, reinforcing electricity and gas networks to increase their flexibility, ensuring the financial sustainability of the energy sector, phasing out emergency measures, and promoting decarbonization in the transport, industry, and heating sectors. Most importantly, these measures need to be implemented based on the just transition principles.

THEMATIC FOCUS
Energizing Europe

Russia's invasion of Ukraine caused turmoil in the energy markets with far-reaching implications. Fossil fuel prices were on an upward trend in 2021 as the recovery from the pandemic gained momentum. After the war in Ukraine broke out, global energy prices skyrocketed. The EU was particularly impacted by higher global energy prices since it is a net importer of fossil fuels. The significant dependence on Russian imports also raised issues of energy security. Higher prices resulted in lower consumption by households while some energy dependent firms had to curtail or completely stop production. The energy price hike led to higher inflation and monetary policy tightening. Although national governments stepped in with support packages, fiscal policy normalization was also underway since governments were facing higher debt levels as a result of the pandemic-era support measures.

The special section of this Regular Economic Report (RER) brings together the macro and micro impacts of the energy crisis in the European Union, with a focus on Bulgaria, Croatia, Poland and Romania.[5] The energy landscape in the EU underwent a significant change in 2022, with reduced reliance on Russian fossil fuel imports, higher liquified natural gas (LNG) imports along with investment in LNG infrastructure, increased share of renewable energy, and greater emphasis on policy measures to ensure energy security and independence. Firms also adapted to the new environment of higher energy prices, primarily by reducing energy consumption, passing on higher costs to consumers, and through reduced profits. Households adapted by lowering energy consumption. However, given the geopolitical uncertainties, there could be further disruptions in energy markets and there is a need for policies which will address medium and longer-term issues related to energy efficiency and the green transition, more broadly.

This report is structured in the following manner. The first chapter discusses the energy context and key challenges facing the EU countries, particularly, Bulgaria, Croatia, Poland, and Romania along with policy options for the medium to longer term. The second chapter quantifies the growth impact of a cessation of Russian gas imports. The third chapter analyzes the impact of the energy price hike on firms and presents policy options for consideration, given the uncertainties in the energy market. The fourth and final chapter describes the energy vulnerable households, analyzes the poverty impact of the energy price hike and proposes options on how governments can better support the energy poor.

5. Depending on data availability, some additional EU countries have also been analyzed or referenced.

Chapter 1

EU Energy Context and Challenges

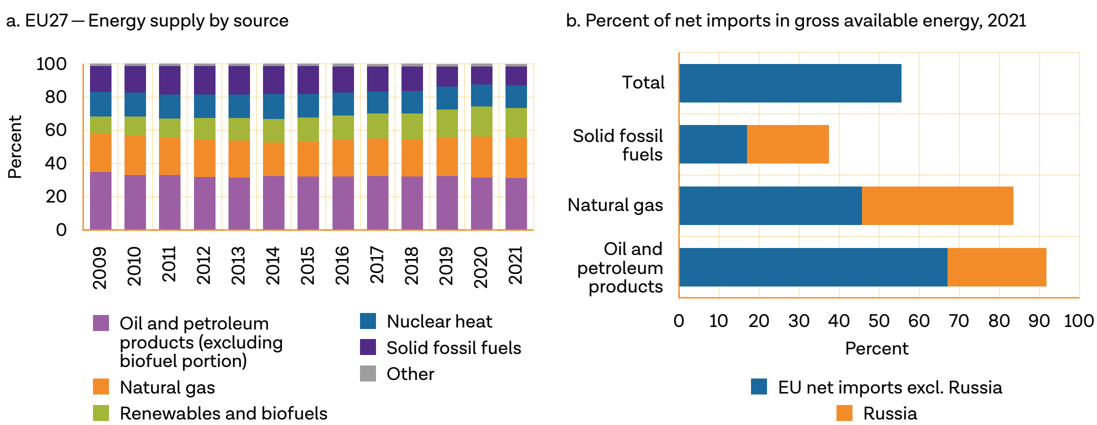
As EU countries were gradually recovering from the pandemic, they were adversely impacted by spillovers, particularly to global energy markets, from Russia's invasion of Ukraine. Russia is the largest supplier of natural gas, oil, and coal to EU member states. The EU imposed sanctions on Russia and Russia, in response, reduced natural gas supplies to Europe. As a result, European natural gas prices skyrocketed along with an increase in other fossil fuel prices. This shock to the energy system in the EU is likely to be sustained and EU member states have responded through various measures.

The war in Ukraine has brought to the fore the debate on energy demand, energy security and independence, transition to green energy, and implications for the European Green Deal. Energy security has moved to the center of European energy priorities and policy while countries also strive to keep the momentum on the green transition. Economies aspire to achieve higher energy efficiency, lower energy intensity (energy consumption per unit of GDP), lower greenhouse gas (GHG) emissions, and greater energy independence. To address the spillovers from the war in Ukraine, EU countries have introduced a spate of policy measures, both at the national and the supranational level. These measures have softened the impact of high energy prices on households and firms, while the successful deployment of policies that change energy consumption and strengthen energy systems and markets will influence the longer run transition to a green and more sustainable economy.

The energy market and dependencies

The EU is highly dependent on fossil fuels for its energy needs and imports more than half of it, raising concerns on energy dependence. Notwithstanding the strong decarbonization agenda in the EU, close to 70 percent of the EU's energy needs were met through fossil fuels (coal, natural gas, and oil) prior to Russia's invasion of Ukraine (Figure 1.1). The EU suffers from a structural and long-time dependence on energy imports and produced only 44 percent of its energy needs in 2021, with the rest being imported. Russia has traditionally been the largest supplier of natural gas, oil, and coal to the EU. In 2021, Russia accounted for 28 percent of crude oil imports, 44 percent of natural gas imports, and 52 percent of solid fossil fuel (mainly coal) imports in the EU. The strong reliance on imports creates legitimate concerns about the security of supply while dependence on fossil fuels also exposes the EU economy and key sectors to large fluctuations in the price of fossil fuels.[6]

FIGURE 1.1 **The EU is highly dependent on fossil fuels, most of which are imported**



Source: Eurostat.

6. Data extracted from Eurostat, https://ec.europa.eu/eurostat/web/interactive-publications/energy-2023.

The four countries — Bulgaria, Croatia, Poland, and Romania — have a varied energy mix, with different levels of dependence on Russian fossil fuel imports. While the level of dependence on fossil fuels in Bulgaria, Croatia, and Romania is close to the EU average, Poland's dependence is much higher at almost 90 percent. The dependence on Russian energy imports varies significantly by country. Romania is among the most energy independent countries in the EU, with energy imports of 28 percent and only 17 percent of its gross available energy imported from Russia. About 38 percent of Bulgaria's energy available is imported and half of its energy imports come from Russia. Poland imports 43 percent of its energy needs and 81 percent of the energy imports, primarily oil, come from Russia. Croatia is the most energy dependent of the four counties, with total energy imports of 54 percent and imports from Russia of 25 percent, mainly coal and gas. For details, see Box 1.1.

BOX 1.1 Energy mix of Bulgaria, Croatia, Poland, and Romania

Bulgaria

Bulgaria imports almost all of its natural gas, and historically most of this natural gas originated from Russia. At the same time, natural gas is not a significant fuel in the country, but it does play a prominent role in district heating and in select industries, which are important from a political and strategic point of view. Bulgaria is home to a large oil refinery that is tuned to a certain volume of Russian crude, which would not be easy to replace with crude oil from alternative suppliers. Furthermore, Bulgaria is dependent on imports of almost all of its oil products, but these are typically easy to source from the global market, albeit at higher prices. Finally, while coal plays a large role in power generation, Bulgaria produces most of its coal domestically, and the small share of coal that historically came from Russia can be easily replaced by coal from the global market, albeit at higher global coal prices.

Croatia

Natural gas plays an important role in the Croatian economy, in particular in power generation. Historically, Croatia imported a large share of its natural gas from Russia, but this changed when the Hrvatska LNG terminal in Krk came onstream in the fourth quarter of 2021. Croatia also imports most of its oil products, but the country was never significantly dependent on Russian gasoline and diesel, and could easily source these products from alternative suppliers, albeit at higher prices. Furthermore, coal is not a predominant fuel in Croatia, so sourcing it from the global market, albeit at higher global coal prices, would not trigger large disruptions.

Poland

Poland has traditionally been critically dependent on Russia in terms of its oil and natural gas supply, but the country has invested significantly in new LNG and pipeline gas infrastructure in recent years to rapidly reduce this dependence. However, like other countries in the region, Poland is facing structurally higher prices for oil (products) and natural gas on the global market, which are affecting strategic sectors of its economy. Poland is practically self-sufficient in terms of coal, which is still a key fuel for power generation in the country.

Romania

Romania is one of the natural gas producing countries in Europe, and the country is still largely self-sufficient in terms of domestic natural gas production to date. Romania traditionally imports crude oil for its refineries from Russia, which is not easy to replace, because a refinery is typically tuned to crude oil with a specific composition. Furthermore, like other countries in the region, Romania is also facing structurally higher prices for oil and coal imports, and there is a spillover effect from global gas markets to gas prices in the country. Finally, Romania is not a large importer of Russian coal, so it would not be difficult for the country to replace its coal imports with coal from alternative suppliers, albeit at higher global coal prices.

The European Union has been particularly successful in decarbonizing the electricity sector but dependence on fossil fuels remains. The EU reached a 38 percent share of renewables in electricity generation in 2021 (Table 1.1). However, fossil fuels still play a significant role in power generation in selected member states, for example, coal in Poland (71 percent) and Bulgaria (36 percent), and natural gas in Croatia (26 percent).

TABLE 1.1 **Fuel mix for power generation in the EU and selected countries in 2021**

Percent

	EU	Bulgaria	Croatia	Poland	Romania
Coal	14	36	10	71	18
Natural Gas	20	6	20	10	17
Oil	2	1	0	1	1
Fossil Fuel	36	43	30	82	36
Renewable	38	22	70	17	45
Nuclear	25	35	0	0	19
Other	1	0	0	1	0

Source: Eurostat, NRG_BAL_PEH.

The dependence of the electricity generation matrix on fossil fuels — especially on natural gas — is responsible for the transmission of natural gas price volatility during the energy crisis to electricity prices, in the context of the current regional power market structure. Electricity price formation mechanisms in the EU are market-driven and integrated at the regional level. Gas-fired power plants are usually the marginal technology in the EU electricity market at different hours of the day and season, and thus the cost of electricity production from gas-fired power plants sets the electricity price in those periods. The regional nature of the electricity market results in market clearance and price formation at the regional level, allowing the maximization of efficiency in the use of power generation assets among Member States. However, this virtuous transmission mechanism for efficiencies was also responsible for transmitting volatile natural gas prices to electricity prices throughout the EU during the energy crisis.

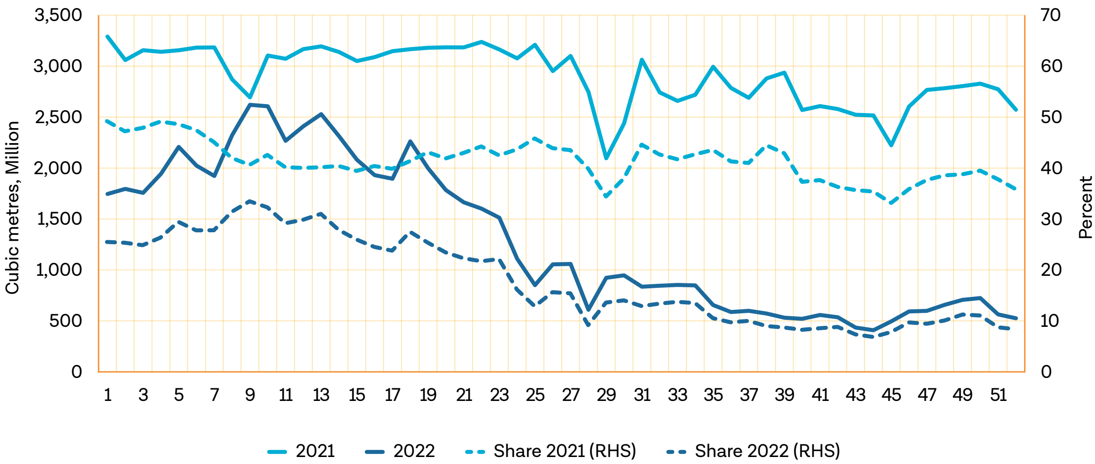
About two-thirds of the EU's total energy in 2021 was consumed by end-users (citizens, industries, and others), with the remaining going to power generation and other energy production processes. Of the two-thirds of final energy consumption, the transport sector accounted for 29 percent, households for 28 percent, and industries for 26 percent. While the transport sector mostly consumed oil products, industry and households mainly consumed electricity and natural gas. Meanwhile, biomass consumption is still relevant in households. In 2021, petroleum products like heating oil, petrol, and diesel fuel accounted for 35 percent of final energy consumption followed by natural gas (23 percent) and electricity (23 percent).

Energy supply disruptions and spiraling prices

The global slowdown in fossil fuel projects during COVID-19 followed by Russia's invasion of Ukraine have led to concerns about the security of energy supply, in particular of natural gas to Europe. The sustained, significant role of fossil fuels in the EU, along with high dependence on Russia for energy supplies, leaves economies in the bloc vulnerable to potential supply chain interruptions and global price shocks. The risk of supply interruptions is particularly relevant for natural gas because of the reliance of gas supplies on pipeline infrastructure, which has limited physical and commercial flexibility. Unlike natural gas pipeline imports, LNG, oil, and coal imports are more flexible and can easily be pivoted to new energy suppliers, if needed, but subject to higher price volatility. They are also easier to store and transport from one market to another.

Russia's invasion of Ukraine in February 2022 led to disruptions in fuel supplies from Russia to Europe, with natural gas deliveries declining by 56 percent in 2022, yoy. Russia stopped all natural gas supplies to certain EU Member States in the Spring of 2022. Meanwhile, the EU announced the REPowerEU program in May 2022, setting the pillars for EU's energy independence from Russian fossil fuels by 2027 by accelerating the clean energy transition and achieving a more resilient energy system. Member States agreed to phase out fuel imports from Russia as soon as practically feasible and individual EU countries started purchasing fuel from alternative suppliers and cutting down fuel consumption to reduce their dependence on Russian imports.[7] The European Commission (EC) also launched the Joint Purchasing Platform in June 2022, which is a voluntary joint purchasing mechanism for natural gas, LNG, and hydrogen to facilitate the access of smaller countries to global energy markets by aggregating purchases. Consequently, natural gas supplies from Russia to the EU in 2022 were 55 percent lower than in 2021 (demand reduction also played a role); in relative terms, the market share of Russian gas in the EU fell from 44 percent in 2021 to 19 percent in 2022 (Figure 1.2).

FIGURE 1.2 Russian gas supplies and the share of Russian gas supplies to the EU



Source: Bruegel, European natural gas imports: https://www.bruegel.org/dataset/european-natural-gas-imports.

With varying levels of dependence on natural gas and on Russian imports of gas, the supply disruptions from Russia have affected EU member states differently, but none of them faced supply shortages to end-consumers. Many EU countries benefited from energy sector investments (in new natural gas pipelines from countries other than Russia, in LNG and renewables infrastructure) that pre-date Russia's invasion of Ukraine and were completed in the recent past or are expected to be completed soon. The impacts on the four countries are discussed below and all four countries saw demand reductions. Despite the impact, all four countries have been able to bring enough natural gas from alternative sources to meet their (reduced) market demand, and to fill up gas storage in line with EU targets.

- **Bulgaria** was cut off by Gazprom in April 2022. Therefore, it has been sourcing more natural gas from Azerbaijan and in the form of LNG through terminals in Greece and Türkiye. These options were enabled by (i) the commissioning of new gas interconnection infrastructure (the IGB gas interconnection pipeline with Greece which was initiated much earlier but completed recently) and (ii) the interconnection agreement concluded between Bulgaria and Türkiye to deliver gas through the legacy Strandzha/Malkoclar cross-border gas interconnection point.

- Historically, **Croatia** imported about half of its natural gas from Russia. However, when the LNG Hrvatska terminal in Krk came onstream in October 2021, Croatia started diversifying its natural gas supply and significantly reduced natural gas imports from Russia prior to the invasion of Ukraine. Today, Croatia's direct imports of Russian natural gas are negligible.

7. The RePower EU program defines measures aimed at tackling rising energy prices, cutting the fossil fuel dependence on Russia by the end of the decade and accelerating the green transition.

- Gazprom interrupted gas supplies to **Poland** in April 2022 as the country refused to pay for gas in rubles. Nevertheless, Poland was well-prepared and managed to import natural gas from alternative sources, primarily through the country's LNG terminal in Świnoujście, the LNG terminal in Klaipeda in Lithuania, and the new Baltic Pipe from Norway that came onstream in the fourth quarter of 2022.

- **Romania** is a large natural gas producer, and largely self-sufficient in terms of natural gas supply. It has traditionally imported a small share of its natural gas from Russia during the winter months. Due to its large domestic natural gas production, and recognizing the reduction in gas demand, the country did not have to replace Russian gas with gas from alternative suppliers.

Energy prices rose sharply in the aftermath of the war in Ukraine, not only in the EU but globally. In the aftermath of the invasion, the EU (and other countries) imposed sanctions on Russia and Russia imposed countersanctions on various sectors, including energy. Russia also reduced its supplies of natural gas to the EU and there were wider supply disruptions because of the war. Since Russia is a large supplier of fossil fuels, these geopolitical developments and the need for the EU to source natural gas and alternate fuels from elsewhere led to a significant increase in energy prices. Natural gas prices had started increasing in the second half of 2021 on the back of firming demand from the pandemic recovery, but then skyrocketed after the war broke out. On balance, the rise in energy prices in Europe in 2021 is largely attributable to a surge in global demand resulting in a tighter supply and lower LNG imports into Europe. At the same time, Russia reduced short-term sales to the EU. Lower supplies were aggravated by the longer heating season over 2020 – 21 as unfavorable weather conditions reduced hydro and wind power generation. The increase in the EU Emission Trading System (ETS) prices also contributed to some of the increase in prices. Over the longer term, inadequate investment in renewables along with a decline in upstream fossil fuel investment has also added to supply pressures. After the war began, Russia reduced its gas supplies to the EU while the maintenance-related temporary shutdown of nuclear power plants in France added to energy shortages. In this context, the share of energy traded in short-term markets in the EU rose, increasing the price volatility.[8]

The significant increase in European natural gas prices hit EU countries particularly hard. The electricity price in the wholesale electricity market is set by the marginal (most expensive technology) supplier, according to the merit order principle. In Europe, the single electricity market increases the economic efficiency of national electricity markets under normal circumstances, but it worked as a transmission channel of high electricity prices throughout Europe during the energy price hike. In 2022, the price of natural gas (Dutch Title Transfer Facility, TTF) rose to a high of EUR 330/MWh, Brent crude oil breached US$130 per barrel, while coal prices increased to nearly US$457 per ton. In Bulgaria, natural gas prices rose to EUR 159/MWh in the third quarter of 2022, that is, 368 percent higher than natural gas prices in the same quarter of 2021. Similarly, natural gas prices went up to EUR 147/MWh, EUR 197/MWh, and EUR 172/MWh in the third quarter of 2022 in Croatia, Poland, and Romania, which was 332 percent, 285 percent, and 282 percent higher than gas prices in the same quarter of 2021, respectively. Croatia has a large share of LNG in its natural gas supply mix, which means that gas prices in the country are generally more correlated with global LNG prices than with European hub (TTF) prices. Meanwhile, the Polish natural gas market is well-connected with the north-west European gas market. Higher natural gas prices contributed significantly to rising inflation. With the recent slowdown in economic activity in the EU and globally and the demonstrated ability of EU Member States to replace Russian energy imports, energy prices have fallen. As of early May 2023, Brent crude prices have fallen to about US$75 per barrel, coal prices to US$166 per ton, and gas prices to about EUR33/MWh.[9]

8. Most of the gas supplies from Russia before its invasion of Ukraine were based on long-term contracts.
9. https://tradingeconomics.com/commodity/coal

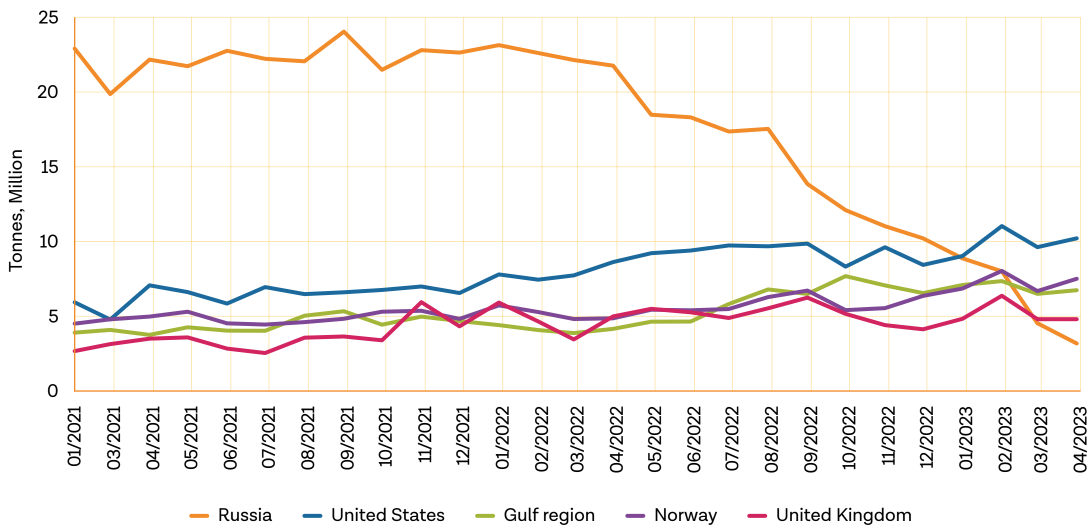
2022 — The changing landscape of the EU energy market

The EU embargoed oil and coal imports from Russia to varying degrees while Russia reduced gas supplies to the EU. Russian coal imports to the EU were embargoed from August 2022. Seaborne Russian crude oil imports were sanctioned from December 5, 2022, while refined oil products were banned from February 5, 2023. These sanctions cover about 90 percent of Russian oil imports to the EU while the remaining 10 percent will be embargoed from 2024 onwards. In addition, a price cap on Russian oil and oil products has also been imposed by the EU and other countries. Natural gas imports have not been sanctioned but Russia reduced its supplies to the EU significantly.

To counter the reduction in fossil fuel imports from Russia, the EU diversified its supply base. Russia's share in EU energy imports fell by 28 percent in 2022 (Figure 1.3). The most perceivable change was in the sourcing of natural gas. The reduction in pipeline gas deliveries from Russia was partly offset by increased liquified natural gas (LNG) imports, primarily from the United States (Figure 1.3 and 1.4). Nevertheless, LNG import terminals and capacity are very unevenly distributed across EU member states along with weak interconnection, leading to natural gas supply disruptions in some Member States. As a result, many EU countries are scaling up their LNG capacity (terminals, storage, and regasification units; Figure 1.5).[10] In addition, the EU has also created a mechanism for joint natural gas purchasing, regulation of cross-border LNG supplies, and the development of an EU index to set natural gas prices (along with a price cap for natural gas if prices are exceptionally high). There are also ongoing efforts to decouple natural gas prices from electricity prices. On gas storage, the EU has set a target of achieving a 90 percent storage level every year by November 1, from 2023 onwards. The EU achieved 90 percent storage for the upcoming winter by August 2023 — among the fastest pace on record. Coal imports have been increasingly sourced from South Africa, Colombia, and Kazakhstan. Meanwhile, the impact of sanctions on oil imports from Russia will be more visible in 2023 and beyond.

FIGURE 1.3 **EU Mineral Fuel Imports by Partner,**

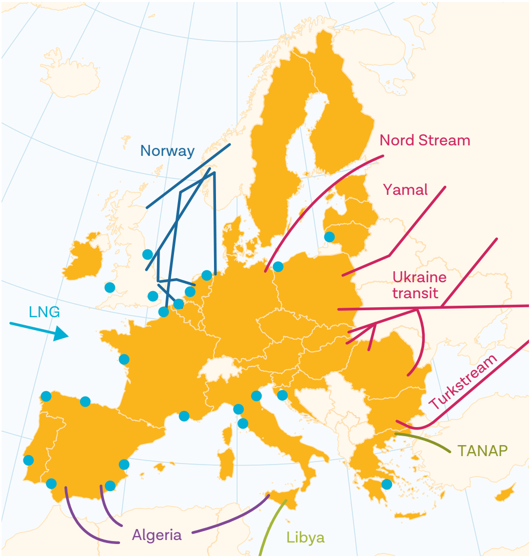
01/2021 – 03/2023



Source: Eurostat Comtext.

10. https://www.gie.eu/transparency/databases/lng-database/

FIGURE 1.4 Main EU Natural Gas Imports routes and LNG terminals

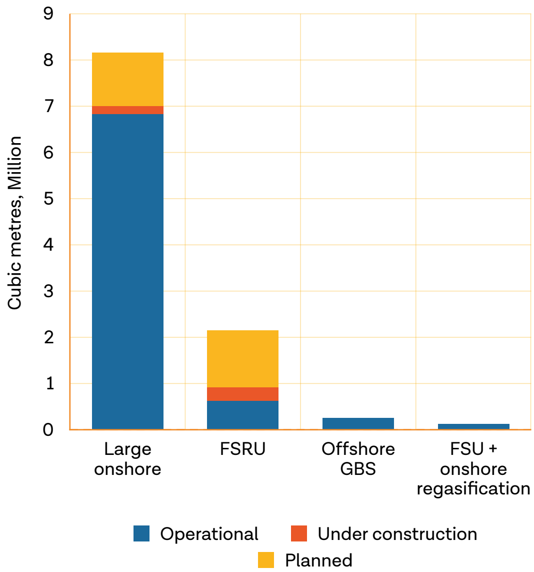


Source: Bruegel, European natural gas imports: https://www.bruegel.org/dataset/european-natural-gas-imports.

Note: TANAP = Trans-Anatolian Natural Gas Pipeline (Azerbaijan via Türkiye).

FIGURE 1.5 EU LNG capacity

As of November 2022



Source: Gas Infrastructure Europe.

Note: * FSRU — floating storage and regasification unit; GBS — Gravity Based Structure.

Demand reduction was a key component of the EU's short-term response to lower energy supplies and it played a key role in avoiding shortages. Policies to reduce demand included a voluntary reduction in monthly gross electricity consumption by 10 percent (compared to the past five-year average) together with a mandatory reduction in peak-hour consumption of at least 5 percent on average per hour. The latter helps lower electricity prices as peak hours are the most expensive. Another measure was a voluntary reduction in natural gas demand by at least 15 percent during August 2022 – March 2023 compared to the average consumption in the past five years. Other short-term measures included encouraging an optimization of heating and cooling temperatures, reduction in air travel, increased use of public transport, and rationalization in electricity usage. Many governments undertook communication campaigns to encourage these behavioral shifts as it required active participation of firms and households. High prices also made some energy-intensive industries uncompetitive, resulting in production halts or reductions in output. As a result, EU electricity demand fell by about 3 percent in 2022 compared with 2021.[11] Overall, natural gas demand fell by 12 percent in 2022 compared to the 2019 – 21 average.[12]

The decline in natural gas demand in Bulgaria, Croatia, Poland, and Romania was close to or exceeded the reduction at the EU level, attributable in part to increased energy efficiency. The corresponding decline in natural gas demand in 2022 in Bulgaria, Croatia, Poland, and Romania was 13 percent, 19 percent, 12 percent, and 14 percent, respectively, compared to the 2019 – 21 average. Key factors responsible for the decline in demand in the four countries included energy efficiency measures taken by households and the commercial sector, combined with a reduction in output from selected energy-intensive industries. While efforts at improving energy efficiency pre-date Russia's invasion of Ukraine and are a critical part of the European Green Deal, additional measures were undertaken during 2022. These

11. https://www.iea.org/commentaries/europe-s-energy-crisis-what-factors-drove-the-record-fall-in-natural-gas-demand-in-2022
12. https://www.bruegel.org/dataset/european-natural-gas-demand-tracker

included efficiency retrofits, boiler replacements, installation of heat pumps, and efficiency gains in industry (discussed in detail later). In addition, Member States continued their progress on the renovation wave to improve energy efficiency of buildings.

The increased contribution of renewable energy in the EU energy mix in 2022 was made possible by accelerated investment in renewable technologies. In 2022, wind and solar generated 22 percent of EU electricity, for the first time overtaking gas (20 percent) and remaining above coal power (16 percent). Solar power generation rose by 24 percent in 2022, owing to an increase of 47 percent in solar installations, yoy. Hydro and nuclear accounted for another 32 percent of electricity generation, while the remainder was accounted for by bioenergy and other fossil fuels and renewables. The severe drought in 2022, along with reduced outturn in the French nuclear power stations, resulted in lower hydro and nuclear power generation compared to previous years. This was, in part, compensated for by higher solar and wind production, demand reduction, and some increase in coal power generation as it was cheaper than natural gas. Nevertheless, coal generation fell by 6 percent in Q4 2022 compared to Q4 2021 because of falling electricity demand.[13]

Governments also undertook measures to delink the electricity and gas markets, but price caps and non-cost reflective tariffs could impact the financial sustainability of energy companies, thereby affecting future green investments. In particular, most Member States have implemented a combination of (i) measures allowing the wholesale market to set prices following market mechanisms and subsequently taxing "windfall" profits in inframarginal technologies; (ii) caps on gas prices in the wholesale electricity market, capping the electricity price at which marginal technologies (gas-fired power plants) can sell electricity in the wholesale market, with a parallel mechanism to compensate marginal technologies for their loses for selling electricity below cost; (iii) price caps in the wholesale electricity market, capping prices at which electricity can be sold in the wholesale market, setting the cap by technology; and (iv) policy interventions to limit consumer tariffs, where Governments instruct the regulators to set a cap on retail electricity tariffs while establishing a mechanism to compensate distribution companies for the tariff deficit. The price caps and non-cost-reflective tariffs could have a negative impact on the financial situation of energy generation, distribution, and transmission companies if not compensated in full, limiting their capacity to undertake the much-needed investments to accelerate the energy transition and increase energy security.

Overall, Russia's invasion of Ukraine has, in part, accelerated some elements of the EU's transition to net zero emissions. This is borne out by the increase in energy efficiency, lower demand for energy (although some of it might not be sustained), and increased use of renewables. The key concern is the increase in LNG capacity which could result in stranded assets at a later date but is important in the medium term to ensure energy security.

In addition to the measures related to the energy sector, governments also stepped in with support measures to households and firms to help them cope with higher energy prices. In Bulgaria, Croatia, Poland and Romania, the total fiscal cost of policy measures (either spent resources or revenue foregone) amounted to EUR 52.1 billion (about 4.7 percent of aggregate GDP) as of April 2023.[14] Support measures have included tax relief (reduction or deferment of taxes, tax exemption, especially VAT and excise) and non-tax measures (subsidies, price caps), with the latter accounting for at least 80 percent of the support in all four countries. Governments have also provided targeted (largely, income support) and untargeted support (tax cuts and price controls). Most measures were directed at both households and

13. https://ember-climate.org/insights/research/european-electricity-review-2023/#supporting-material

14. 70 out of 96 policy measures have a fiscal cost estimate. Measures introduced between September 2021 and April 2023. Aggregate GDP of the four countries.

firms simultaneously, while some were targeted to specific sub-groups. In the four countries, nearly 90 percent of the energy-related support measures were set to be phased out in less than two years but many of them have clauses that allow for extensions, and political economy considerations could make roll backs difficult. Many of the support measures have distorted energy prices, thereby encouraging the use of fossil fuels and reducing efforts aimed at energy efficiency.

Energy sector — the path ahead

EU Member States have so far managed the energy sector spillovers from Russia's invasion of Ukraine, but downside risks remain. While the mix of policies put in place by the EU has helped member states to avoid energy supply shortages over the winter season 2022 – 23, structural dependence on fossil fuels and energy imports remains a key risk. The impact of meteorological events (colder winter, dry summer, or variability in rainfall and wind cycles) could potentially increase energy demand or reduce the availability of renewable energy, increasing global demand for LNG and resulting in price pressures. Europe is especially exposed to these risks due to its large dependency on (imported) fossil fuels.

Consequently, EU governments will need to make sustained efforts at increasing energy security, while also meeting ambitious climate goals. EU governments need to accelerate the replacement of fuels imported from Russia with fuels from other countries, the shift toward alternative energy sources, as well as the reduction in energy consumption. The latter two would also reduce GHG emissions and have a positive impact on ambitious climate change mitigation targets. The EU aims at becoming the first climate neutral region by 2050, requiring a deep transformation of the economy and the transition of the energy sector. Therefore, Member States need to prioritize strategies which contribute both to energy security and to energy transition targets.

EU Member States would benefit from fostering further electrification of their economies and diversification of their energy matrix. This diversification is needed in terms of the energy mix and geography in terms of import origins. The energy transition agenda must be accelerated to increase the share of local renewable energy and investment in new technologies. The geographical diversification of energy imports will also be critical and imports from a single source should be limited to a certain share of total imports. Within countries, energy generation should also be geographically spread to mitigate the effect of local climate events (i.e., droughts affecting specific river basins) and natural disasters on energy supply, especially in the context of climate change, which is expected to increase the intensity and frequency of these events.

Continued focus on energy efficiency should be a priority, targeted towards a longer-term optimization of energy demand. Member States should increase the pace of renovation of the building stock to improve seismic resilience, energy efficiency, and inner comfort. Buildings are one of the main energy consumers and improving their insulation is critical to reduce losses in heating systems. For firms, large industries usually have the resources to implement energy efficiency investments and measures to optimize their cost structure, while SMEs may require financial and technical support to implement these measures and investments. Optimizing the use of energy will contribute to climate change by reducing emissions and energy security, with positive spillovers on economic competitiveness and affordability of the energy bill for households and businesses. Behavioral change communication campaigns have been found to be effective in these situations.

Electricity and natural gas networks must be reinforced to increase their flexibility to cope with future challenges arising from the energy transition and to increase international interconnections. Additional investments in gas infrastructure, especially in LNG, may be required to increase the capacity to import natural gas in the form of LNG. These investments would include new LNG terminals, transport infrastructure, and storage capacities. While these investments are critical (during the transition to net zero) to ensure energy security in the medium term, a key concern is that they may result in stranded assets at a later stage or lock in these technologies for the longer term. As of now, it is difficult to clearly anticipate the impact of these investments in the longer term and implications for the transition to net zero. The Joint Purchasing Platform for gas and hydrogen should be maintained and developed to facilitate access to global energy markets for smaller Member States, so that they benefit from more competitive prices for large-scale purchases. Electricity networks should also be strengthened to cope with the increasing share of variable renewables by repurposing existing power generation assets (i.e., hydro power plants to provide balancing and ancillary services), installing additional power storage capacity, and investing in distribution and transmission networks. Strengthening international interconnections would allow further flexibility at the country level and improve the efficiency of the overall system. Member States may increase their international interconnections beyond the mandatory target of 15 percent, which in turn may reduce the need to invest in storage facilities due to the additional flexibility that interconnections can provide.

The financial sustainability of the energy sector should be maintained, and sufficient low-cost financial resources should be mobilized to sustain the energy transition, while also incentivizing private investments and participation. Power utilities have been negatively impacted by, first, the COVID-19 pandemic and then the tariff caps to reduce the impact of soaring energy prices. Although compensation mechanisms have been implemented, these mechanisms do not always fully offset the financial impact on these companies. Funding mechanisms and financial instruments to compensate for consumer tariff caps must be clear and transparently defined and implemented in a timely manner to limit financial distress of energy companies. The financial health of these companies is needed for them to undertake the investments in power generation and electricity networks to enable the energy transition. Private investment also needs to be facilitated as public resources will not be sufficient to fund the energy transition. Public resources should leverage private participation to create new markets, and the use of public resources as grants should be limited to poor households so as to avoid market distortions. The current context of tighter financial market conditions, increased cost of financing, and highly indebted governments (potentially crowding out private access to financing), may impact the competitiveness of new low-carbon capital-intensive technologies and delay their deployment at scale, impacting the energy transition.

A plan to progressively phase out the emergency measures implemented during the crisis should be defined and reforms to increase the resilience of European energy markets against price volatility should be implemented. With the substantial reduction in energy prices, it will be important to gradually phase out support measures. The back-to-normal should be carefully planned and progressively and smoothly implemented, protecting the most vulnerable populations, acknowledging that structural weaknesses remain in the energy sector. The European Commission released a draft proposal for the reform of the EU electricity market design on January 23, 2023. The reform proposal focuses on four main areas, namely (i) delinking electricity prices from short-term fossil fuel prices and boosting the deployment of renewables; (ii) increasing the security of supply by better utilizing storage and demand response options; (iii) enhancing consumer protection and empowerment; and (iv) improving market transparency, surveillance, and integrity. These reforms will support price formation through market mechanisms and price signals to the extent possible as well as maintain incentives to increase efficiency in the wholesale market, carry out investments in new infrastructure, and improve the efficiency of energy consumption.

While the focus over the next few years is on decarbonization of the energy sector, the transformation in the transport, industry, and heating sectors should be accelerated to reduce Europe's dependence on fossil fuels. The transport sector is the main consumer of oil products and one of the main GHG emitters. The shift from traditional technologies to low carbon options (i.e., electric transport, green hydrogen) needs to be accelerated, especially with new technologies becoming economically viable. The incentive of modal shifting, last mile transport alternatives, the promotion of quality public transport, and the development of railways and waterways for freight transport should also be at the center of the decarbonization strategy of the transport sector. At the industrial level, improved energy efficiency, electrification of low temperature processes where economically viable, increases in the use of renewable heat options (i.e., geothermal and solar heat), and the use of low carbon gases like hydrogen are key drivers to reduce GHG emissions and fossil fuel use. In parallel, the heating sector should transition to sustainable heating options. Boiler replacements with more efficient and lower carbon fuel technologies, broader installation of heat pumps, more intensive use of renewable resources for heating (solar and geothermal heat, sustainable biomass, and green hydrogen), and improvements in the efficiency of district heating networks (reduced leakages and heat loses) would be the cornerstone of the transition strategy towards sustainable heating, with positive spillovers on air quality and health. Investments in innovation and the development of new technological options like green hydrogen would be key for the successful transition of these hard-to-abate sectors.

Governments need to revise their current subsidy and support schemes to electricity and fossil fuels. Member States still provide support to fossil fuels, explicitly as subsidies and less explicitly through transfers and support schemes to SOEs in the sector. A more coherent policy aligning public support to decarbonization and energy security objectives and eliminating these support schemes needs to be put in place. Subsidies to retail electricity prices for end-consumers should be progressively replaced by more targeted support through financial transfers to the most vulnerable population. This would imply developing national registries of vulnerable populations to design safety nets and channel public support. These measures will reduce the fiscal burden and reduce the distortion to price signals, which is required to optimize energy demand.

Finally, all these strategies need to be implemented following the just transition principles. The energy transition may have an asymmetric impact on different Member States and population groups and firms. Facilitating access to the benefits of the transition to the most affected population (and regions) will be key for a smooth process. The shift to new technologies will require new skills: while the introduction of new technologies may require more sophisticated skills, others like the renovation of buildings may not. Enabling skilling and reskilling opportunities for the most vulnerable population to ultimately improve their opportunities to access the new labor market, should be at the heart of the transition strategy. In addition, effective, well-targeted and resource-efficient safety nets should be deployed to cover the most vulnerable and impacted population.

Chapter 2

Energy and growth — a macro perspective

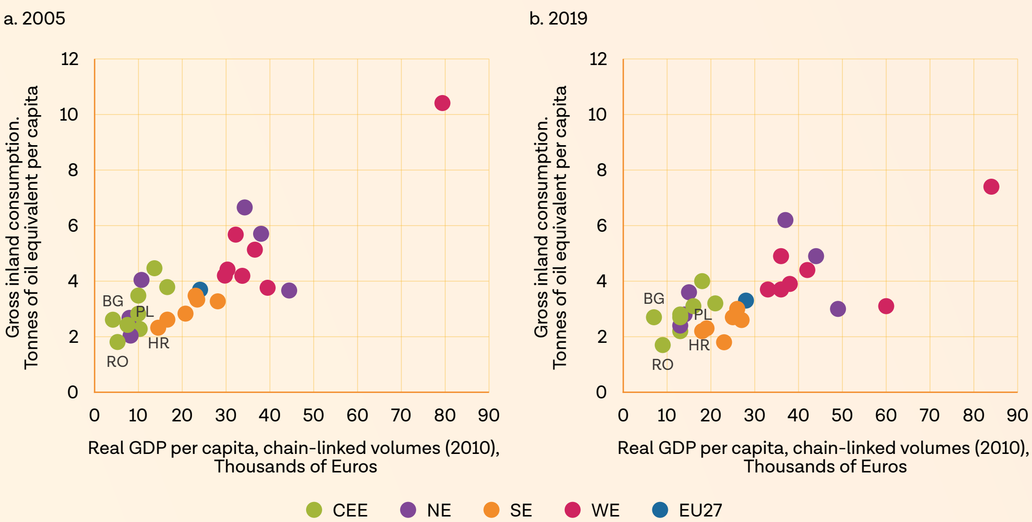
The complex relationship between energy and growth

Energy and growth are interlinked but the relationship between the two is complex. Economic growth requires energy consumption, but higher growth can also lead to more energy use. There are four key types of relationships between energy consumption and GDP growth that have been observed — GDP growth resulting in higher energy consumption, higher energy consumption causing GDP growth, a bi-directional feedback relationship, or no causality. Meanwhile, although energy and incomes are linked, there are large variations in energy use among countries with similar income levels. At any given income level, four factors influence the energy intensity of demand among countries (see Box 2.1): the structure of the economy, the degree of urbanization, technology, and government policies.[15] As the economy moves from an agricultural to a manufacturing base, its energy needs spike as manufacturing is more energy intensive, and as an economy transitions from a manufacturing base to a services base, energy requirements begin to decline since services are less energy intensive. Highly urbanized economies tend to be more energy efficient through economies of scale and network effects; people tend to drive less and walk more than their rural counterparts, urbanized cities tend to have more developed

BOX 2.1 Energy Intensity

The EU's energy intensity decreased by 24.3 percent between 2005 and 2019, at an average rate of 1.9 percent a year.[a] Gross inland energy consumption decreased at a rate of 1.1 percent a year, while output grew on average by 1.3 percent annually over the same period, indicating a decoupling of energy consumption from economic growth in the EU (Figure B2.1.1). Energy intensity decreased in all EU Member States, with the largest decreases in Central and Eastern European countries, reflecting changes in their economic structures (moving from heavy manufacturing to services). Moreover, energy-saving technologies are shifting down the energy-income curve (Bogmans et al. 2020), playing a critical role in reducing emissions and decoupling energy consumption from growth.

FIGURE B2.1.1 Gross inland energy consumption per capita has decreased on average, while GDP per capita has increased



Source: Eurostat.

Note: 2005 — Base year of comparison when the first EU ETS was implemented.

15. World Bank, 2022.

While there is variation among countries, there is a trend in some countries of falling energy intensity. In general, the relationship follows an inverted U shape. At low levels of income, the demand for commodities grows rapidly and as income increases demand plateaus and then begins to decline at higher income levels.[b] The plateauing or decrease in energy demand can be interpreted as a reduction in energy intensity of GDP. That is, as income increases, the marginal quantity of energy needed to produce an additional unit of GDP decreases. At higher income levels, at which most physical infrastructure needs are met, growth is associated with increases in the consumption of services, which are less energy intensive in their production (World Bank, 2022).

Energy consumption per capita has remained largely the same in Poland and Romania in the last three decades but has been steadily rising in Bulgaria and Croatia. In terms of the relationship between income per capita and energy consumption per capita, these trends have translated into a plateauing for Poland and Romania and a still increasing demand for energy with income growth in Bulgaria and Croatia. Yet, all countries have achieved reductions in their energy intensities

Nevertheless, the four countries remain among the most energy- and carbon-intensive EU economies. GDP per capita growth in the four countries has been achieved with impressive improvements in energy intensity (around 50 percent during 2000 – 19, even higher in Romania, but somewhat lower in Croatia although starting from a lower base). However, carbon intensity (a measure of how clean electricity production is) remains high in the four EU countries with Bulgaria's carbon intensity being nearly four times as high as Germany.

a. Energy intensity is defined as the amount of energy used to produce a given level of output.

b. The per capita consumption — income profile of commodities in general has sparked various empirical studies. The commodity consumption-income relationship at different development stages has been examined in the literature under various names, including the environment Kuznets curve the S-shaped curve the inverted U-shaped curve, the dematerialization hypothesis, the intensity of material use hypothesis, and the plateauing hypothesis (World Bank, 2022; Bogmans et al. 2020; Clark 1940; Herman, Ardekani, and Ausubel 1990; Kuznets 1971; Tilton 1990; Cleveland and Ruth 1998; Radetzki et al. 2008). Moreover, the empirical literature on the commodity consumption-income relationship is further split between studies focused on individual commodities, and a smaller literature on group aggregates, principally energy. Some studies have looked at individual energy commodities, including oil (Gately and Huntington 2002; Hamilton 2009), natural gas (Krichene 2002), and coal (Chan and Lee 1997; Shealy and Dorian 2010). Other studies examine demand for energy at the aggregate level (Burke and Csereklyei 2016; Csereklyei and Stern 2015; Dahl and Roman 2004; Jakob, Haller, and Marschinski 2012; Bogmans et al. 2020).

and efficient mass public transport systems and tend to have more apartments that are more energy-efficient than detached houses.[16] Technological advancements and increasing the rate of technology adoption also lead to significant efficiency gains in both consumption and production, reducing the amount of energy needed to consume or produce the same quantity of goods or services. Finally, government policies also influence energy consumption through taxes and subsidies, discouraging or encouraging specific energy sources.[17]

The elasticity of growth to energy consumption for a unit increase in income also varies significantly, making it difficult to transpose the experience of developed countries on developing countries. Most studies have found an income elasticity of demand for energy of less than one, suggesting that per capita energy consumption grows more slowly than per capita income.[18] Some studies have also found that the income elasticity of demand for energy is negative.[19] One study that included low-income countries found evidence of a positive income elasticity of demand for energy while another study finds evidence of a dynamic elasticity; one which is low and increasing at low-income levels, peaks at middle income levels, and declines at higher income levels.[20,21]

16. Detached houses have more exterior walls and have more energy losses in heating and cooling.

17. World Bank, 2022; Bogmans et al. 2020; Brounen, Kok, and Quigley 2012; Satterthwaite 2011.

18. World Bank, 2022; Burke and Csereklyei, 2016; Csereklyei and Stern, 2015; Jakob, Haller, and Marschinski, 2012.

19. World Bank, 2022; Dahl, 2012; Fouquet, 2014; Jakob, Haller, and Marschinski, 2012.

20. (Burke and Cserekyei, 2016). Bogmans et al. (2020).

21. The relationship between energy elasticity and growth could be very different if the entire energy supply came from green sources.

Growth impact of zero gas supplies from Russia — a macro perspective

The response of EU Member States to gas supply reductions from Russia along with a mild winter season (2022 – 23) supported EU economies and enabled them to fill gas storage as per existing targets last year. While some of this success was attributable to supply diversification, energy efficiency measures, and increased use of renewables, there was also a significant demand reduction (voluntary and otherwise), particularly from energy intensive firms. Hence, there exists a latent demand for natural gas in the EU.

Nevertheless, given the risks to the energy outlook in the EU, this chapter attempts to quantify the impact on the four countries — Bulgaria, Croatia, Poland, and Romania — of a total disruption in gas supplies from Russia, reduced from 2022 levels. Despite the complexities in the relationship between energy and growth and given the high energy intensity in Bulgaria, Croatia, Poland and Romania, this chapter assesses the growth impact of a cessation in natural gas exports from Russia to the EU. With EU sanctions on Russian oil and coal, the import of these fossil fuels will be phased out in the near term and can be compensated for in the international market as they are easier to store and transport, although they might come at higher global prices. Hence, this chapter only assesses the impact of zero natural gas supplies from Russia.

A computable general equilibrium (CGE) model is used to simulate the growth impact of a stop in natural gas trade between the EU and Russia. The analysis features a multi-regional CGE model, capturing the global economy to incorporate the interaction in global fossil fuel markets and especially between EU countries. The CGE model relies on a neoclassical structural modeling approach and mostly follows standard assumptions in the CGE literature (Box 2.2). However, the parameters in the CGE model are adjusted to reflect the short-run nature of this assessment.

BOX 2.2 Key features of the CGE model

Production activities in the CGE model are geared towards profit maximization under returns-to-scale technologies. They use different types of labor, capital, land, other natural resources, and intermediate inputs to produce goods and services (referred to as goods henceforth) for domestic and international markets. The production function utilizes nested constant elasticity of substitution functions, which illustrate substitution possibilities between primary factors, between primary factors and intermediates, and between intermediates. The model depicts multiple activities producing electricity, differentiated by source (coal, natural gas, wind, hydro, oil, and other) as well as by peak and base load, where applicable. The different types of electricity are not assumed to be perfect substitutes such that per unit production costs can differ. The mix reacts to a limited degree to changes in these per unit costs.

The CGE model enables production activities to endogenously determine their energy intensity depending on energy prices. It is assumed that capital and energy inputs are substitutes, such that higher energy prices incentivize firms to invest in energy-saving capital. At the same time, firms endogenously determine their cost-minimizing energy mix, taking substitution possibilities between different energy types into account. For this exercise, this option is significantly reduced as substitution possibilities in the short run are very limited.

Energy production in the model is differentiated based on fuel type (coal, natural gas, hydro, solar, wind, nuclear, and other renewables) and, where appropriate, by peak and base load. The electricity mix can thus adjust to some degree to mimic the short-run or long-run changes. In this exercise, the adjustment possibilities have been reduced given the short time frame of the study.

All goods markets in the model are perfectly competitive such that domestic sales prices are equal to domestic marginal costs in equilibrium, with the exception of electricity as discussed above. However, imported and domestically produced goods, including energy carriers, are assumed as imperfect substitutes according to Armington assumptions. This can also be interpreted as reflecting rigidities in international distribution networks (electricity grid, pipelines, LNG terminals, etc.). Firms compete for primary factors (labor, capital, land), while other natural resources (fish stocks, extraction reserves, etc.) are assumed to be sector specific. For the current exercise, labor and capital mobility have been reduced to account for the short-run nature of the study. The strong reduction in capital mobility mimics a situation where capital is sector specific.

The government collects taxes to finance consumption, savings, and transfers. Government consumption and savings follow real GDP, provided the budget deficit is not too large. At higher debt burdens, they are increasingly driven by tax income. Differences between tax revenues and spending are closed by issuing government bonds. Their yield is endogenously determined by the savings preferences of households. It is assumed that the government partly finances investments in process emission abatement through production subsidies.

The model follows a savings-driven closure where aggregate investment is flexible and equal to the available volume of savings. Foreign savings depend on the expected returns to capital compared to global averages. This also implies that the balance of trade is endogenous. Government and household savings are also endogenous.

The model draws on the GTAP Power Data Base Version 10 (Chepliev 2020),[a] and emission factors are derived from Aguiar et al. 2019.[b] The database distinguishes between 66 sectors and 56 products and captures 9 primary factors (land, natural resources, capital, six labor types). The database includes 10 power activities that produce a homogenous electricity commodity and a labor distinction based on male and female workers based on WBG data. The model breaks up the world into Romania, Bulgaria, Croatia, Poland, Rest-of-the-EU, Russia, and Rest-of-the-World.

a. Chepeliev, M. (2020). GTAP-power data base: Version 10. *Journal of Global Economic Analysis,* 5(2), 110–137.

b. Aguiar, A., Chepeliev, M., Corong, E. L., McDougall, R., & Van Der Mensbrugghe, D. (2019). The GTAP data base: version 10. *Journal of Global Economic Analysis,* 4(1), 1–27.

The model assumes the following scenarios (key assumptions are outlined in Box 2.3):

- The baseline scenario, against which scenarios are assessed, assumes the status quo in 2022, with reduced gas supplies from Russia as well as disruptions in fossil fuel markets from Russia's invasion of Ukraine. The model parameterization (substitution elasticities in production, capital and labor mobility) was changed such that changes in demand and overall inflation is broadly at the 2022 level. In 2023 and 2024, substitution possibilities and factor mobility increase somewhat as firms start slowly to adjust technology to the new energy landscape.

- Scenario 1 assumes zero natural gas supplies from Russia (reduced from 2022 levels) to the EU, with demand at levels seen in 2022 and no further shocks to fossil fuel markets.

- Scenario 2 assumes zero natural gas supplies from Russia (reduced from 2022 levels) to the EU in combination with a harsher winter than in 2022–23.

BOX 2.3 Key assumptions underlying the CGE model

The impact of a complete stop of Russian natural gas supplies to the EU is analyzed under the following assumptions:

- While Russian natural gas stops flowing to EU Member States as of April 2023, Russian natural gas will continue to flow to non-EU countries at the same level as observed in 2022. For example, Russia will continue to supply gas to Serbia, in fact, by making use of the Bulgaria's natural gas system for transit.
- No changes in other markets (fossil fuels or otherwise) compared to 2022 are assumed.
- EU Member States will be able to fully utilize LNG import terminals located in the EU. Furthermore, LNG cargos are generally available in the global market, albeit at a higher cost.
- EU Member States will be able to fully utilize cross-border capacity as laid down in interconnection agreements to import natural gas, net of non-negotiable commitments (for example, to fill gas storage) and long-term gas transit arrangements, for instance, for transit of Russian gas to Serbia through the gas system of Bulgaria.

- EU Member States will not close their borders for natural gas supply to other Member States.
- In principle, EU Member States will fill natural gas storage in line with EU targets.
- EU Member States responded to the increase in energy prices with a spate of measures that were introduced at different points of time and for varying durations. These measures have not been explicitly incorporated into the model and therefore the estimates of the impact on growth represent an upper bound.
- The model also does not account for the availability of stocks which are crucial in the output response function of firms to higher energy prices.
- The elasticity assumptions are not country specific. The substitution elasticities in the different production nests, including capital-energy and in-between energy substitutions have been divided by 8 in 2022, 6 in 2023 and 4 in 2024 to reflect short-run closures, compared to the default values taken from the GTAP-Power and other sources used for comparative-static analysis. The same holds for substitution elasticities between different types of electricity, which are at 3/8, 3/6, and 3/4 of their defaults, respectively. Capital mobility, measured by the elasticity of transformation, is very low at 0.1/8 in 2022, 0.1/6 in 2023, and 0.1/4 in 2024, which makes capital close to sector specific. Labor mobility is somewhat higher at 0.2/8, 0.2/6 and 0.2/4, respectively. All Armington elasticities have been halved, and the ones for gas and gas-distribution reduced considerably to 5 for substitution between import partners and 2.5 between domestic and imported sourcing. This reflects the short- to medium-term rigidities in adjusting the distribution network. The parameterization was chosen to get plausible results for the 2022 baseline while the model solves for the shocks introduced thereafter.

With very different supply and demand conditions, each of the four countries — Bulgaria, Croatia, Poland, and Romania — will react differently to a full cessation of Russian natural gas supplies to the EU, reduced from 2022 levels. Nevertheless, all countries will face higher prices because of higher EU demand for LNG or higher demand through non-Russian pipelines. Country level dynamics will depend on natural gas production capacity, import avenues, export obligations to other EU countries under existing solidarity arrangements and the availability of LNG terminals. Specificities for the four countries under zero natural gas supplies from Russia to the EU are discussed below

- **Bulgaria has significant natural gas import capacity.** It can import from the Trans Adriatic Pipeline (TAP) system through the new Interconnector Greece Bulgaria (IGB) pipeline (3 bcm/year or 96 GWh/day), and in the form of LNG through Greece (cross-border capacity of 64 GWh/day), and through Türkiye (25 GWh/day) based on a recently concluded agreement to access 1.5 bcm/year of capacity from Turkish LNG terminals. Towards the north, Bulgaria is an important transit country for gas supplies to Romania and Hungary and small EU-associated neighbor Moldova. Towards the West, Bulgaria still serves as an important transit country for Russian natural gas to Greece and to non-EU country Serbia, and onwards to Hungary. Bulgaria is already under a no-Russian natural gas scenario, but its neighbors are not. With zero natural gas supplies to the EU, it is assumed that Bulgaria will only be able to import 36 GWh/day of LNG through the Greek system until the new Alexandropoulos LNG terminal in Greece becomes operational in January 2024. That will allow an additional 28 GWh/day of import capacity available to Bulgaria. The country will also have access to 82 GWh/day of contracted gas from Azerbaijan and gas through the IGB pipeline.

- **While Croatia has a large LNG import terminal, it is the primary source of supply to Hungary, which is highly dependent on Russian natural gas.** Croatia is very well-connected to neighboring countries, notably Hungary (51 GWh/day export capacity) and Slovenia (7 GWh/day export capacity), and the country has an LNG terminal in Krk with a relatively large capacity (79 GWh/day import capacity) than the typical natural gas consumption in the country (63 GWh/day). However, Croatia serves as an important transit country for LNG to Hungary, and Hungary does not have many options when it comes to replacing Russian natural gas supplies, since the country only has limited cross-border capacity with Romania and may not be able to source significant new volumes from

Northwest Europe in times of need. Croatia is also a small natural gas producer at a current level of approximately 16 GWh/day. With zero natural gas supplies from Russia to the EU and continued exports to Hungary and Slovenia under the EU solidarity principles, Croatia will face lower supplies and therefore comparatively higher prices until the expansion of the Krk LNG terminal comes onstream in April 2024.

- **Poland has a well-diversified network for natural gas suppliers and also produces some natural gas.** It is also already in a 'no Russian gas' scenario. The country has always been a significant natural gas producer, with the current level of production about 159 GWh/day. Furthermore, long before the Russian invasion of Ukraine, Poland had started diversifying its natural gas supply and currently has significant LNG import capacity in Świnoujście (220 GWh/day), and the new Baltic Pipe from Norway (148 GWh/day) that came onstream in Q4 2022. The country also has a long-term contract for the import of LNG through the Klaipeda LNG terminal in Lithuania at 58 GWh/day. While the natural gas system of Poland is well-connected with Germany and non-EU neighbors Ukraine and Belarus in terms of import capacity, it only has a 27 GWh/day of export connection with Germany and a 145 GWh/day export connection with the Slovak Republic. With zero natural gas supplies from Russia, exports will continue to Germany and the Slovak Republic. Exports to the Slovak Republic will be particularly critical as it may not have many alternative options to replace Russian natural gas supplies. Also, the Baltic States and Finland that are connected to the Polish system have excess gas supply capacity, so they would not have to rely on imports from Poland to diversify from Russian natural gas supplies.

- **Romania is a large natural gas producer and is also well connected to Bulgaria for additional natural gas supplies.** Its natural gas production currently stands at approximately 258 GWh/day. Recently the country has brought onstream new natural gas fields in the Black Sea that are estimated to add ten years to the country's reserves to production ratio. Romania is also very well connected to its neighbors Ukraine and Bulgaria and also Moldova. Romania is particularly keen to help Moldova since many Romanians have family in Moldova. Finally, Romania has an interconnection point with the Hungarian gas market with an export capacity of 73 GWh/day. With zero natural gas supplies from Russia to the EU and continued natural gas exports to Hungary and Moldova, Romania will have access to transit natural gas from Bulgaria, in addition to own production.

Given the above specificities,

- Under **scenario 1**, existing natural gas supply arrangements and storage capacities will satisfy the 2022 demand in all countries with the exception of Croatia. This is primarily because of Croatia's natural gas export arrangements with Hungary, which in turn is highly dependent on Russian natural gas and does not have access to alternative supplies. Nevertheless, all countries will face somewhat higher prices.

- Under **scenario 2**, existing gas supply arrangements and storage capacities will not satisfy higher demand resulting from a harsher winter in all four countries. Hence, the growth implications of the price increase will be somewhat more significant.

Country level changes in the natural gas supply (as a result of zero natural gas exports from Russia to the EU — reduced from 2022 levels) are translated to relative changes in the natural gas quantity index in the CGE model to assess the impact on growth. The model ensures that rents from price increases for natural gas following supply cuts accrue to natural gas-exporting countries and not to firms in the EU. The model considers adaptation by economic agents in response to higher natural gas prices. Households can reduce their demand for gas according to price elasticities, a response clearly observed in 2022. Firms can to some very limited degree substitute natural gas by other energy carriers and do some short-term investments to save natural gas, but the relation between natural gas use and physical output remains rather stable. Natural gas savings in the industry stem therefore mostly from output adjustments. This does not hold for power generation, where changes in the power generation mix were observed and are also reflected in the model layout. Considering that adjustment options of firms increase over time, substitution elasticities and labor mobility increase slightly with each simulated year, which implies that macroeconomic impacts from the cut in natural gas supplies will soften over time as offsetting measures are implemented.[22]

The main channel of impact on growth in the four countries is through the industrial sector (see next chapter) and the impact diminishes over time as economies adapt. Many households in the four countries under consideration are linked to district heating systems of which few are natural gas-fired with the exception of Croatia. The other main channel of impact is via electricity prices. As less electricity can be produced from natural gas, the resulting gap needs to be met to the extent possible with other types of power generation. The output from renewables cannot be expanded in the short run, as this requires physical installation of new capacities. Thus, output from for coal-fired power plants, and where available, oil-fired ones, is pushed up. This results in an increase in coal and oil prices. Accordingly, electricity prices go up. This, in turn, raises industrial production costs in sectors that use fossil fuels or a large amount of electrical energy. These production cost increases are then passed along the value chains. Consequently, consumer price indices increase. The impacts in the years 2023 and 2024 are relatively smaller because of adaptation to the new energy scenario. Firms start to introduce some measures to replace natural gas by other fuels and also undertake energy-saving investments. With a higher degree of substitutability, this process intensifies over time and reduces macroeconomic losses, conditioned on no further or significant cut in energy supplies. The impact on growth under the two scenarios is presented in the table 2.1.

TABLE 2.1 Growth impact of zero gas supplies from Russia to the EU compared to already reduced supplies as in 2022

percentage point change in real GDP growth

		2023	**2024**
Bulgaria	Scenario 1	0.11	0.03
	Scenario 2	-0.11	0.03
Croatia	Scenario 1	-1.63	-1.45
	Scenario 2	-3.48	-1.74
Poland	Scenario 1	0.05	0.02
	Scenario 2	-0.06	0.03
Romania	Scenario 1	0.00	-0.01
	Scenario 2	-0.07	-0.08

Source: World Bank staff calculations

The growth impact of zero natural gas supplies from Russia to the EU (compared to already reduced gas supplies as of 2022) on the four countries under consideration is relatively muted. The impact on growth in the four countries, under the two scenarios, ranges between +0.11 to -3.48 percentage points, assuming no government support. Under both scenarios, the growth impact on Croatia is the largest while the

22. The model assumes mobility of production factors and the report does not discuss product and labor market rigidities given the shorter time frame of the analysis.

impact on other countries is close to zero. The difference in natural gas availability and economic structures of the different countries results into price increases which in turn impacts aggregate demand in the economy. Government support measures (not considered) could further reduce the impact on growth. The muted impacts reflect that Romania and Bulgaria do not see a change in gas availability under the first scenario, while their ability to adjust to the gas shortage situation also improves. Poland sees its supplies of natural gas drop, but the low share of natural gas in total energy use implies a limited macroeconomic impact.s Croatia sees a more significant drop in natural gas availability which explains the stronger impact on growth. A harsh winter as captured in scenario 2 somewhat worsens the situation in most countries, but increased adaptation efforts lower the growth impact.

Over the medium- to longer-term, labor and product market rigidities will play a crucial role in determining the economic impact of the energy transition process. These aspects will need to be carefully incorporated into future studies that assess the impact of the transition to net zero emissions.

Chapter 3

Impact of high energy prices on EU firms — a micro perspective

The industrial sector has borne the brunt of higher energy prices in the EU. It has resulted in higher production costs which can translate into lower profits, pass-through inflation, job destruction, higher market exit, loss of competitiveness and liquidity problems, especially for firms for which energy prices represent a significant share of their total costs.

This chapter assesses the impact of higher energy prices on firm behavior and proposes policy options for consideration. Although energy prices have reduced significantly since August 2022, with geopolitical uncertainties and the potential for further disruption of gas supplies to the EU, energy prices could go up again. In addition, the green transition will raise the price of fossil fuels going forward, making it essential for firms to adapt to alternative energy sources.

How have firms responded to the energy price hike?

Firms can adjust to a rise in energy prices along multiple dimensions (simultaneously). There are multiple adjustment mechanisms that firms widely use — price passthrough, energy efficiency improvements, product portfolio changes, production process adjustments, production shifts between plants, onsite electricity generation using renewables, shifts from in-house production to import of certain energy intensive products, other production factor adjustments (See Box 3.1).[23,24]

Firms differ substantially in terms of their levels of energy efficiency, even within the same country and sector. Production methods, technologies and organization differ substantially across firms between and within sectors, and so do energy needs.[25] For example, in highly energy-dependent sectors such as transport activities, energy expenses in electricity and fuels[26] can account up to 33 percent of total costs, while in low energy-dependent industries such as manufacturing of electronical equipment, the share of energy in total costs is 2 percent, on average. However, what is remarkable is that even within sectors there are significant differences in how much output can be produced with the same amount of energy, which might be ultimately driven by the businesses' organizational capacities, the vintage and intensity of capital, the investments in environmental-friendly technologies and the production function of firms. Figure 3.1 shows that these differences between firms within their sector and size group are even larger than differences between sectors-by-size.[27] For instance, the average firm in the top quartile of the efficiency distribution[28] within its size class in food and beverage processing produces 3.7 times as much output as that of the firm at the bottom quartile with the same amount of energy.[29]

According to a World Bank qualitative survey of 28 firms undertaken in Bulgaria, Croatia and Poland, the key channels of response for the firms included price pass throughs and reduction in profits. The details of the survey are presented in Box 3.2. Although the majority of the firms had energy costs below

23. See Annex 1 for details.

24. Fontagne et al. 2023; Joussier et al. 2023; Ganapati et al. 2020; Abeberese 2017; Brehm 2019; Grubb et al. 2021; Hassler et al. 2021; Popp et al. 2010; Rottner & von Graevenitz 2022

25. Müller and Mertens 2022 show that out of the 1,600 product categories, 300 are responsible for almost 90 percent of natural gas consumption. The five products with the highest gas consumption are basic chemicals and make up around 5 percent of total industrial gas consumption.

26. Fuels includes anthracite and bituminous coal, coke, natural and manufactured gas, fuel oil, liquefied petroleum gas, gasoline, and all other fuels, including purchased steam.

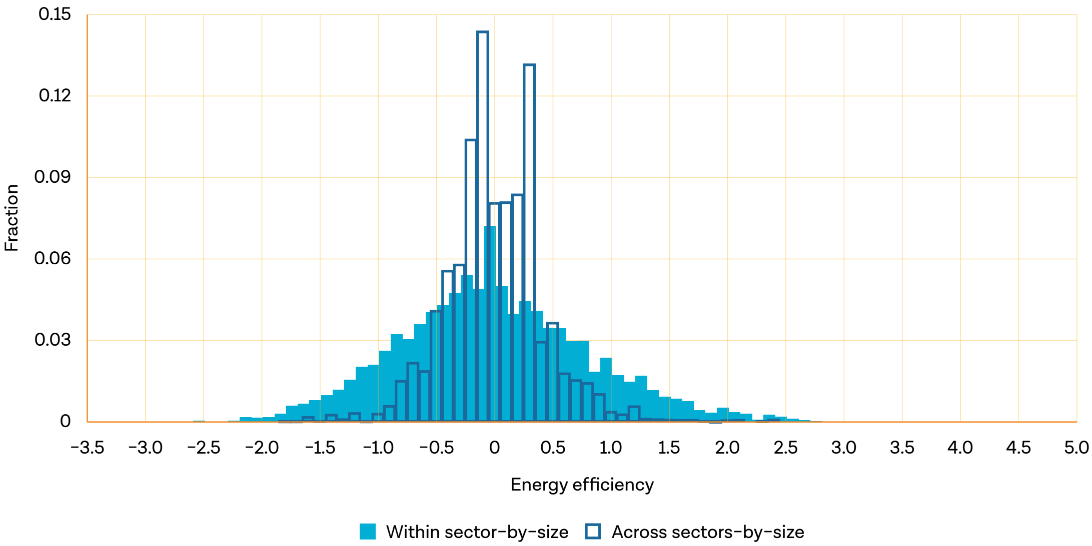
27. Due to the sample size, we define industry classifications at the two-digit level of ISIC Rev. 3.1 and size class based on the number of full-time workers as SME (0 – 99 employees) and large (at least 100 employees).

28. To deal with outliers, energy efficiency variable has been trimmed at the 5th and 95th percentiles at the country level. Monetary variables are converted to PPP US dollars using World Bank PPP conversion factors.

29. While we are referring here to "output production" what we measure in the data is the revenues generated from the output produced so this effect could be driven both by pure efficiency measure (producing more units of outputs with same amount of energy) as well as by quality and the nature of output.

10 percent of the total, they still reported as being affected to some extent by the rise in energy prices. The main mechanisms of adjustment used by the firms in the World Bank case studies were profit reductions and product price increases rather than a cut in output or employment. Out of the 28 firms, 19 reduced profits and 24 passed energy prices to product prices. Only 8 of them reduced or stopped production and only 3 reduced employment. Also, according to firms' responses, other margins of adaptation have been less used. For example, only 3 firms changed their product portfolios or adjusted their processes and there are no firms that substituted inputs in response to the energy price increase.

FIGURE 3.1 Energy efficiency dispersion within sectors across countries



Source: World Bank elaboration based on WBES.

Note: Within sector-by-size energy efficiency dispersion is calculated as the difference between the firm efficiency and the sector-by-size average efficiency at the country level. Across sector-by-size dispersion is measured as the difference between the sector-by-size average efficiency and the economy-wide average efficiency at the country level. Size class defines firms based on the number of full-time workers as SMEs (0 – 99 employees) and large (100+ employees); sector is defined at the two-digit level of ISIC Rev. 3.1.

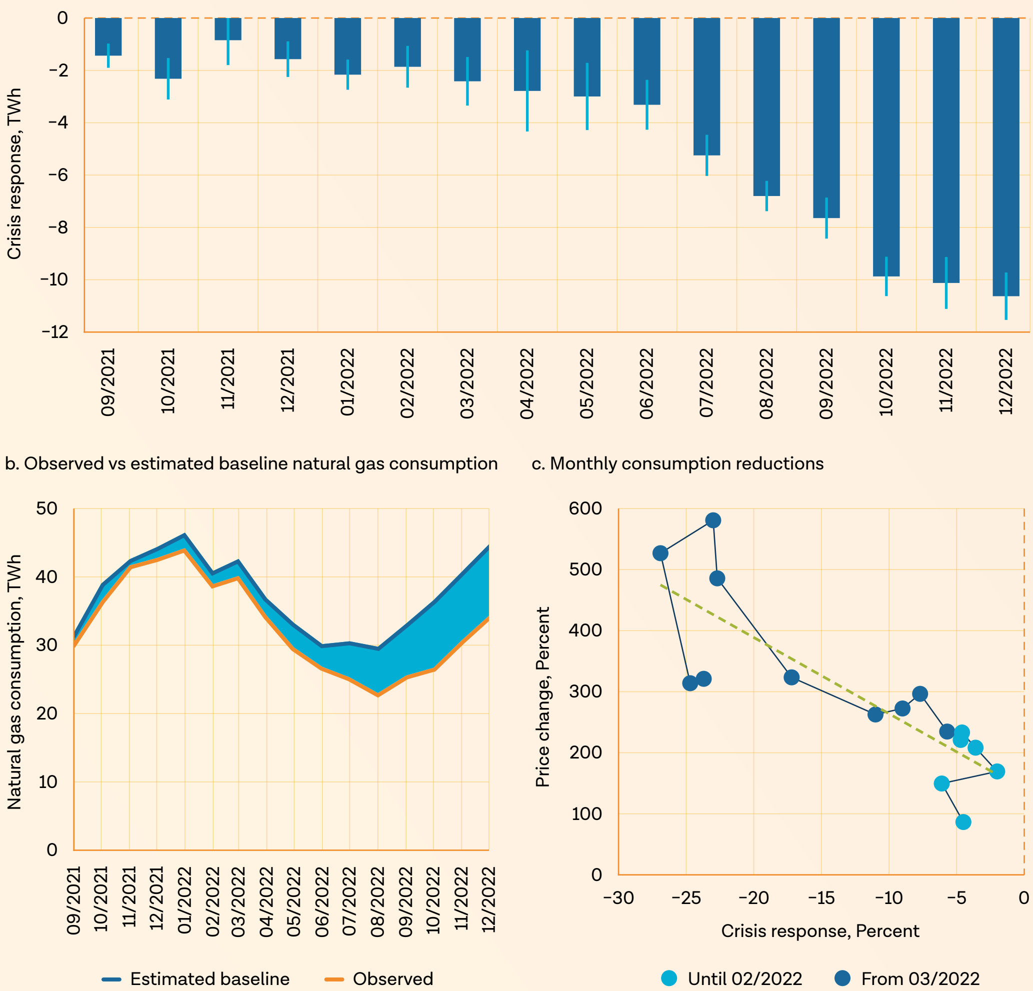
BOX 3.1 How firms in the EU have, in practice, weathered the energy price increase?

The spiraling of energy prices following Russia's invasion of Ukraine raised voices on the negative economic consequences of bans on Russian gas and oil imports. Industry lobby groups and politicians warned that cutting off Russian energy supply to the EU would lead to production disruptions, massive job losses and costly damages to production facilities. For instance, concerns raised during the spring of 2022 highlighted that many German firms and sectors were highly exposed to energy price hikes and therefore a significant share of jobs were at risk. Nevertheless, these bans were put in place and gas imports from Russia fell drastically. By January 2023, the general mood had radically changed and policy makers were already underscoring the resilience of the society and industry during the last several months. Although energy consumption reductions were significant, the reduction of output was much more moderated. What happened?

Industrial consumers responded to higher energy prices by reducing energy consumption (Ruhnau et al. 2023). For example, in October 2022, the German industry reduced energy consumption by 23 percent due to a 540 percent gas price hike for industrial consumers relative to pre-crisis levels. This implies a price-consumption elasticity of -0.04, which may actually be a lower bound according to more recent estimations (Fontagne et al. 2023, estimate the elasticity is around -0.4 for electricity and -0.9 for gas in French manufacturing firms) and considering measurement errors in industrial energy prices.[a] For instance, government support and contract trading at spot market prices anchored at historical low prices affected the price paid by businesses. In addition, the rebound of economic activity after COVID-19 and the changes in consumer behavior were also relevant factors affecting energy consumption. Hence, this suggests that the actual price response was even larger than estimated.

FIGURE B3.1.1 Estimated change in gas consumption of industrial consumers

a. Estimated monthly crisis response



Source: Ruhnau et al. 2023.

In addition to the reduction of energy demand, businesses have responded in other ways simultaneously. Fontagne et al. 2023 document that firms passed-through the full impact of energy cost shocks into product prices, reallocated energy and output across plants within the firm, and substituted locally produced intermediate inputs with imported ones (likely those with more energy content). Furthermore, they became more resilient by adapting their technology and productive processes to a new economic environment with higher energy costs.

a. Ruhnau et al. 2023.

BOX 3.2 **Firm survey details**

The qualitative survey included a total of 28 firms[a] across Bulgaria, Croatia and Poland and was conducted in early 2023. The firms operate in the manufacturing, construction, wholesale and retail, and hospitality industries. The average firm has nearly 170 employees and the median firm 60. Also, 3 business are micro firms (1–9 employees), while 17 are SMEs (10–249), and 8 are large (250+). The average firm age is 33 years old and the median age is 22. Hence, the surveyed firms are not startups but businesses with sufficient experience in their activity, with knowledge about production methods and machinery and equipment (M&E). These methods and M&E, however, are not necessarily at the frontier of their industry. The interviews with these firms primarily serve as case studies to better understand how businesses have responded to the 2021–2022 price shock, their energy efficiency performance and their investment plans on energy efficiency.

Firms state they are still far from the energy efficiency frontier based on their self-evaluated efficiency level. The average and median energy efficiency of respondents was 50 percent (where 100 percent is the best efficiency they could achieve). Also, out of the 28 firms, 20 respondents stated that energy costs accounted for less than 10 percent of total costs and in 13 cases, they were less than 5 percent. Only 4 firms reported energy costs at above 20 percent.

a. The selection of the firms while not statistically representative was made purposefully to cover both sectors that were characterized by high energy intensity as well as by moderate-low energy intensity. Similarly, the selection aimed at interviewing both a mix of micro and small firms, as well as large ones. Finally, the selection targeted firms that had done investment in upgrading and improving energy efficiency as well as those that had not done so in order to collect a varied range of opinion about both drivers and obstacles for upgrading and energy efficiency.

In addition, although the energy price hike could have acted as an incentive to improve energy efficiency, with lower profits and tightening credit conditions, some of the surveyed firms stopped their energy efficiency investments. Due to the increase in costs and the fall in profits, about one-third of the respondents — 10 firms — stated that they stopped or delayed investments in energy efficiency, while nearly two-thirds did not change their investment plans. However, only half of these firms are currently undertaking investments to enhance energy efficiency. In this regard, firms appear to be less likely to invest in energy efficiency under the current context compared to the previous 3 years, when 21 out of 28 firms reported investments, mainly in photovoltaic panels, building insulation, lighting systems, machinery and equipment upgrade and improvements in the productive process.

To improve energy efficiency, the surveyed firms prefer government assistance in the reduction of bureaucratic hurdles, price stabilization measures, financial assistance, and improvements in competition and energy infrastructure. Several businesses found legislation and program applications too cumbersome or complex. Some also mentioned that a reduction in bureaucracy, a simplification of the application procedures for operational programs and financial assistance were key for investing in energy efficiency. Regarding price stabilization, one of the main concerns of firms was price stability. On the competition environment, firms mentioned increased competition from countries facing lower energy prices than those paid by firms in Europe. IIn the construction sector, for example, firms claimed that they were subject to the pricing strategies of firms with significant market power and hence were unable to effectively pass on higher energy costs. Additionally, firms also wanted upgrades to the energy infrastructure, through increased energy storage, an upgrade of the distribution networks for renewable energy and the creation of incentives to generate, conserve and trade onsite renewable power. Also, firms emphasized the importance of ensuring energy security. Finally, a very small number of firms also pointed to the need to introduce temporary fiscal support measures or reduce wage taxes during the periods when excessive energy prices threaten their viability.

Impact of the energy price hike on trade competitiveness

There is significant concern in the EU of a decline in trade competitiveness as a result of the increase in energy prices; this was also highlighted in the survey responses discussed earlier. Higher energy prices may reduce competitiveness, especially for firms operating in energy-intensive industries.[30] In businesses more exposed to global trade, this could affect both the extensive and intensive margins of trade. For example, rising costs could reduce export growth through a lower number of firms exporting or by reducing the average export value per firm. Alternatively, firms may increase the demand of (cheaper) goods from foreign countries where energy costs are lower (surveyed firms indicated import price competition from China and India). At the same time, the energy price shock may have heterogeneous effects across firms within the same country and sector. For instance, surging energy costs may benefit high energy efficiency companies by enhancing their competitive advantage over low energy efficiency competitors. In sum, the effects on import and export flows can be ambiguous.

This section assesses the impact of higher energy prices on trade between the EU and the rest of the world, disaggregated based on energy intensity. It relies on Eurostat data on trade flows (exports and imports) and uses annual EU inter-country input-output tables to examine whether products whose sector displayed a greater dependence on energy in 2019 have experienced larger changes in export and import values and quantities. The analysis aggregates non-EU export(import) flows from(to) all EU countries at the two-digit level of the Classification of Products by Activity (CPA) code and computes the EU-level two-digit industry's (NACE Rev. 2) energy requirements per unit of output, defined as the inputs used from activities D35 "Electricity, gas, steam and air conditioning" and C19 "Manufacture of coke and refined petroleum products" over the total output produced by each sector. Sectors with energy requirements above the median are classified as "high energy-intensive" (HEI), while those with lower-than-median requirements are "low energy-intensive" (LEI). Finally, EU-level energy requirements by activity are linked to the trade database using two-digit CPA codes. Export and import flows are aggregated at the EU level according to intensity in the use of energy of EU-wide sectors. Table A4.1 (Annex 4) reports aggregate export and import value performance over 2017-2022 across low and high energy intensive sectors. Only bilateral relationships between EU countries with non-EU countries are considered, so that intra-EU trade flows are discarded (i.e., for export flows, we keep exports from EU countries to non-EU countries, while for imports we keep imports from non-EU countries to EU countries). UK data is not considered in this analysis.

Pre-pandemic, the EU's energy intensive exports were standardized heavy commodities while low energy intensive exports were differentiated manufactured goods characterized by higher unit values. This could potentially make HEI exports more price sensitive. In 2019, HEI sectors' aggregate export value was one-third that of LEI sectors, although the quantity exported, measured in kilograms, was more than 4 times higher. This suggests that high energy intensive industries export standardized, heavy goods while low energy intensive sectors export more differentiated goods (higher price per kilogram). Similarly, aggregate imports in 2019 in HEI industries represented two-thirds of LEI sectors' imports, although traded volumes were significantly larger — more than 9 times — in HEI industries. Differences in the innovation and technology embodied in low and high energy intensive sectors are such that the average price per kilogram of imported (exported)[31] goods by HEI sectors was EUR 0.51 (EUR 0.92) and EUR 7.76 (EUR 11.40) by LEI sectors. The fact that the magnitude of trade volume and the characteristics of traded goods is substantially different across HEI and LEI sectors could determine the size of the impact of disruptive changes in energy markets through the trade channel.

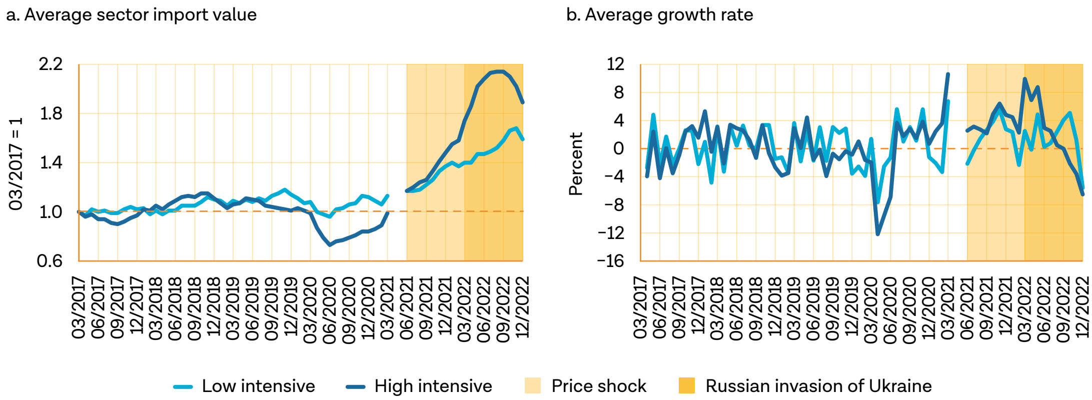
30. Abeberese 2017

31. Export (import) prices per kilogram are calculated as the export (import) value divided by the export (import) volume expressed in kg. in the following way: $p_{it}^{j} = \frac{value_{it}^{j}}{volume_{it}^{j}}$, where j = *export, import*, i = *HEI,LEI* and t denotes the year and number of month.

The export volume of low and high energy intensive products declined in 2022, although values increased, primarily because of higher prices. During 2021 – 2022, import and export value growth was remarkably higher in high energy intensive sectors, likely reflecting energy price increases. In the last two years, export and import value grew nearly two and three times faster in HEI sectors, respectively. Such increases in trade flows value appear to be driven by higher import and export good prices (EUR per kg.) rather than by larger volumes traded. In 2022, while the aggregate export value in HEI industries grew by 24 percent, quantities traded declined by 7 percent and prices surged by 33 percent. Similarly, import value rose by 60 percent, although volumes grew less than 1 percent and prices surged 59 percent. In LEI industries, export value trade grew by 16 percent, despite a decline of 11 percent in volume and a rise of 30 percent of prices. In terms of imports, aggregate value increased by 24 percent, volume by 3 percent and prices by 20 percent. Overall, although export and import value growth is associated with higher prices than due to larger volumes traded, trade dynamics appear to be different across LEI and HEI sectors (see Table A4.1. in Annex 4).

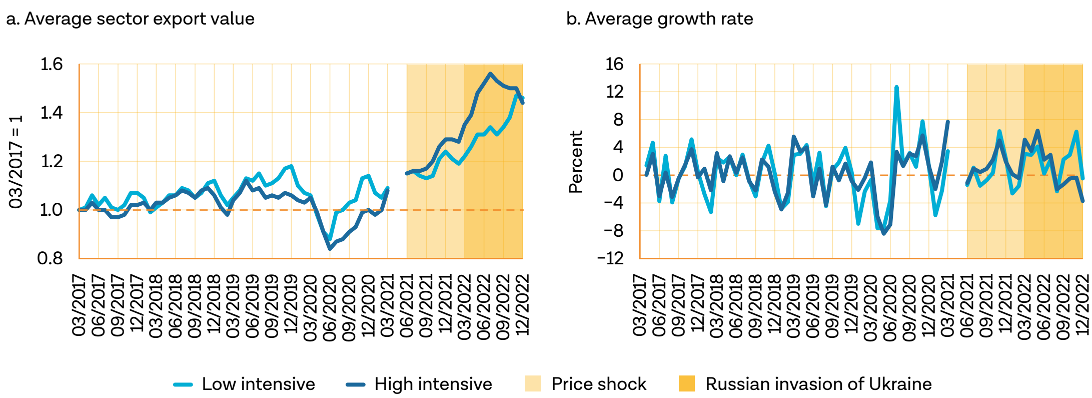
The growth rate of imports and exports (in value terms) of high energy intensive industries declined significantly after Russia's invasion of Ukraine, but similar trends were observed for low energy intensive industries, albeit with a lag. The key difference is that export and import trends for HEI and LEI industries were much more homogenous before the energy price increase (pre-2021) and the divergence between the two increased after mid-2021 (Figure 3.2 and Figure 3.3), because of volume and price effects. While there

FIGURE 3.2 Imports (value terms) appears to be declining more in high energy intensive sectors after the Russian invasion of Ukraine



Source: World Bank elaboration based on Eurostat's input-output tables and COMEXT data.

FIGURE 3.3 Export values continued to growth as energy prices surged



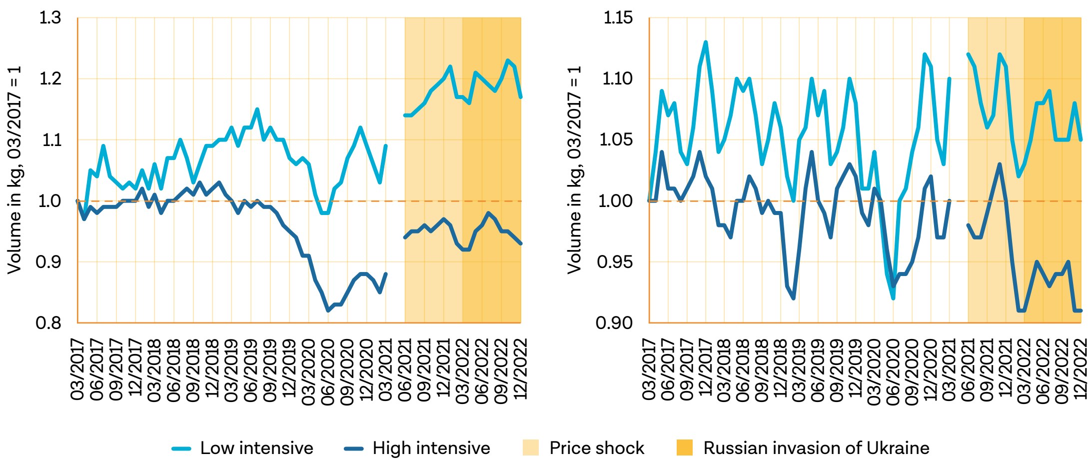
Source: World Bank elaboration based on Eurostat's input-output tables and COMEXT data.

are various exogenous factors affecting trade during this period, such as removal of some of the supply constraints during the COVID recovery and the increase in demand, we assume these factors to be common across sectors and not distinctly affect higher energy intensity products relative to lower energy intensity ones.

In volume terms, the divergence between HEI and LEI imports and exports also increased, although not very perceptibly, implying that a large part of the divergence in value terms is explained by price increases. Between April 2021 – December 2022, export volumes in LEI and HEI industries dropped by 9 percent and 11 percent, respectively. Hence, trade volumes showed very similar patterns across HEI and LEI sectors between April 2021 and December 2022; however, in the last six months, (July – December 2022), both import and export quantities fell slightly more in HEI sectors (Figure 3.4).

FIGURE 3.4 Trade volumes appear to be declining in high energy intensive industries

a. Average import performance b. Average export performance



Source: World Bank elaboration based on Eurostat's input-output tables and COMEXT data.

Overall, trade patterns during 2022 do not conclusively suggest a loss of competitiveness by EU firms. One possible reason could be that energy prices have increased globally, affecting most countries. In some emerging markets, exchange rate depreciations could have added to energy import price increases. Another possibility is that EU firms have adapted well to the energy price increase. The recent decline in trade for both HEI and LEI products could be indicative of a decline in global trade. It is also possible that the loss of competitiveness will be apparent with a lag.

Simulating the impact of energy efficiency improvements and price shocks on firms

This section discusses the results of two simulation exercises[32] that illustrate the (i) impact of improving the energy efficiency[33] of less efficient firms on energy savings, costs and profits and (ii) the impact of improving energy efficiency on energy costs, profits and employment amidst an increase in energy prices. Differences in energy efficiency within sectors suggests that firms can significantly reduce

32. The simulation exercise uses World Bank Enterprise Survey data.

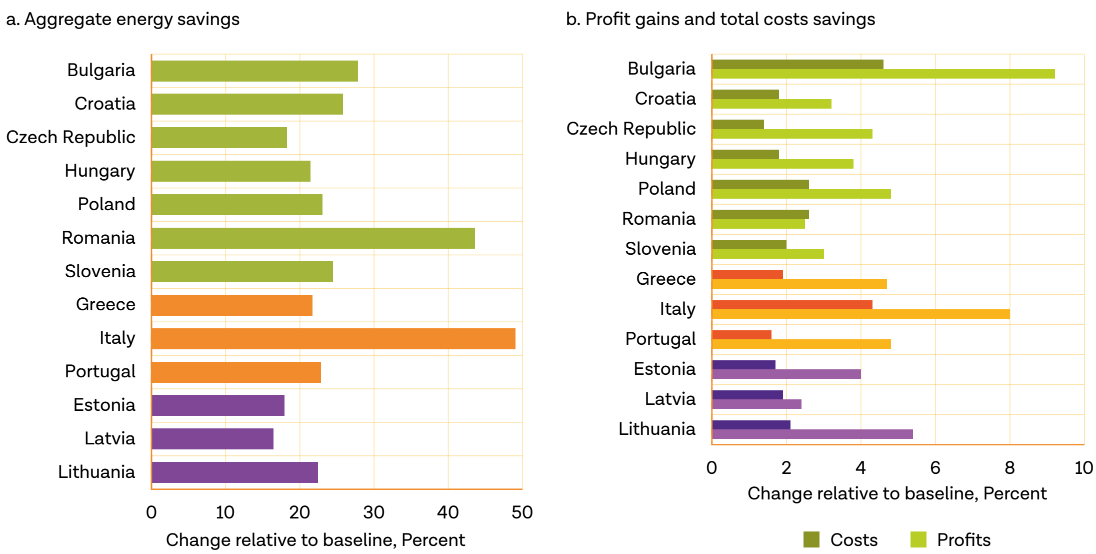
33. Energy efficiency captures how efficiently firms are able to turn energy inputs into outputs. Accordingly, it is defined as the value of revenues over energy costs (results are robust to use value added over energy costs but we don't use value added over energy costs because missing observations for value added reduce our sample size)

energy consumption without affecting output. In the simulation exercise, energy efficiency levels of "less efficient" firms (i.e., those with a below median efficiency) improve to the median level within the sector and size group. The simulation of the energy price shock relies on the increase in energy costs for non-residential consumers across EU27 Member States between the first semester[34] of 2019 and 2022.[35] According to Eurostat, the kilowatt-hour (KWh) net-of-tax electricity price for medium-sized industrial consumers[36] increased by 90 percent for the average EU country between the first semester of 2019 and 2022 while the equivalent natural gas price per gigajoule (GJ) rose by 108 percent over the same period. The choice of the 13 countries included in the analysis is determined by data availability.

Simulation 1

The first simulation shows that even a moderate improvement in energy efficiency (among less efficient firms) leads to significant savings in energy consumption (and consequent reduction in emissions), although cost reductions and profit gains are modest. This simulation does not assume an increase in energy prices but it raises the energy efficiency level of less efficient firms to the level of the median firm in their sector and size[37] in their country. Results show that aggregate energy savings are large (Figure 3.5) and range between 15 – 50 percent. This would also lead to lower emissions. In addition,

FIGURE 3.5 Improving energy efficiency could lead to significant aggregate energy savings but modest profit gains and costs reductions of inefficient firms



Source: World Bank elaboration based on WBES.

Note: Energy costs are the sum of electricity and fuel annual costs. Total costs are defined as the sum of labor, energy, raw materials and costs of goods sold and profits are calculated as total sales net of total costs. Baseline values are average profits and costs per firm before efficiency improvements. For energy reductions, aggregate savings are reported. Average total costs savings and profits gains are calculated on the basis of inefficient firms only.

34. EUROSTAT provides information on "average prices over a period of 6 months" (Jan – June and Jul – Dec each year). Prices include basic price of electricity, transmission charges, meter rental and other services. Prices are without VAT and other taxes (as non-commercial consumers are often able to recover those taxes).

35. The latest information available is 1st semester of 2022 as of the 10th of February of 2023.

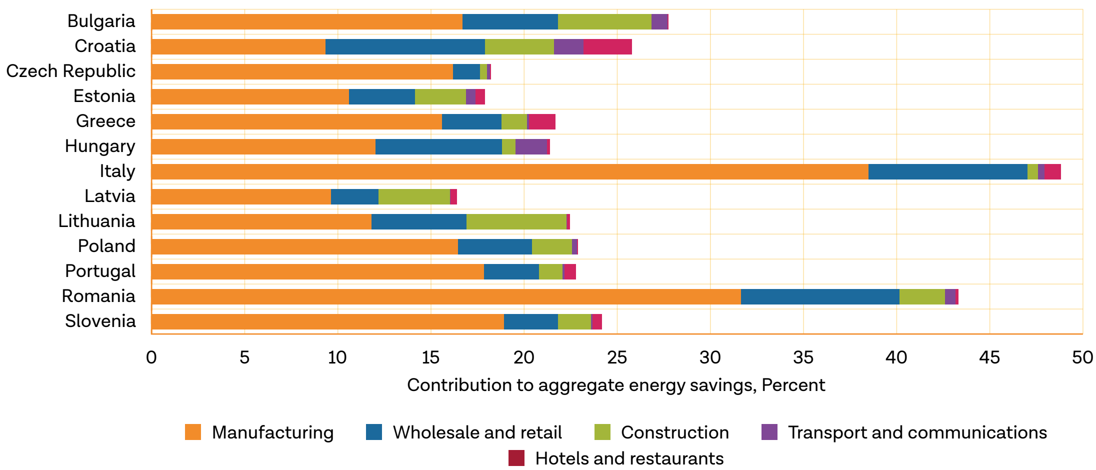
36. Electricity IC band applies for non-residential medium-size industrial units that consume between 500 MWh and 2,000 MWh per month. For natural gas, I3 band refers to industrial units whose consumption ranges between 10,000 GJ and 100,000 GJ per month.

37. Sector-by-size groups are defined according to the firm two-digit industry (ISIC Rev. 3.1) and size class (whether the firm is a SME -0 to 99 employees — or a large enterprise — at least 100 employees).

enhancing efficiency would lead to a modest reduction in total costs and a modest increase in profits among inefficient firms. On average, total costs would fall by 2.3 percent and profits would rise by 4.6 percent as energy accounts for 8 – 10 percent of total firm costs in European countries, on average. Overall, aggregate benefits of energy savings (consumption and carbon emissions) appear to be significantly larger than benefits to firms that are undertaking such investments (See Annex 2).

Manufacturing and commerce account for the lion's share of aggregate energy savings. The simulation allows for quantifying the sectoral contribution to energy savings in order prioritize sectors where the opportunities with the largest potential, which ultimately depend on the size of efficiency gap, the level of energy intensity, and the economic relevance (i.e. weight) of the sector. Results show that the manufacturing and commerce activities would account for 75 percent to 85 percent of total energy savings. Importantly, these contributions show a stable pattern across European countries. The largest savings would come from the manufacturing industry, which typically contributes between half and two-thirds of energy consumption reductions. Although in the remaining sectors there is room for improving energy efficiency, their contributions would be much more modest, especially among hotels and restaurants, and transportation and communication activities. Nonetheless, some variation in sectoral contributions across countries can make some of these sectors especially important in some countries, such as commerce in Croatia or Hungary.

FIGURE 3.6 **Manufacturing and commerce would make the major contributions to energy savings**



Source: World Bank elaboration based on WBES.

Note: The sum of sector energy savings adds up to aggregate energy savings; energy and total costs definitions apply as above; calculations are based on the following sectors: Manufacturing; Construction; Wholesale and retail trade, and repair activities; Real estate, renting and business activities; Transport, storage and communications.

Simulation 2

In the event of a hike in energy prices (as witnessed in the EU during late 2021 – early 2023), firms with greater market power and those operating in markets with highly inelastic demand may respond by marking up prices while smaller firms stand to lose. However, for those firms with less market power (e.g., SMEs operating in competitive markets), higher costs may imply lower or negative profits, which might have direct consequences on output (e.g., stop low-profit production lines) and employment (e.g., redundancy, lay-offs, business closures). Increasing energy efficiency could therefore offset the impact of rising costs and reduce inflation by moderating the magnitude of the price pass through, while maintaining employment levels.

The second simulation exercise assesses three scenarios. These include a) an energy price shock under no efficiency improvements; b) an energy price shock in which firms below the median efficiency level (inefficient) of their sector-size [38]are able to catch-up to the efficiency level of the median firm; c) inefficient firms are able to catch-up to the efficiency level of the firm at the 75th percentile. Moreover, as firms may have different electricity and fuel requirements and due to heterogeneous variations in energy prices by type of energy, the analysis considers the energy requirements of the firm and the European Union[39] (EU27) average electricity and gas price changes to simulate the impact at the country level. The analysis is static by definition, since it compares relevant outcomes across the same firms before and after the energy price shock and the energy efficiency improvement intervention. Nonetheless, the scenario a) can be extended and include a dynamic approach by considering firm entry and exit. Briefly, the dynamic simulation considers that a firm exits the market if its profits before the energy price shock were above the 10th percentile (threshold) within their sector and country and fall below the threshold after the shock. Firms that exit the market are replaced by an equivalent number of entrants, which are randomly selected from the distribution of young firms (0 – 5 years) that manage to keep their profit level above the threshold (see Box 3.3 for further methodological details). Overall, results do not change substantially between the static and dynamic analysis, although firm selection reduces the magnitude of the impact of the price shock.

BOX 3.3 A dynamic extension of the energy price shock simulation

The simulation exercise assesses firm-level costs and profits before and after the energy price shock and the energy efficiency improvement. Since it compares outcome changes for the same firms, the analyses in this chapter are, by definition, static. However, as shifts in energy prices affect costs and profits, some businesses may consider exiting the market if the level of their profits becomes too low. At the same time, exiting firms can be replaced by new businesses that find market opportunities and are profitable under the current conditions.

Therefore, we can extend the simulation analysis by including entry and exit business dynamics. The dynamic analysis compares firm outcomes (i.e., costs and profits) before and after the energy price shock taking into account that the initial set of existing firms may change after the shock. Specifically, there are firms that exit the market, which are replaced by an equivalent number of newcomers. Therefore, in the dynamic simulation, the baseline scenario (before the price shock) includes continuers and future exiting firms, whereas after the price shock the sample of firms includes continuers and entrants only.

Exiting firms are defined based on a profitability threshold, namely the 10th percentile of the profit distribution within each country and sector.[a] When the energy price shock reduces the profits of a businesses below a certain threshold level, these are classified as exiters and we assume they will not continue in operations because their profitability is too low. As fixed costs matter for determining the decision to exit we assume that these fixed-costs vary across sectors and countries, so the relevant threshold will also vary across sectors and countries. Additionally, we assume that exiting firms will be substituted by an equal number of entrants. These entrants are selected through a random draw among the existing young firms (0 – 5 years) within each sector and country that before and after the price shock have profits above minimum exit threshold. Accordingly, the number of firms in each sector remains unchanged but there is a composition effect, driven by profitability, levels of energy efficiency and production scale. In this dynamic simulation, around 5 percent of firms exit the market.

38. Due to data limitations, sectors are defined at the two-digit level of ISIC and size class (0 – 100 employees — SME; More than 100 employees — large).

39. We consider here the European Union (EU27) average electricity and gas price changes to simulate the impact at the country level. We use the average electricity and gas price change of the 27 country members of the European Union. According to Eurostat, between the 1st semester of 2019 and the 1st semester of 2022, electricity prices rose by 90.5 percent and gas prices by 107.8 percent. We acknowledge that energy prices grew less in Balkan countries. However, we aim to show the potential impact of energy prices in the absence of interventions to keep price levels down.

Entrants are more energy efficient than exiting firms, have lower average production costs but similar sales, which point to higher profitability and overall efficiency and help explain the results of the dynamic simulation. A simple comparison between entrants and exiting firms shows that after accounting for industry (2-digit), size class (SMEs) and country characteristics, entrant firms show a better performance than exiters in terms of their energy efficiency, production costs and profits. On average, entrant firms are 42 percent more energy efficient than exiters and displayed average costs 34 percent lower, although there are no significant differences in the value of sales. Therefore, in our exercise, newcomers display larger profits (167 percent higher) than exiters.

Taking into account firms dynamics increases the positive impact on efficiency and reduces the negative impact on employment. As entrants are more energy efficient and also more profitable, the new results that consider entry and exit dynamics suggest that the negative impact of the energy price shock on the economy is less negative in terms of the increase in costs and the reduction in employment. On the contrary, the price shock improves the overall average energy efficiency due to a composition effect as more inefficient firms exit and more efficient ones enter.

a. Sector is defined at ISIC 1 digit.

Impact on Costs

Simulation results show that the assumed average increase in electricity and gas prices would lead to an increase in firms' costs of 2 – 3 percent assuming no energy efficiency improvements, and with considerable heterogeneity across sectors. For instance, in the case of Bulgaria, costs could increase by up to 6.1 percent as Bulgarian firms are more dependent on energy.[40] However, the impact on inefficient firms (those below their sector-by-size median) could be considerable higher, with costs increasing by 5.1 percent, on average, and up to a maximum of 10 percent. The most energy-dependent sectors are likely to suffer the largest negative consequences of the energy price shock. For instance, transport activities and wholesale trade average costs per firm would rise by 4 to 17 percent, significantly more than in most manufacturing industries (2 – 4 percent cost rise per firm). Similarly, in construction and hotels and restaurants, two labor-intensive sectors, costs could increase between 10 – 14 percent. However, in the dynamic extension (see Box 3.3 for a description), the rise in costs would be smaller compared to the baseline static scenario mainly because entrants are, on average, more energy efficient and tend to have lower production costs. For instance, costs would be, on average, 1 – 2 percentage points lower than baseline, while in most cases, the increase in average costs would be 2 – 4 percentage points lower.

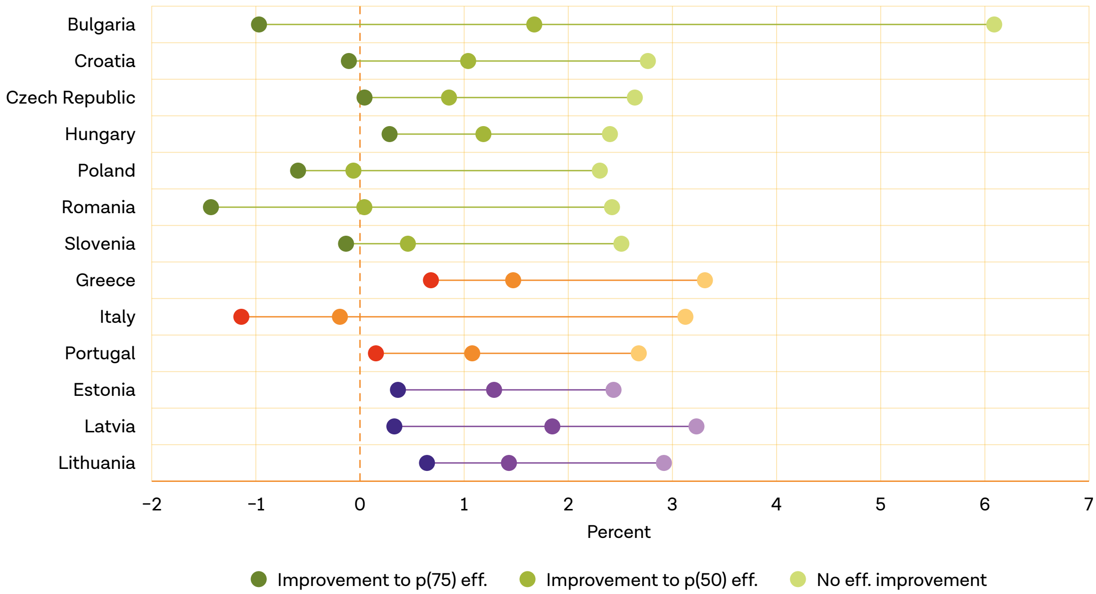
An increase in energy efficiency of less-efficient firms to the median level of their sector-by-size could halve the adverse impact on firms' costs. The increase in costs in this scenario would range between 0 and 1.7 percent in nearly all countries, and for certain countries costs could even fall marginally. The magnitude of this effect depends on the distance between the efficiency level of the inefficient firm and the median efficiency level of their sector-by-size (Figure 3.7).

A more ambitious efficiency improvement can fully offset the negative effects of higher energy prices on firms' costs. If inefficient firms (i.e., less efficient than median) were able to catch-up to the efficiency level of firms in the 75th percentile within their sector and size group, average total costs would decline for the average firm (-0.1 percent).

40. The share of energy expenses in total costs is between 2 and 3 percent for the average firm (irrespective of its level of efficiency). However, the average plant in Bulgaria doubles the energy share in total costs.

FIGURE 3.7 **Enhancing energy efficiency can significantly ameliorate the effects of the energy price shock**

Change in costs relative to baseline



Source: World Bank elaboration based on WBES and Eurostat.

Note: No efficiency improvements consider the impact of the energy price shock on average firm-level total costs assuming the price increase is the average EU27 electricity and gas price changes. Improvement to the 50th percentile — p(50) — efficiency means that efficiency of firms below median of the industry-by-size efficiency threshold are improved to the threshold value. The equivalent exercise if performed for the 75th percentile — p(75). Baseline costs are those under no efficiency improvements.

Impact on profits

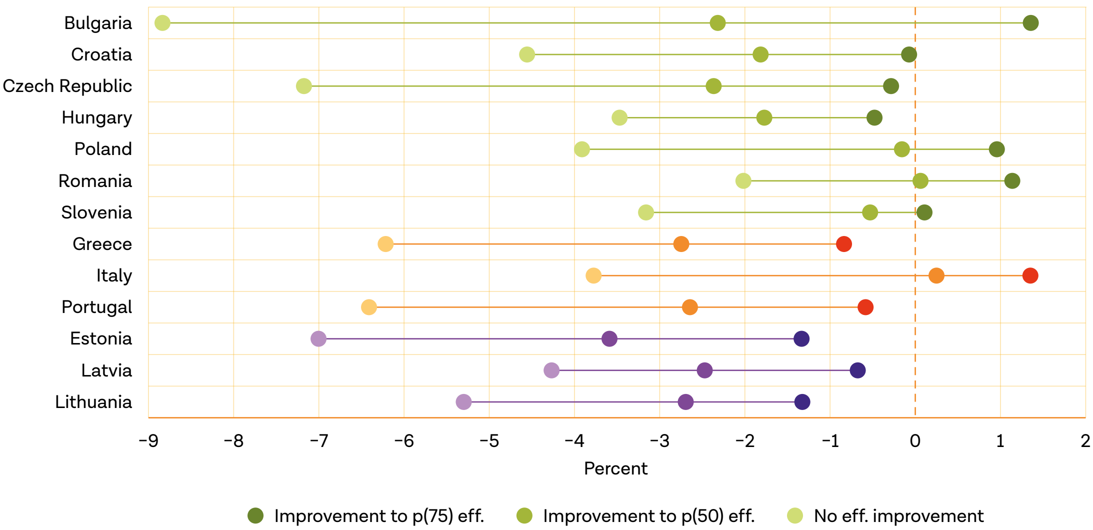
If firms neither respond to the energy price shock[41] nor enhance efficiency, profits would decrease by 4.6 percent, on average. Profits are defined as sales net of labor, input and energy costs. In 10 out of 13 countries, the average profit drop is estimated to be between 2 and 6.5 percent, but in all cases, it is expected that earnings would fall by no less than 2 percent and could reach up to 9 percent (Figure 3.8). Accounting for selection effects (entry and exit of businesses), in the dynamic simulation the drop in profits would be smaller than in the static scenario (2 percent on average and ranging between 2 – 4 percent). Due to the inefficient use of energy, it is expected that the price shock would hit low-efficiency businesses the hardest. For such firms, profit loss would average 10 percent, although it could reach up to 20 percent in Bulgaria.

If less-efficient firms catch-up with median levels of efficiency or higher (within the same size class and sector) the reduction in profits could be reversed or considerably lowered. The figure below shows the positive impact on profits of improving energy efficiency. This would significantly reduce the number of firms reporting financial distress.

41. We assume that firms do not pass the increase of costs to prices (pass-through is zero) and there are no changes in output.

FIGURE 3.8 **Modest efficiency improvements can reverse the negative impact of the energy price shock on profits**

Change in profits relative to baseline



Source: World Bank elaboration based on WBES and Eurostat.

Note: No efficiency improvements considered the impact of energy price shocks on average firm-level profits assuming the price increase is the average EU27 electricity and gas price changes. Improvement to the 50th percentile — p(50) — efficiency means that efficiency of firms below median of the industry-by-size efficiency threshold are improved to the threshold value. The equivalent exercise if performed for the 75th percentile — p(75). Baseline costs are those under no efficiency improvements.

Impact on jobs

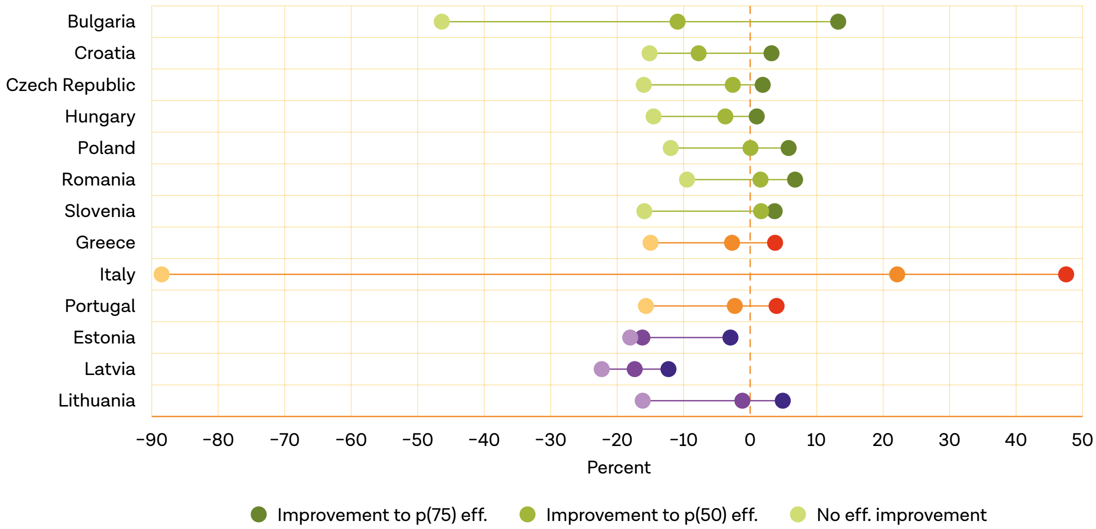
To assess the impact on jobs, the simulation allows firms to adjust employment to reverse negative profits. This section focuses only on firms whose profits turned from positive to negative after the energy price hike (6.3 percent of firms overall across the 13 countries, however in the case of Bulgaria and Romania these percentages are respectively 15 and 10 percent). For this subsample of firms, the simulation estimates the magnitude of firm downsizing (in terms of full-time workers) to keep business profits at baseline level.

Under no efficiency improvements, simulation results show a potential reduction of full-time workers of about 10 – 20 percent if firms aim to keep profits at the pre energy shock levels. For example, if a given firm reports 10 employees and the adjustment of labor costs is equal to five full-time workers, then the estimated downsizing would be equal to 50 percent. In 11 out of 13 countries, the expected firm downsizing resulting from the pure price shock would be between one-tenth and one-quarter of the original firm size. The case of Italy, on the other hand, suggests that some firms may be highly sensitive to energy cost changes, in particular due to large firms with high energy expense burdens (above 20 percent) and low profit levels.

With efficiency improvements, the downsizing is close to zero. Even with an efficiency improvement of less-efficient firms to the median level of their cohort, firms will not need to downsize to maintain pre-energy price hike profits (Figure 3.9).

FIGURE 3.9 The energy crisis could lead to considerable firm downsizing

Change in the number of workers as percentage of average firm size



Source: World Bank elaboration based on WBES and Eurostat.

Note: No efficiency improvements considered the impact of energy price shocks on average firm-level profits assuming the price increase is the average EU27 electricity and gas price changes. Improvement to the 50th percentile — p(50) — efficiency means that efficiency of firms below median of the industry-by-size efficiency threshold are improved to the threshold value. The equivalent exercise if performed for the 75th percentile — p(75). Baseline costs are those under no efficiency improvements.

More energy efficient firms: The role of capital vs green management

Different firms may require a different set of interventions to enhance energy efficiency. For some, upgrading capital may be the more effective solution as they have outdated, polluting machinery and equipment. For firms with modern capital, the adoption of green management practices[42] could be a much more impactful solution (See Annex 3).

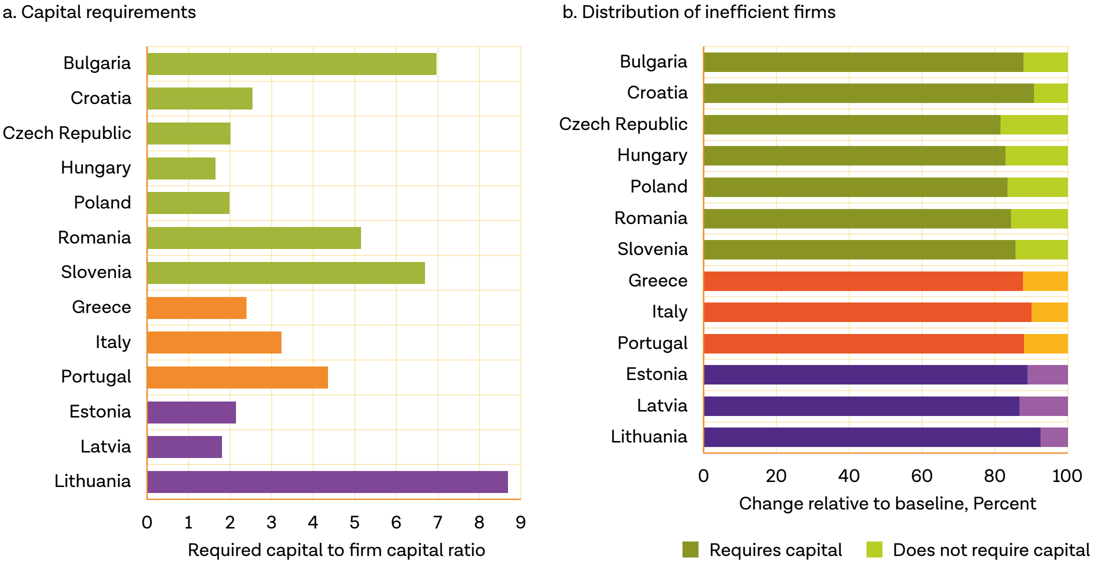
Nearly 85 percent of inefficient firms in thirteen EU countries have a level of capital that is below the average capital endowment of the firm at the median of the efficiency distribution.[43,44] Capital requirements differ across EU countries (Figure 3.10, panel a). For example, in Czech Republic, Poland or Hungary, a lower share of inefficient firms display lower capital levels relative to the average capital of firms "near" the median efficiency (within their sector and size). Conversely, in Croatia, Italy and Lithuania a greater fraction (close to 90 percent) appears to need a capital upgrade for improving efficiency (Figure 3.10, panel b). Capital requirements can be enabled by increasing access to finance and steering funds to green investments.

42. Both general management practices such as monitoring practices, as well as specific green managerial practices as waste management, monitoring of energy or CO_2 emissions, etc.

43. Based on the World Bank Enterprise Surveys' data for 13 countries. The choice of countries reflects recent data availability. Countries include Bulgaria, Croatia, Czech Republic, Estonia, Greece, Hungary, Italy, Latvia Lithuania, Poland, Portugal, Romania and Slovenia.

44. The share of firms requiring capital is calculated as the number of firms below the median efficiency whose capital level is below the average capital of the firms "close" to the median energy efficiency (e.g., 20 percent of a standard deviation) over the total energy inefficient firms. The required amount of capital is calculated as the difference between the capital endowment of the inefficient firm requiring capital and the average capital of the firms "close" to the median efficiency.

FIGURE 3.10 **Inefficient firms require capital in large amounts to optimize energy use**



Source: World Bank elaboration based on WBES.

Inefficient firms that require capital need to increase their capital endowment by two to nine times to reach median efficiency levels, with striking disparities across countries. For instance, in Croatia, Czech Republic, Estonia, Greece, Hungary and Poland, firms would need to have 1.6 to 2.5 times as much more capital as they currently have. In other countries such as Bulgaria, Lithuania, Romania and Slovenia, the ratio between the extra capital required and the current capital is nearly between 5 – 9, meaning there are large capital differences between inefficient and median efficiency firms.

In addition, firms are more likely to invest in green mixed rather than in pure green technologies. Businesses can either invest in technologies that seek to specifically reduce the environmental impact (pure) or in technologies for which the reduction of the impact on environment is a by-product of other objectives (mixed). Companies are more prone to invest in technologies that reduces the consumption of energy such as energy management systems, and heating, cooling or lighting system improvements. On the other hand, the percentage of firms investing in air pollution control technologies is substantially lower although uptake varies across countries.

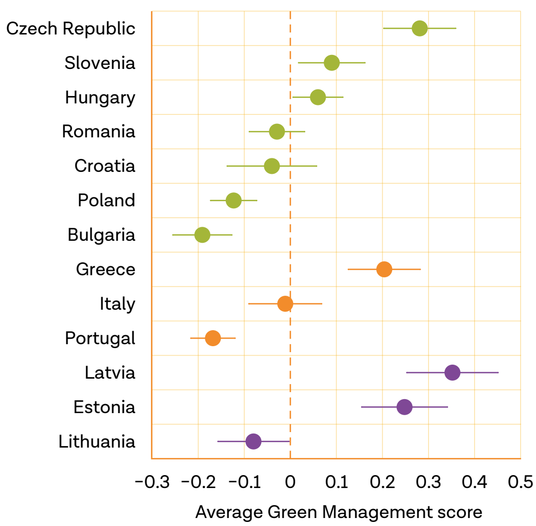
A growing body of literature has highlighted the importance of management and technology as drivers of firms' energy efficiency levels. In particular, technology and the vintage of capital used by the firms are key for determining energy requirements of firms. Investing in modern, energy-saving technologies can make substantial contributions to increase energy efficiency. However, there are factors beyond the vintage of capital that may affect the efficiency at which business use energy. The economic literature has shown the positive links between energy efficiency and the adoption of organizational and managerial practices.[45] Good quality management within the organization may boost the organizational capabilities of firms and thus its efficiency but may also be a strategic complementarity for unlocking innovation and greener technology adoption.[46] Green management practices (GM) can be regarded as an extension of management practices focused on improving input choices and the firm's environmental footprint.

45. Bloom et al. 2010; Martin et al. 2012
46. Grover, Iacovone & Chakraborty 2019

In the EU, green management practices appear to be focused on optimizing the use of inputs rather than minimizing the environmental impact of production. Monitoring energy consumption and water usage are the most common monitoring practices among EU firms, but they fail to monitor the emissions they generate. In 10 out of 13 countries, three-quarters of businesses report monitoring energy consumption and in the remaining cases (Bulgaria, Italy and Romania), only half the firms monitor energy consumption. However, only a small share of firms monitor carbon emissions or other pollutants. In 8 out of the 13 countries, the share of firms monitoring CO_2 emissions along its supply chain is below 10 percent. Furthermore, the fraction of firms monitoring other pollutants is below 15 percent in the same number of countries. Therefore, there is ample room for encouraging the take-up of green management actions across EU firms. Moreover, there are several management practices that could also vary in the intensity of adoption. Hence, this analysis uses green management z-scores, an indicator that gauges the overall green management quality by averaging the z-score of the four types of GM practices (objectives, responsibility, monitoring and targeting).[47]

The quality of green management varies both across and within countries substantially, even after considering the firm size, the economic structure and geographic factors. The adoption of GM practices may be associated with the sector composition of countries, the economic development of regions and the size of the establishments, which ultimately could determine the capacity to incorporate green-related practices to the structure of the organization. However, after controlling for such factors, results suggest that there is still substantial variation in green management quality. Figure 3.11 shows that GM quality differs substantially across countries. Firms in Latvia, Czech Republic and Estonia have, on average, the highest scores in green managerial performance, in contrast to Slovenia, Portugal and Bulgaria, which have the lowest.

FIGURE 3.11 Green management quality varies both within and across countries



Source: World Bank elaboration based on WBES.

Note: Figures uses a two-stage regression approach: it regresses the green management score on the size of the establishment, sector of operations, and region of location and generates the residuals, which are then regressed on country dummies.

FIGURE 3.12 Green Management quality is closely associated with overall management quality

The relationship between General and Green Management Practices

Source: World Bank elaboration based on WBES.

Note: Figure plots a binned scatter using 50 bins, controlling for age and size class, 2-digit industry, country and region of location within the country.

47. The green management z-score summarizes establishment-level records about environmental and green practices. The score for each question is normalized so that each has zero mean and standard deviation of one (z-score). After variable normalization, z-scores are aggregated into four categories (strategy, responsibilities, monitoring, targets), and then the overall green management z-score is calculated as the unweighted average score of the four types of practices.

The quality of environmental-related practices is strongly associated with the overall quality of management. Green management could be regarded as a subset of general managerial practices undertaken by the organization. Therefore, the quality of GM is expected to be associated with the quality of overall management. In fact, there is a positive and high correlation between general and green management practices. Even after controlling for firm size and age class, industry (2-digit) and region of location of the plant, the correlation between overall and green management is positive and significant. However, this association is not as strong in every country. In specific cases such as Croatia or Latvia the association is weak and non-significant. Lack of knowledge about how to perform specific green management actions or low awareness among firms about the importance of internalizing green growth issues could be driving these results, although there may be several factors affecting such relation.

Policy options to support firms

Countries could reduce the costs of supporting firms and improve the effectiveness of policies in the context of high energy prices by following the FIRST principles. **F**oster **i**nnovation to improve efficiency. **R**educe uncertainty by making measures not just time-bound but state-contingent (i.e. directly linked to observable level of prices). Make support conditional to energy **s**avings, especially for those firms that are inefficient relatively to their sector benchmark. Improve **t**argeting and focusing on viable firms, to ease liquidity challenges faced but also address solvency risks.

Government support measures should incentivize and be contingent on energy efficiency improvements. Improving energy efficiency is widely recognized as the most effective approach to reducing the impact of high energy prices and achieving long-term emission reduction goals. To encourage such improvements, incentives could be provided in the form of accelerated depreciation for investments in more efficient capital equipment, lighting, and insulation, particularly for large firms. For small and medium-sized enterprises (SMEs) and younger firms, supporting investments in energy efficiency may require grants, vouchers, or concessional credit lines. Furthermore, it is essential that support be contingent on measurable savings and improvements in energy efficiency. Specifically, support to inefficient firms should be contingent on them making significant efforts to improve energy efficiency, so that government support does not inadvertently encourage more intensive use of energy.

There is also a need to incentivize "green management" by addressing key market failures. Several market failures hinder firms from adopting more efficient green managerial practices. Firstly, studies suggest that poorly managed firms are often unaware of their shortcomings and overestimate their management capabilities. Such firms could benefit from feedback and information on their current levels of efficiency, online self-diagnostic tools, targeted information campaigns, or energy audits. Secondly, even if firms are aware of the need to improve their green management practices, they may struggle to assess the returns on investment of such improvements, leading them to delay or withhold investments. These firms could benefit from the development of markets for energy audits and consultants, coupled with energy savings performance contracting.[48] Thirdly, the reduction of energy consumption has important externalities, such as lower CO_2 emissions and health benefits. Due to the externalities associated with reducing energy consumption, the social benefits of firms upgrading their green management and technologies are greater than the private

48. Energy Savings Performance Contracting (ESPC) is a financing model that enables energy efficiency improvements without upfront capital costs. In an ESPC, an energy service company (ESCO) conducts a comprehensive energy audit for a facility to identify potential energy savings opportunities. The ESCO then designs and implements energy efficiency measures and guarantees that the improvements will generate energy cost savings sufficient to pay for the project over the term of the contract. The cost savings are used to pay back the ESCO for the investment made in the energy efficiency upgrades. If the savings don't meet the guaranteed levels, the ESCO is typically responsible for the difference. This model allows organizations to improve their energy efficiency, reduce their energy costs, and mitigate financial risk, as the ESCO assumes the performance risk of the energy-saving measures.

benefits of the firms incurring the respective investment costs. This creates a private investment gap, where firms may be hesitant to invest in green management practices despite the potential long-term benefits to society. To address this challenge, some countries have adopted blended finance incentives schemes that provide firms with "cash back" after completing investments in upgrading their management and technologies and can certify an improvement in their levels of efficiency (or a reduction in energy expenses).

Support should be tied to specific levels of prices. This approach provides businesses, particularly those heavily reliant on energy resources, with greater certainty by clearly defining the duration of support. This facilitates better long-term planning and risk management, reducing uncertainty for businesses. At the same time, it safeguards government finances by calibrating support to decrease public expenditure as energy prices return to lower levels.

Finally, it is key to stress the importance of targeting and differentiating among firms. Effective targeting of support measures requires distinguishing between viable and non-viable firms and focusing on the former. To determine viability, solvency and vulnerability must be considered. Assessing viability is a complex and forward-looking exercise, while vulnerability may be more objective and depend on the sector and size of the company. Support provided to viable firms should aim to ease liquidity and address solvency risks.

Examples of specific policies: A portfolio approach

Policy support to improve energy efficiency can also support competitiveness and growth. Improving energy efficiency not only helps firms become more productive and resilient to energy shocks, but also reduces carbon emissions. This, in turn, reduces the potential size of future government interventions aimed at alleviating the effects of surging energy prices. We group policy interventions to help businesses become more energy efficient into two categories. The first category includes interventions that encourage firms to upgrade their capital equipment through improved access to finance conditions. The second category includes interventions focused on improving firm organization, processes, routines, and capabilities. As there is no single solution to address energy efficiency upgrading and green transition, we present a set of different interventions, highlighting the need for a portfolio of different approaches and summarize them in Table 3.1.

Finance

Accelerated depreciation to incentivize the investments in green technology. Accelerated depreciation enables businesses to deduct a larger portion of the cost of machinery and equipment within the first years after acquisition, resulting in a lower tax bill and facilitating the upgrade of equipment to more energy-efficient capital. Governments often adopt accelerated depreciation instruments although they are not usually focused on energy efficiency. However, there are some examples around the world of this instruments encouranging a more efficient use of energy. The Australian Federal Government's Accelerated Depreciation for Small Business Entities initiative allows small businesses to make use of accelerated depreciation to boost their energy efficiency. Similarly, the Irish Accelerated Capital Allowance (ACA) is a tax incentive scheme that promotes investment in energy-efficient products and equipment. The ACA is based on the long-standing "Wear and Tear Allowance" for investment in capital plant and machinery, whereby capital depreciation can be compensated through a reduction in an organization's tax liability.

Grants, vouchers, concessional credits and special loans to support SMEs' and young firms' green investments. Barriers to credit can partially explain underinvestment in energy efficiency, particularly among very small firms or those without a credit track record. Grants and vouchers can help unlock investments in energy-efficient equipment, especially if they are targeted to firms that would not otherwise invest in this type of machinery or for projects that would not otherwise be funded. However, to be effective, application procedures should be streamlined and provide adequate information and technical guidance to firms. Grants and tax relief schemes are common in countries such as the UK and Germany. For instance, the Energy Technology List (ETL) scheme in the UK provides tax reliefs for businesses that invest in energy-efficient equipment. In terms of bank loans, governments and development banks can provide special or concessional credit lines through commercial banks to address credit market access constraints. These instruments are particularly useful for firms that do not meet credit requirements, such as collateral, interest rates, and payback period. In Germany, for example, the KfW finances up to EUR 25 million per project at favorable interest rates for small enterprises, with up to three repayment-free start-up years.

Utility on-bill financing and on-bill repayment, equipment leasing, developing the market for ESCOs are additional measures to unlock green investments. In a context of high barriers to access credit market and limited public resources, governments can consider complementary instruments to promote green investments. *On-bill financing* provides firms with the possibility to pay for clean energy upgrades through their utility. The energy retailer finances the project, and the client repays the investment through an additional charge on the monthly bill. This program can considerably lower credit risks, as the financier can proxy bill repayments using past bills, and failure to pay can be tied to disconnection. These initiatives have proven to be effective internationally. Leasing energy-efficient machinery can also be useful for SMEs with limited capital and no access to commercial loans. In a leasing agreement, the customer pays for the right to use the equipment from the financier, who owns the asset instead of buying it. In certain cases, the customer may gain a reward from reduced energy costs. The Energy Leasing Program in Virginia, US, and the Strategic Bank Corporation of Ireland offer leasing to SMEs to finance green plant, machinery, and transport equipment. Finally, Energy Service Companies (ESCOs) provide energy efficiency solutions and finance the upfront costs. ESCOs design, construct, operate, and finance energy efficiency equipment and upgrading, and the customer pays for energy savings through an agreed rate conditional on the level of energy savings or pays a fee for a guaranteed level of service. ESCOs usually function best with large-scale projects and prefer large companies to avoid risks during the project.

Firms' and workers' capabilities

Enhancing managerial and employees' capabilities beyond investing in technology. Developing firms' managerial and organizational capabilities can improve firm productivity while addressing energy and environment-related concerns. Public interventions that create demand for consulting services, training managers and workers on energy efficiency aspects, providing technical assistance for improving production techniques, and providing advice for firm digitalization and technology adoption, are part of the portfolio to enhance business management and workers' abilities. These programs vary from general to customized services that develop specific business skills (e.g., hard and soft) with wider or narrower perspectives according to the needs of the organization. There are several examples of programs that aim to improve the quality of management across organizations. The European Energy Managers (EUREM) is a standardized energy management training that provides graduate courses for becoming accredited experts for energy audits or energy managers and joining a large pan-European network. Additionally, the Swedish National Energy Efficiency Network is a program established in 2015 and run by the Swedish Energy Agency to set up networks of SMEs (6 – 16) with the aim of exchanging best practices and providing individual counseling and group consultancy from an external energy expert.

TABLE 3.1 Summary of Policy instruments for enhancing firms' energy efficiency

Policy area	Policy instrument
Finance	Introduce or enable accelerated depreciation for green projects
	Provide grants and tax incentives
	Extend special credit lines and concessional loans
	Develop Utility on-bill financing and repayment
	Enhance equipment leasing
	Enable energy savings contracting (ESCO market)
Capabilities	Provide consulting and outsourcing services
	Train managers and workers on energy efficiency
	Provide specialized technical assistance for production techniques
	Support firm digitalization
	Boost technology adoption

Source: World Bank elaboration.

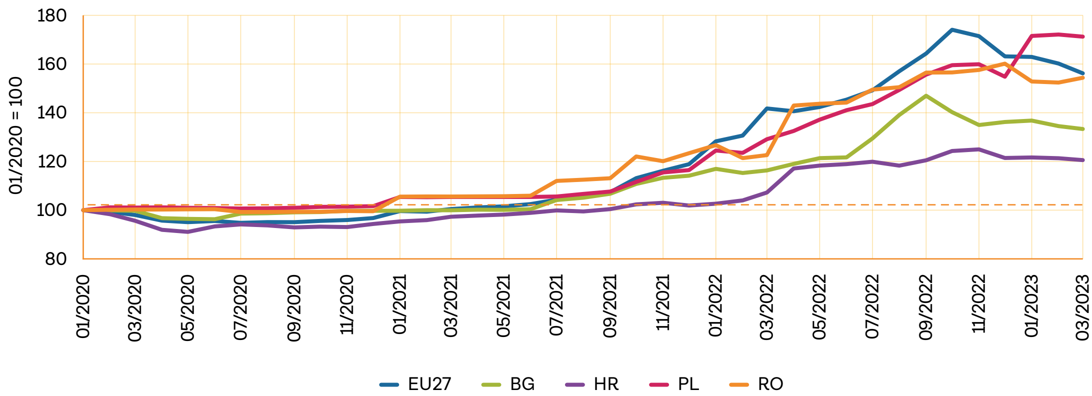
Chapter 4

How have households coped with price increases

Energy prices increased by 55.5 percent (EU-27 average) between March 2021 and March 2023, with an uneven passthrough to consumer prices across EU countries.[49] The varied pass-through is a reflection of differences in domestic energy markets, exposure to Russia, and government support measures (Figure 4.1). For example, consumers in Bulgaria and Croatia have experienced more limited increases linked to government price caps, while energy price increases have been higher in Poland and Romania.

FIGURE 4.1 Evolution of energy prices (index) by countries

Energy inflation growth, 01/2020 – 03/2023



Source: Eurostat (prc_hicp_midx), 2020M1-2023M3.
Note: The energy inflation is constructed for electricity, gas, and other fuels using theharmonized consumer price index.

EU Member States have extensively used energy price caps and excise and VAT reductions to protect consumers and firms from price rises. The retail price caps help to protect households and firms from price increases, which can be especially damaging for those who spend a larger share of their expenditures or costs on energy. Governments favor price caps because they are simple to implement and provide a clear energy pricing framework that is easy to monitor. The equity and effectiveness of price caps remain a topic of debate.[50] In contrast, better-targeted income support measures such as cash transfers or tax breaks can be more complex and challenging to administer but fiscally less costly and likely more effective in helping the most vulnerable cope with higher prices.

Who are particularly vulnerable to energy price increases?

Energy spending accounts for a significant share of households' average expenditure but it decreases as households get wealthier, implying that energy price increases could have adverse distributional effects. The share of household income spent on energy was higher among the bottom income quintiles in Croatia, Bulgaria, Poland, and Romania,[51] suggesting that poorer households are more vulnerable

49. According to the Eurostat harmonized consumer price index.

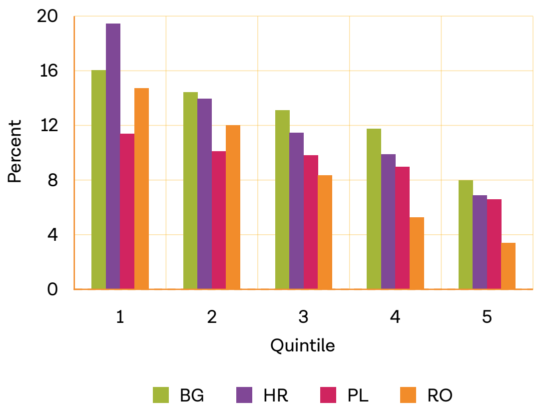
50. Hardy et al., 2019, Philibert et al., 2008, Guo et al., 2019; Fisher et al., 2017

51. Sources: WB staff analysis using Croatia 2017 Household Budget Surveys (HBS), Bulgaria 2021 HBS and 2021 Romania HBS. For Croatia, the figures refer to the share of household expenditures by consumption quintiles. For Poland, Bulgaria, Romania and Poland, the figures refer to the share of household incomes spent on energy, by income quintiles. In Romania, energy includes solid fuels, liquid fuels, natural gas, thermal energy and electricity and renewables. In Bulgaria, energy includes electricity, natural and town gas, liquified hydrocarbons, liquid fuels, coal, heating energy and other solid fuels. In Croatia, energy includes electricity, gas, heating energy, and solid fuels. Transport related energy expenditures are not included. Quintiles are based on income per capita and are trimmed for negative values. It should be noted that the energy expenditures recorded are actuals and are not adjusted to take into account potential underreporting or the stock nature of solid fuel sources. The figures for energy poverty use the IBS (2019) hypothetical energy concept, which is used to capture energy poverty in Poland.

to rising energy prices (Figure 4.2). Bulgaria's poorest households allocated, on average, 16 percent of their overall household budget on energy, while the richest ones spent only 8 percent. In Romania, the respective share is 15 percent in the lowest expenditure quintile and 3 percent in the highest. In Croatia, the pattern is similar — the poor spent around 19 percent of their budget on energy, while the richest spent only 7 percent. There are also differences in the average share of energy spending in total household budgets across different EU countries, with Lithuania, Latvia, and Estonia being below 11 percent, while Hungary is close to 16 percent (World Bank, 2013). There is also a significant heterogeneity across population groups, with single elderly households and rural residents having particularly high spending shares on energy.[52] In Romania, high expenditures on energy in rural areas is explained by several factors, including sources of heating and cooking, like wood, coal, and oil stoves that are used more than natural gas. Leakages in buildings are also more prevalent in rural areas.[53] These energy sources can also have harmful environmental impacts.

FIGURE 4.2 Energy spending shares by income quintiles

circa 2021



Source: Bulgaria HBS 2021. Romania HBS 2021. Croatia HBS 2017. Poland 2018.

Note: In Bulgaria, Poland and Romania, the spending shares are constructed using energy spending over the observed household monthly income from the budget surveys. In Croatia, the observed expenditures are used in the denominator without imputed rents for owner-occupied households. The energy costs related to transportation in Romania, Bulgaria and Poland are excluded for comparability. The income and energy spending information across countries are not fully comparable.

Some households may spend more on electricity, natural gas, or coal than others, depending on several factors, such as the size of the home, number of occupants, and access to various energy sources. Access to electricity[54] is near universal in all four countries, while access to network natural gas sources is more limited. In Romania, only half of the households report positive spending (proxy of connectivity) on natural gas. This can reflect the lack of access to natural gas in certain rural areas, although it could also be the household's preference to use other energy sources.[55] For example, regarding energy spending on electricity, in Bulgaria, it is relatively higher for households with children and those with at least one unemployed (more than 60 percent). On the other hand, rural households and those with more than five members spend nearly 50 percent of their energy on other solid fuels.

Energy poverty rates vary significantly across different demographic groups, with rural areas and single elderly households having the highest rate. Energy poverty rates,[56] measured as the share of households spending more than 10 percent of their income on energy, are consistently higher in Bulgaria and Poland than in Romania (Figure 4.3). In particular, in all three countries, the highest rate is observed in households with single elderly, with 73 percent in Bulgaria, 76 percent in Poland, and 57 percent in

52. Sources: Bulgaria and Romania HBS.

53. Own estimates based on 2020 EU-SILC.

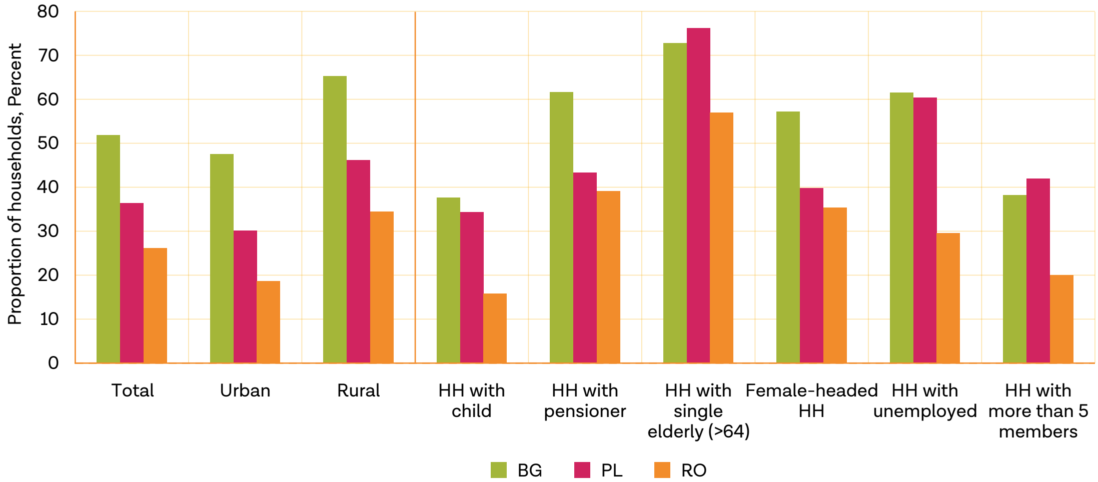
54. We proxy electricity connectivity by analyzing the share of households with a non-zero household expenditure on electricity. We proxy connectivity to natural gas by analyzing the share of households using natural gas for cooking and/or heating.

55. There are no estimates of connectivity to gas in Bulgaria to compare.

56. Energy poverty is multi-dimensional by nature. It is difficult to reflect the need for comprehensive approaches in indicators that measure energy poverty. Most measures are driven by the following factors: low income, energy efficiency, and energy prices. In this report, we use the 10 percent measure. Under this definition, energy poverty is defined as the share of households that spend a significantly high portion of their household budgets (10 percent or more) on energy. 10 percent is an absolute threshold related to a minimum level of energy consumption to maintain an adequate level of warmth.

Romania. The higher energy poverty rates among single-elderly are also consistent with findings from other countries (Inoue et al, 2022). The energy poverty rates are also especially high in households with pensioners, unemployed persons, and those headed by females. In Romania, energy poverty is strongly correlated with household income and the technology used for cooking and heating.[57] However, even among households with similar characteristics and sources of heating and cooking, those with pensioners, unemployed, and female-headed households are still more likely to be energy poor.[58] Energy poverty in Poland is largely linked to heating costs and is greatest among those with local heating sources living in older housing stock (IBS, 2018). Upgrading the housing stock to replace old and leaking houses with energy-efficient technology can help overcome energy-poor conditions in the medium term. In the short term, social safety nets are the most important measure to protect the most vulnerable households from energy poverty.

FIGURE 4.3 Energy poverty rate by groups, 2021



Source: Romania HBS and Bulgaria HBS, 2021; Poland HBS, 2018.

Notes: The spending shares are constructed using the energy spending over the observed household monthly income from the budget surveys. Energy poverty is defined as the share of households spending more than 10 percent of income on energy. The income and energy spending information across countries are not fully comparable.

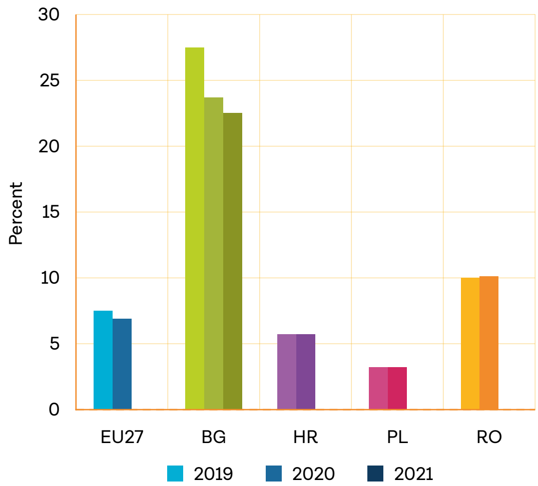
Nonmonetary measures of energy affordability show similar results — there are large disparities across EU countries while within countries, single elderly households experience higher arrears on utilities and an inability to keep their homes warm. For instance, in 2020, Bulgaria reported the highest rate of households unable to keep their home warm in the EU (23.7 percent). In Romania, the rate was 10.1 percent, in Croatia, 5.7 percent, and in Poland, 3.2 percent (Figure 4.4). Regarding the rate of households with arrears on utility bills, 19.2 percent of households in Bulgaria have arrears, one of the highest rates in the EU and just below Greece, while in Croatia it is 15.2 percent, in Romania 7.3 percent, and in Poland 5.2 percent (Figure 4.5). The latest data in 2021 does not show striking differences relative to previous years, indicating that this information has not changed much over time. Single-elderly households have a higher rate of arrears on utility bills than other household types and the largest rates of energy poverty. Thus, there is some consistency between nonmonetary and monetary measures of energy affordability.

57. Age and conditions of the dwelling can potentially explain the level of energy poverty in a household. However, the survey data do not have a proxy for these indicators.

58. Source: World Bank estimates based on regressions of energy expenditure shares using the Romania 2021 HBS. Covariates include household-level characteristics.

FIGURE 4.4 **Inability to keep home adequately warm**

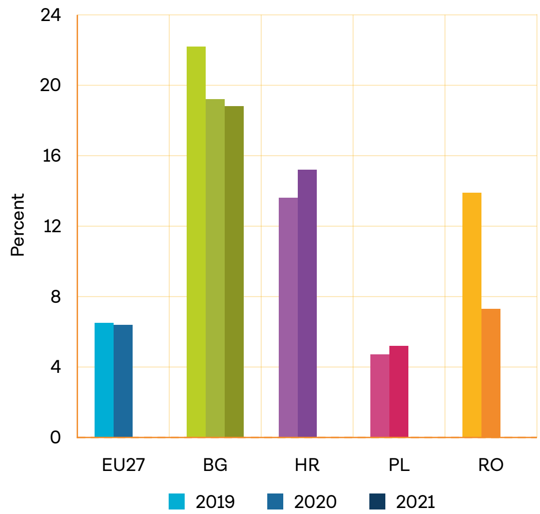
2019 – 2021



Source: Eurostat (ilc_mdes01 and ilc_mdes07) based on EU-SILC (2022 to 2020, income years 2021 to 2019). No data is available for certain countries in 2021.

FIGURE 4.5 **Arrears on utility bills**

2019 – 2021



Source: Eurostat (ilc_mdes01 and ilc_mdes07) based on EU-SILC (2022 to 2020, income years 2021 to 2019). No data is available for certain countries in 2021.

Most low-income households reside in detached houses, likely due to their location in rural areas, and leakages are more prevalent. Such houses may require renovations to adhere to better energy efficiency standards. Households in the lowest income quintile live disproportionally in detached houses. For instance, in Bulgaria and Poland, the share of households in this quintile living in detached houses is more than 60 percent, and in Romania, it is more than 90 percent. Leakage issues seem more prevalent in such houses, with 24.8 percent of households in the lowest income quintile reporting leakages in Romania, 23.3 percent in Bulgaria, and 18 percent in Poland. In contrast, these shares are only 3.2 percent in Romania, 4.2 percent in Poland, and 4.7 percent in Bulgaria in the highest income quintile. The poor quality of dwellings, especially for those at the bottom of the income distribution, poses a significant challenge for the government to address energy poverty.

To conclude, vulnerable households are more likely to face difficulties meeting higher energy prices, which could translate into increased inequality. The energy crisis can disproportionately affect the poor for several reasons. First, the poorest consistently spend a higher share of their income on energy and are less prepared to deal with a price shock, as they tend to have fewer financial resources and buffers to cope. Second, they are more likely to live in low-quality housing with poor insulation and leakages, which increases their energy needs and exacerbates the impact of rising energy prices. Third, they might be less able to access energy-efficient appliances or renewable energy sources, which can reduce their energy costs in the long run, and might have limited mobility options, making it difficult to access cheaper energy sources or job opportunities in areas with lower energy costs. Inequality is also expected to increase as the impact of increased energy prices is not uniform across all households. Therefore, it is crucial to provide effective policies that support those who require it the most and ensure that affordable energy remains accessible to all.

Poverty impact of the energy price increase

According to microsimulation results,[59] food and energy inflation have welfare-reducing effects in Bulgaria, Croatia, Romania, and Poland (RER9-Part I).[60] In particular, they are expected to increase poverty[61] rates by 0.3 to 1.8 percentage points across the four countries, with the poorest households experiencing the highest relative welfare losses. Indirect effects explain most of the increase in poverty as they ripple through core inflation.[62] While income support measures could potentially mitigate some of these losses, poorer households are more vulnerable due to their consumption patterns. In particular, some population groups — such as single-elderly households — are more affected by rising energy and food prices (RER9-Part I). The pre-crisis relative poverty among single elderly households was between 17 and 34 percentage points higher than the national poverty rate depending on the country, despite their access to pension income. The overlap between energy poverty and poverty rates facilitates the creation of targeted measures for certain subgroups.

How have governments mitigated the impact of higher energy prices?

The definition of energy poverty varies across countries. Currently, there is no official definition of energy poverty in Bulgaria, and the government has formed an inter-ministerial working group to work on a formal definition of energy poverty under the Energy Act and design policy tools to alleviate it. In Romania, energy poor are defined as those individuals that require social protection measures and additional services to ensure the minimum energy consumption of a single person/family for lighting, optimal cooling and heating of the home, supporting cooking facilities, and providing hot water in the home, using means of communication that require the use of energy or powering medical devices to sustain life or to improve people's health (Law 226 — Romanian Parliament, 2021). In Croatia, the government is working on defining the criteria but still does not have an official definition of energy poverty. EU Member States are required to provide a definition and develop a set of criteria for measuring energy poverty under both the Electricity and Gas Directive (2009/73/EC) and the revised Electricity Directive ((EU) 2019/944). The Energy Poverty Observatory defined it as a set of conditions where "individuals or households are not able to adequately heat or provide other required energy services in their homes at affordable cost." (EEN, 2019). More precisely, they use four main indicators to identify energy poverty: low absolute energy expenditure, a high share of energy expenditure in income, arrears on utility bills, and inability to keep the home adequately warm.

Several governments in Eastern Europe, including Bulgaria, Croatia, Poland, and Romania, have established support programs to help consumers and businesses cope with rising energy prices. For example, Croatia has implemented a price limit on natural gas, oil derivatives, and electricity, while Bulgaria has frozen energy and heating costs for a few months and provided temporary heating assistance to financially challenged households. In Poland, the government has reduced VAT on food, gas, fertilizers, petrol, diesel, and heating and assisted households in need with energy bills. Similarly, the Romanian government has imposed a temporary limit on electricity and natural gas prices and introduced grants and vouchers to help vulnerable Romanians and businesses.[63]

59. Using household budget surveys.

60. https://www.worldbank.org/eurer

61. 6.85 US$ per day in 2017 PPP.

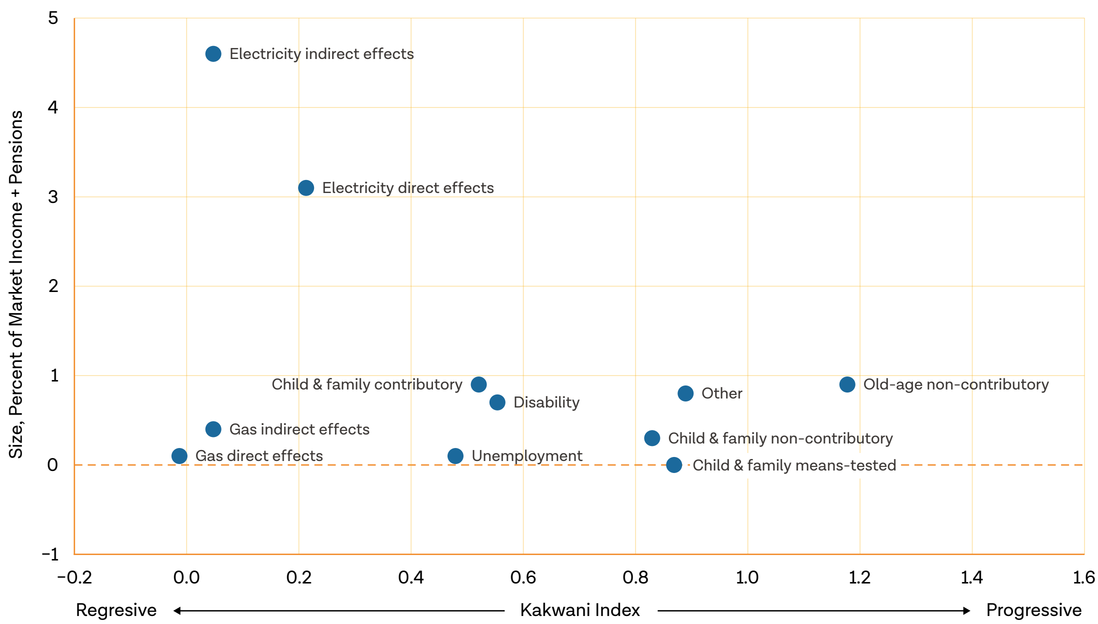
62. These estimates reflect welfare simulations of the observed price changes, which already take into account the price caps the governments are implementing. They do not take into consideration the additional income support measures given directly to households.

63. For the fiscal impact of government support measures, please refer to EURER9-Part I, Box I.3. https://www.worldbank.org/eurer

In Croatia, an assessment of the distributional impacts of the VAT reduction shows a small increase in household income and a modest decline in the at-risk-of-poverty rate. Government support measures in Croatia, like the VAT reduction of natural gas, heating energy, and firewood from 25 percent to 5 percent in 2022, are ways to tackle high energy prices. A microsimulation using a Commitment-to-Equity model shows that households at the lowest income decile experienced an income boost of 1.5 percent compared to 0.4 percent among the richest. These small income gains translated into some poverty reduction. The share of Croatians at risk of poverty[64] declined by 0.4 percentage points. Similarly, poverty depth fell by 0.3 percentage points.

In Bulgaria, most household protection has been focused on electricity and natural gas price caps; however, the inter-ministerial working group is designing short-term mitigation measures to protect energy-vulnerable households from high energy prices and policies to enhance energy efficiency. An analysis of the progressivity of indirect subsidies and transfers suggests that electricity subsidies, which can be increased as a result of the price caps, might be less progressive (as shown by a lower Kakwani Index) but larger in size than direct social transfer programs; natural gas subsidies might also be less progressive, but they are smaller in size (Figure 4.6). Furthermore, these subsidies reduce poverty and inequality significantly less than direct transfers (Vaughan & Cabrera, 2022). Therefore, efficiently targeted transfers can be more effective and less costly to minimize the consequences of rising energy prices on poorer families.

FIGURE 4.6 **Indirect Subsidies and Social Transfer Programs, Size and Progressivity in Bulgaria**



Source: World Bank estimates based on Bulgaria CEQ.

64. Based on consumable income to account for VAT consumption. The official AROP is based on household disposable income.

Policy options for consideration

Combating energy poverty is a complex issue that requires a multifaceted approach involving various sectors, given its multidimensional measure. It entails the participation of numerous stakeholders, including those in energy, transportation, and infrastructure, as well as those in social sectors like social protection, health, and education. Effective strategies for addressing energy poverty also necessitate integrated approaches at different geographic scales, ranging from EU-wide policies to local-level monitoring. Therefore, involving a diverse range of stakeholders is essential for defining and monitoring energy poverty (Robayo-Abril and Rude, forthcoming).

Governments can play a crucial role in mitigating the impact of rising energy prices by implementing targeted transfers that help most affected households. Under a social protection system that can identify and promptly help those in need, this approach has proven to be more cost-effective and efficient than general price caps. The success of such transfers will depend on each country's social assistance structure and policy objectives for safeguarding its vulnerable populations. There are different options to consider regarding energy-related social assistance, such as means testing, proxy means testing (PMT), a categorical approach, or a hybrid approach. Each alternative has varying implications for coverage and targeting effectiveness, as well as different budgetary and implementation requirements. Currently, Bulgaria, Croatia, Romania, and Poland have energy benefits for all families. However, these benefits only reach a small percentage of the vulnerable population. In Croatia, for example, the Government's compensation for electricity costs only reached about 20 percent of the poorest — those at the bottom decile of the income distribution.[65] The non-contributory heating allowance in Bulgaria also has low coverage, with roughly one in four poor in 2019. However, it is expected to expand with the recent guaranteed minimum income (GMI) threshold increase.[66] In Romania, the home heating aid is quite progressive, but its poverty and inequality impacts are small.

Social safety nets are crucial for protecting individuals from energy poverty, particularly in the short term; energy efficiency measures for households can also increase household welfare, particularly in the medium run. Policy solutions need to provide support to upgrade the efficiency of the housing and heating appliance stock — through subsidized investments — as well as to operational (heating) expenditures for those households who struggle to pay their energy bills. Energy efficiency can have positive effects through several channels, such as the price channel (by reducing energy bills), but also others, such as improving indoor comfort and air quality, increasing the property's value, creating new job opportunities, and reducing the dependence on fossil fuels. A renovation program in Romania, which has already been approved, has ambitious goals to enhance the energy efficiency of buildings[67] and investments in energy-efficient housing, especially among poorer households, that could have beneficial effects. In Bulgaria, the inter-ministerial working group is also working on medium-term mitigation measures, including energy efficiency measures. In addition, the Recovery and Resilience Plans of all four countries have allocations for green projects, including for energy efficiency.

Evidence for Poland shows that the design and implementation of energy efficiency programs must consider structural and behavioral barriers to facilitate the journey to more energy-efficient practices among households. There is a considerable opportunity to improve the energy efficiency of buildings by leveraging energy behaviors that have not yet been fully utilized (Lopez et al., 2012). Evidence from

65. Own calculation based on HBS 2017.

66. Own estimates based on CEQ and 2019 SILC.

67. The program aims to promote the use of heat pumps as a means of significantly reducing energy demands for heating and transitioning to electrification.

the Poland Clean Air Priority Program (CAPP), one of the largest air-quality and energy-efficiency programs in Europe, suggests that understanding structural and behavioral factors,[68] is critical for households to invest in sustainable heating practices (World Bank, 2020).[69] Therefore, these should be taken into account in policy design.

68. These can include such as high upfront costs and no access to affordable financing, limited knowledge or access to newer technologies or fuels, perceived risks associated with new technologies, contractors and actual energy savings, underpriced externalities on CO_2 and air quality.

69. There is limited evidence on the adoption of energy efficiency programs for the other countries.

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ANNEX 1

The channels of firm responses to rising energy prices

The eight main adjustment mechanisms that firms widely use include the following

1. **Passthrough:** Firms can translate, partially or fully, the increase of costs due to higher energy prices into their prices (Fontagne et al. 2023). The energy price shock is likely to impact marginal costs of production. Depending on the market structure, the elasticity of demand and the internal and external competition environment, firms can pass through higher costs to product prices. For instance, Fontagne et al. 2023 and Joussier et al. 2023 show that under the 2021 – 2022 energy price shock, French firms passed through the energy cost increase to production prices. Ganapati et al. 2020, and Sadath & Acharya 2015 also find the price markup strategy as a relevant adjustment mechanism.

2. **Energy efficiency:** A second margin of adaption is upgrading energy efficiency through energy-saving innovations. A relevant number of studies provide evidence on the positive effects of energy price shocks on the number of energy-efficiency innovations (Grubb et al. 2021; Hassler et al. 2021; Popp et al. 2010; Popp 2002). Thus, this margin of adjustment can be relevant to moderate the impact on prices and carbon emissions.

3. **Product portfolios:** Higher energy prices may affect business' decisions on their product mix, especially in multiproduct firms (Abeberese 2017). For instance, firms can switch between industries depending on the energy intensity of production. For example, Elliot et al. 2018 find that due to rising energy costs, firms are more likely to switch the industry of their main product to a less energy intensive industry and reduce their dependency on energy.

4. **Production process adjustments:** A relative change in the price of certain energy sources can lead the firm to switch between power sources (Brehm 2019).

5. **Production shifts between plants**: In multiplant firms that face different energy prices, a mechanism of adaptation could be the reallocation of production between plants towards those with the lowest prices. Fontagne et al. 2023 provide evidence that energy demand and production increases in establishments with lower prices. However, the extent to which multiplant firms can adapt their production process may depend on the cost of output reallocation and of the productive process adjustments.

6. **Onsite electricity generation:** Energy price shocks could spur onsite energy generation under appropriate energy market regulations (i.e., whether onsite generated energy is exempted from network charges and firms can trade energy surplus; Rottner & von Graevenitz 2022, 2020). Generating own electricity can mitigate the price and output effects, while also reduce the carbon footprint of the economic activity.

7. **Reduce in-house production of certain energy intensive inputs and shift to import them:** another channel of adjustment is to increase imports of more energy intensive intermediate inputs rather than producing them in-house or acquiring them from local suppliers (Rentschler & Kornejew 2017). There is evidence that firms respond to energy price shocks by altering their production process through substituting locally produced by foreign-produced inputs (Fontagne et al. 2023). For some companies, this may involve stop the production of certain inputs inhouse, while for some others seek input suppliers in more energy regulated markets or less exposed to energy price hikes. In certain cases

where firms are not able to perfect substitute product inputs, the substitution process may lead to a downgrade in product quality as well.

8. **Other production factors adjustments:** businesses can also respond through adjustment employment within the intensive (hours worked) or the extensive margin (number of workers; Dechezleprêtre, Nachtigall & Stadler 2020; Marin & Vona 2017), which in the limit could result in the plant exit (Brucal & Dechezleprêtre 2021).

ANNEX 2

Elasticity of energy consumption (in response to energy price changes) for businesses

Recent studies leverage firm-level data on energy consumption and network charges in Germany, France and Italy to estimate the price elasticity of energy, in particular, electricity and gas. In the case of Germany, Rottner & von Graevenitz 2022 estimate that the average elasticity of electricity usage on manufacturing firms is around -0.4 and -0.6 in the short term. However, long-term elasticity is much smaller and non-significant, suggesting that the responsiveness of manufacturing plants to changes in electricity prices are not permanent. Also, besides short- and long-run effects, the estimated elasticity appears to show a decreasing trend. For instance, a one percent increase in network charges was associated with a reduction in energy consumption of about 0.7 to 0.9 in 2010 – 2011 but by only 0.3 to 0.5 in 2016 – 2017. In this regard, marginal abatement costs appear to be increasing more than proportionally and hence businesses require larger energy price increases to reduce energy consumption in the same proportion than they did in previous years. Also, Runhau et al. 2023 estimate a lower-bound gas elasticity of -0.04 for industrial consumers.

In France, Fontagne et al. 2023 estimate the elasticity of manufacturing firms over the period 1996 – 2019 and find that businesses adjust energy consumption strongly and rapidly to higher energy prices. The estimated demand elasticity is around -0.4 for electricity and -0.9 for gas. As Rottner & von Graevenitz 2022, the authors also report that the electricity elasticity decreases with time, even for large price hikes. An interpretation for this is that firms have mostly adapted to price shocks in the past and now have less space for adjustments. Moreover, considering the current scenario, the authors look at the largest price increases — much lower than current price hikes — noting that the elasticity, although significant, is small both for electricity and gas. Nonetheless, consumption reductions are still significant due to the size of the price shock. These results are to those in Wolverton et al. 2022 for the US. For a sample of manufacturing firms for the period 1992 – 2015 they estimate the average electricity elasticity is -0.7, while for energy-intensive trade-exposed industries is -0.8.

Nonetheless, the responses to energy price increases may not be homogeneous across EU countries. For instance, Alpino et al. 2023 find that for the sample of medium and large firms (more than 50 employees) in Italy, the electricity and gas elasticities during the recent energy crisis are very small (-0.2) and not statistically different from zero. However, they document that for plants subject to the European Emissions Trading System (EU ETS), the gas elasticity is much larger, around -0.8. These differences in estimated elasticities could be explained by the fact that the gas intensity of EU ETS firms is much higher than of non-EU ETS firms and that natural gas price changes in 2021 were larger for the former than for the latter group of firms.

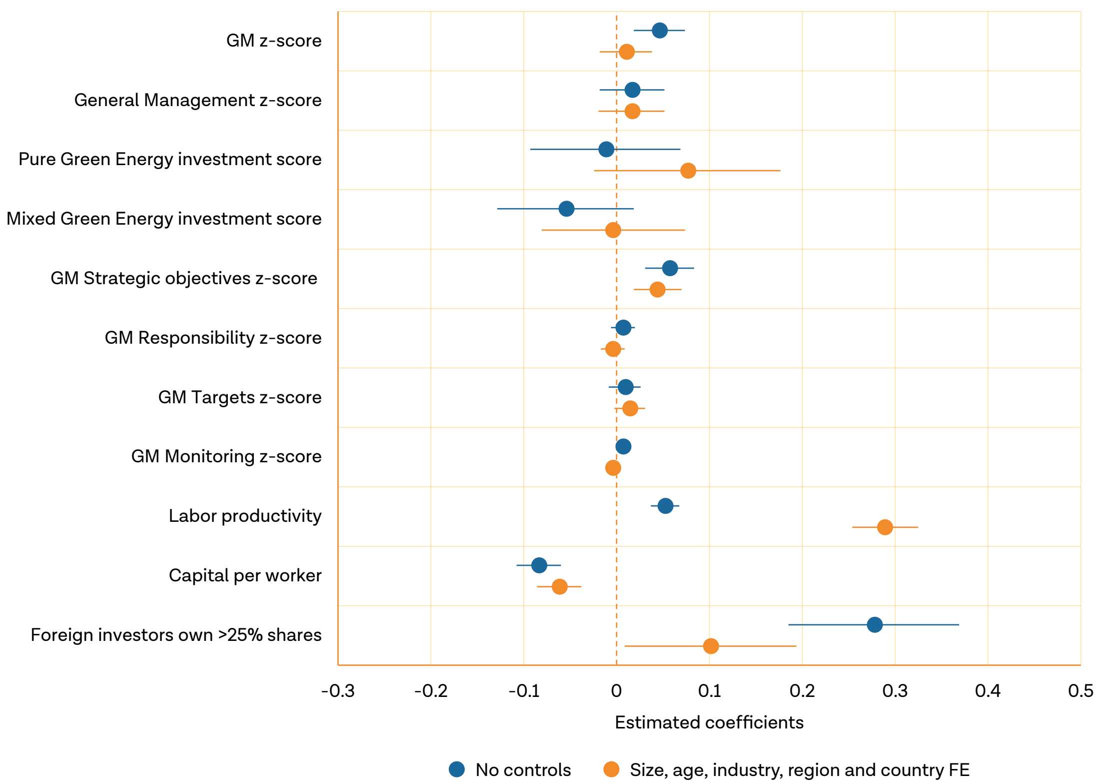
Overall, recent research for EU countries and the US shows that firms reduce energy consumption as they face higher prices. However, the amount of such reductions (i.e., the demand elasticity) could vary across countries and across firms within countries based on the energy input, firms' dependence on energy, market characteristics and binding regulations. Studies estimate the electricity and gas elasticities at about -0.4 to -0.9 in Germany and France, and -0.2 in Italy. Remarkably, energy elasticity has decreased with time and firms' short-term responses may diminish in the long-term.

ANNEX 3

How do energy efficient firms look like?

More productive and foreign-owned firms tend to be more energy efficient. Two of the characteristics that are positively correlated with energy efficiency is the (log) sales per worker and the ownership of the company. A 10 percent increase in labor productivity is associated with a 30 percent increase in energy efficiency after accounting for firm size, age, industry and geographic fixed effects (FE). Moreover, plants where foreign shareholders own more than one-quarter of total shares are between 10 to 30 percent more efficient. General management appears to be positively associated with efficiency levels although the estimated coefficient is not significant. Nonetheless, this could be related to sample size limitations rather than to an stylized fact. Importantly, firms whose GM score in strategic objectives is higher are more efficient, which highlights the importance of good management practices in the plant. The remaining estimated coefficients associated with GM quality are not statistically significant. On the other hand, more capital-intensive firms are less efficient, which denotes that, other things equal, using capital more intensively consumes energy, emphasizing the importance of investing in pure and mixed green technologies.

FIGURE A3.1 Firms with higher productivity, foreign investors, higher GM quality and GM strategic objectives are more energy efficient



Source: World Bank elaboration based on WBES.

Note: Energy efficiency is regressed on each independent variable separately, With and without size, age, industry and geographic controls. Confidence intervals displayed at the 90 percent of confidence.

The business cases provide additional qualitative evidence to examine how efficient firms look like. Firms are asked to self-evaluate their energy efficiency level, where the best energy performance the company could achieve is 100 percent. According to firms' responses, the average and median energy efficiency is 50 percent, which suggests that the interviewed firms are still far from the optimal efficiency. Firms that show energy efficiency ratings above 70 percent appear to be actively investing in efficiency measures such as photovoltaic panels, systems for waste heat recovery, adapting their production process, upgrading capital which is often outdated and needs to be replaced for modern machinery and equipment, and building insulation. Remarkably, firms that show better efficiency scores tend to be larger than firms that report efficiency levels below 50 percent. These firms tend to be larger than low-efficiency firms, which may suggest that some of the investments may require minimum capital amounts and that there is a structure within the organization that can lead the green transition of the firm.

ANNEX 4

Import and Export performance of sectors differentiated by energy intensiveness

TABLE A4.1 Export and import performance of low and high energy intensive sectors

	Exports		Imports		Exports growth		Imports growth	
Year	Low intensive	High intensive	Low intensive	High intensive	Low intensive	High intensive	Low intensive	High intensive
				A. Value (EUR, million)				
2017	99,479	35,558	77,032	51,371	-	-	-	-
2018	102,927	37,536	80,342	58,829	3.47	5.56	4.30	14.52
2019	108,145	37,836	85,443	56,861	5.07	0.80	6.35	-3.35
2020	99,748	33,930	81,313	45,219	-7.76	-10.32	-4.83	-20.47
2021	111,788	41,806	94,051	66,040	12.07	23.21	15.67	46.04
2022	129,601	51,886	116,424	105,737	15.93	24.11	23.79	60.11
				B. Volume (kg, million)				
2017	9,474	41,726	10,175	112,008	-	-	-	-
2018	9,476	40,785	10,584	114,154	0.02	-2.26	4.02	1.92
2019	9,490	41,165	11,009	111,301	0.15	0.93	4.02	-2.50
2020	9,190	40,300	10,461	97,808	-3.16	-2.10	-4.98	-12.12
2021	10,552	41,029	11,440	105,715	14.82	1.81	9.36	8.08
2022	9,413	38,186	11,784	106,673	-10.79	-6.93	3.01	0.91
				C. Prices (EUR per kg)				
2017	10.50	0.85	7.57	0.46	-	-	-	-
2018	10.86	0.92	7.59	0.52	3.44	7.98	0.26	12.20
2019	11.40	0.92	7.76	0.51	4.92	-0.11	2.24	-0.78
2020	10.85	0.84	7.77	0.46	-4.76	-8.38	0.15	-9.59
2021	10.59	1.02	8.22	0.63	-2.40	21.02	5.76	35.28
2022	13.77	1.36	9.88	0.99	29.96	33.37	20.18	58.56

Source: World Bank elaboration based on Eurostat's input-output tables and COMEXT data.

Note: Only export (import) flows from(to) EU countries to(from) non-EU countries considered. The United Kingdom is excluded from the analysis due to the change in the membership status during the examined period. vv

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