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ENERGY CRISIS AND STRUCTURAL CHANGE: PROSPECTS FOR GERMAN INDUSTRY

This is a translated version of the original German-language chapter "Energiekrise und Strukturwandel: Perspektive für die deutsche Industrie", which is the sole authoritative text. Please cite the original German-language chapter if any reference is made to this text.

KEY MESSAGES

↘ Energy prices are likely to fall again in Europe in the medium term, but are not expected to return to pre-crisis levels. Energy-intensive industries facing strong competition from non-European competitors are particularly affected.

↘ This will accelerate the structural change in industry that is already expected as a result of decarbonisation, but it is unlikely to lead to broad-based deindustrialisation.

↘ State support should target companies with sustainable business models and not seek to maintain the status quo. The expansion of renewable energies should be stepped up.

SUMMARY

In recent months, the **economic situation in Europe** has been **burdened by the sharp increase in wholesale prices for energy carriers**. Industry in Germany is currently confronted with prices for natural gas and electricity, which in August were on average 265 % (electricity) and 200 % (gas) up on the previous year. In countries like the **USA or China,** the price increases for some energy sources were **much more moderate**. If futures prices are taken as a yardstick, the international price-level differences will continue until the end of 2024. In the long term, wholesale prices in the different regions are expected to converge again but not fully.

The sharp increase in prices – both in absolute terms and relative to many other regions – will **accelerate the structural change in industry** that is already expected as a result of decarbonisation. Energy costs make up a relatively small percentage of total costs in most sectors of the economy: between 2 % and 5 %. For energy-intensive sectors, however, costs have risen significantly as a result of the higher energy prices. **Hardest hit** are **energy-intensive industries and products** that simultaneously face particularly strong competition from non-European companies, such as metal production and processing, glass and glassware processing and manufacture, ceramics, non-metallic mineral processing and the products of the basic chemicals industry. In these sectors, some areas of production could move abroad. However, **no broad-based deindustrialisation is to be expected**. The energy intensity of industry in Germany has already fallen significantly in the past decade. This was due to a change in the industrial structure but, above all, to an increase in energy efficiency in the individual economic sectors. This development will be further accelerated by the current crisis.

In response to the energy crisis, a range of **government measures** are planned to **reduce energy costs** in the short term. The proposed ceilings on gas and electricity prices ('price brakes') should be designed in such a way that they **maintain energy-saving incentives**, particularly to prevent gas shortages. At the same time, windfall effects for companies planning to relocate production should be prevented. In the short term, energy supplies should be expanded wherever possible in order to lower prices. Unlike in the case of the coronavirus pandemic, for example, state support measures should not be about maintaining the status quo, but should target companies that have a **viable medium- and long-term business model** in Germany and Europe.

In the medium term, the **availability of cheap, low-carbon energy** will cut companies' energy costs and strengthen their competitiveness. This requires measures to secure hydrogen imports, an accelerated expansion of renewable energies, the development of the energy infrastructure and more flexibility in energy demand.

I. INTRODUCTION

268. Russia's war of aggression on Ukraine and the resulting distortions on the energy markets have **revealed** considerable **problems in Germany's energy supply**. These include the country's heavy dependence on Russia for energy imports and a lack of supervision and coordination between authorities regarding infrastructures such as gas storage facilities. **Energy prices in Germany have risen sharply since last year**, mainly due to declining natural gas supplies from Russia, but also as a result of increased uncertainty about the energy supply as a whole. As a result, the risk of possible **supply shortages** of natural gas and electricity cannot be entirely ruled out either this winter or in the winter of 2023/24. ↘ ITEMS 291 FF. Other factors contributing to price increases have included a reduction in the supply of crude oil by OPEC+ and transport difficulties caused by low water levels on the Rhine.

269. Many other EU countries are also severely affected by energy price increases. The close interdependencies between European energy systems require a **coordinated approach within the European Union (EU)** to jointly address the necessary adaptation of supply chains and infrastructure. Against the backdrop of geopolitical developments, a new balance must be struck **between supply security and economic efficiency**.

270. Energy prices in the various regions of the world are likely to converge again as supply chains and infrastructures adjust. However **European natural-gas prices** are expected to remain **permanently higher** than before the crisis relative to other regions due to the higher transport and production costs associated with substituting Russian natural gas with liquified natural gas. ↘ ITEM 302

271. In addition to the serious short-term challenges for firms, the future **development of relative energy prices** will have a significant impact on the long-term **competitiveness of German industry** and the viability of individual business models. Changes in energy prices, along with decarbonisation (GCEE Annual Report 2020 items 352 ff.; GCEE Special Report 2019 items 177 ff.) and digitalisation (GCEE Annual Report 2017 items 60 ff.; GCEE Annual Report 2019 items 305 ff.), will significantly determine structural change in industry. The effects can **vary** greatly depending on the energy intensity of the economic activity, the geographical distribution of the most important competitors and the decarbonisation pathways planned to date. The industrial sectors manufacture of basic metals, manufacture of other non-metallic mineral products, as well as the products of the basic chemicals industry are particularly affected by the current developments. ↘ ITEMS 315 FF.

272. At the same time, economic **decarbonisation pathways** are expected to change. Natural gas was seen before the war – and continues to be seen – as a key energy source for many bridging technologies, such as the decarbonisation of steel production. Higher energy prices and the need to save on natural gas may make it more attractive for some industrial sectors to move to low-carbon production processes more quickly. ↘ BOX 16

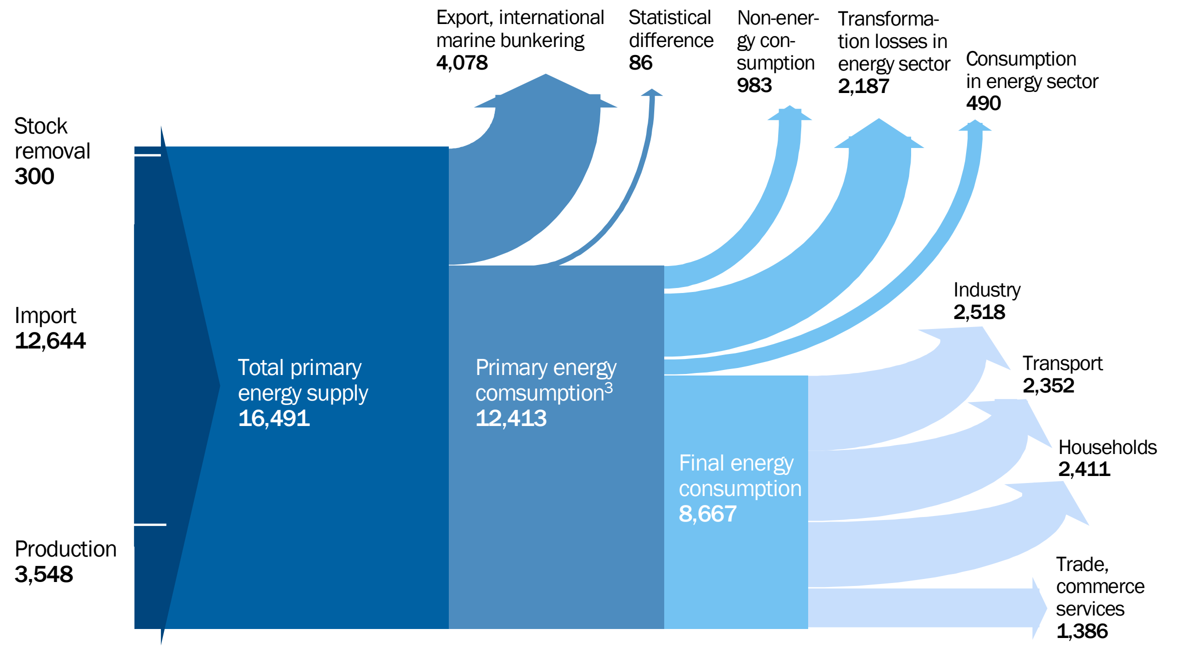
273. By creating appropriate framework conditions and taking targeted measures in the fields of energy policy, industrial policy and climate protection, the state should help **cushion the negative effects of the energy crisis** on viable firms and at the same time **press ahead with the necessary structural change**. Especially in the short term, supply-side and demand-side measures should be used consistently to dampen energy-price increases. The planned gas-price brake will partially ease the pressure on industry in the short term without reducing energy-saving incentives. However, it should be accompanied by further instruments that support medium- and long-term structural change and promote industrial decarbonisation. Furthermore, the measures must be designed in such a way that incentives to innovate are maintained or even increased. Experience following previous energy crises, such as in Japan, suggests that although the economic structure changes as a result of a crisis, a broad de-industrialisation is not to be expected even with higher energy prices. Energy intensity has already been significantly reduced in Germany, especially in the past decade, thanks to an increase in energy efficiency in the individual sectors of the economy and a change in the industrial structure. The current crisis can be expected to expedite this development. Finally, in view of the **energy crisis,** the switch to renewable energies should be speeded up in order to achieve **climate neutrality** by 2045. ↘ ITEMS 343 FF.

II. TENSE SITUATION ON THE ENERGY MARKETS

1. Situation before the war

274. Even before the Russian war of aggression against Ukraine began, the **development of European energy systems** ↘ BACKGROUND INFO 13 was dominated by the **transformation towards climate neutrality.** Reducing carbon emissions requires a profound change in energy supply and consumption (Ariadne, 2022; BCG, 2021; dena, 2021). It can be assumed that this will involve adjustments to the energy mix, shifts in the countries supplying energy, as well as energy savings and improvements in efficiency. The industry is particularly relevant for the **transformation towards climate neutrality** (BCG, 2021; dena, 2021). On the one hand, it is an **important consumer of energy**, accounting for around 29 % of total final energy consumption in Germany. ↘ BACKGROUND INFO 13 ↘ CHART 66 On the other hand, it is an important energy producer, as it generates many secondary energy carriers such as electricity or coke for its own consumption.

↘ CHART 66
Energy flow chart for Germany in 2021[1]
in petajoules (PJ)[2]



1 – Deviation in total due to rounding. 2 – Peta = one quadrillion. 3 – The share of renewable energy sources in primary energy consumption is 15.7 %. Primary energy consumption includes both primary and secondary energy.

Source: AG Energiebilanzen
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+

↘ BACKGROUND INFO 13

Relevant terminology

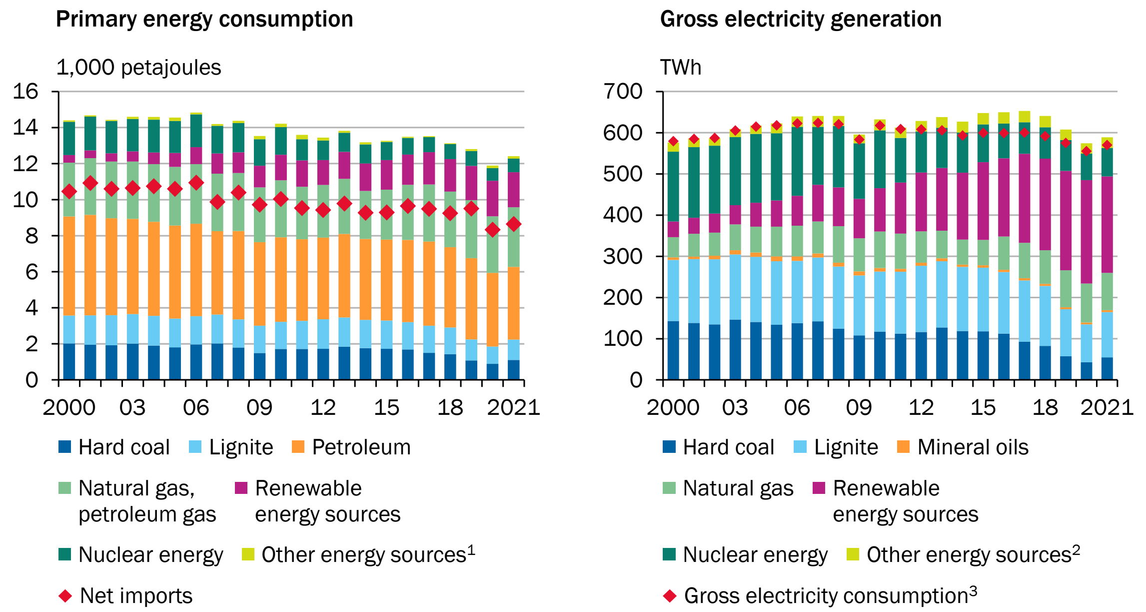
Primary energy consumption means the energy content of all domestically consumed **primary energy carriers**, such as crude oil, natural gas, coal and renewable energies, as well as net imports of electricity and district heating. The consumption of primary energy carriers can be **divided into non-energy and energy consumption.** In non-energy consumption, energy carriers are used as raw materials in the manufacture of products such as plastics or chemicals. In the case of energy consumption, the energy carriers are used to generate heat or mechanical energy (e.g. for machines or in transport). Primary energy carriers can be used directly or converted beforehand into **secondary energy carriers** such as electricity, district heating or fuels (e.g. petrol or diesel). Conversion losses occur during the conversion process. **Final energy consumption** indicates the energy content of primary and secondary energy carriers in final consumption by industry, households, transport and the commerce, trade and services sector. Gross final energy consumption also includes all conversion and transmission losses (European Parliament and Council of the European Union, 2009). The levels of final consumption in industry, households and transport are about the same and approximately equal to the conversion losses in secondary energy production. ↘ CHART 66

Crude oil refers to the as-yet untreated energy carrier **petroleum.** Crude oil is further processed in a refinery into various **petroleum products**, such as petrol, diesel or heating oil.

The standard unit for **measuring energy consumption** is the **joule** (J). Other common units of measurement are watt-hour (Wh), tonnes of oil equivalent (TOE), and British thermal unit (Btu).

↘ CHART 67

Energy consumption by energy source in Germany



1 – Non-renewable wastes, other energy sources, trade balance of district heat, other gases and net import of electricity.
2 – Pumped storage, non-renewable waste. 3 – Including pumped electricity generation; excluding generation from natural inflow.

Sources: AG Energiebilanzen, own calculations
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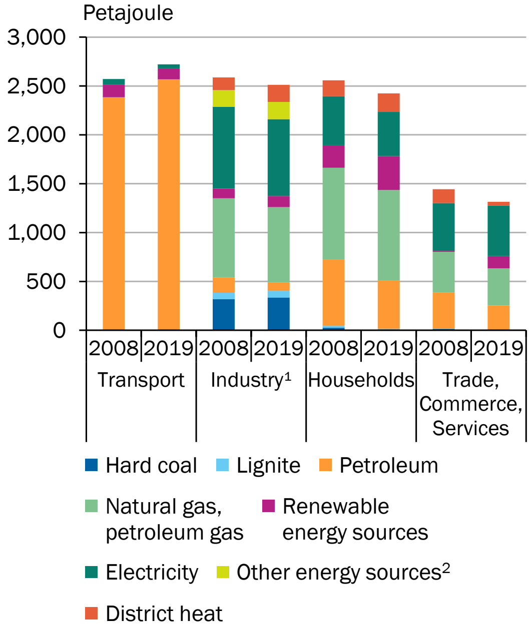
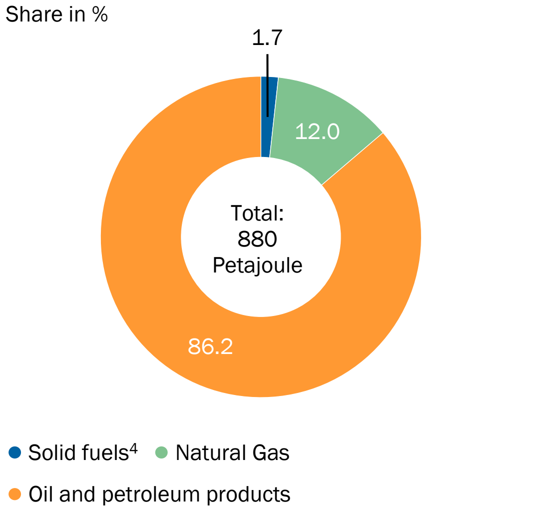
Energy mix in Germany and the EU

275. Until now, about 70 % of **primary energy consumption** in Germany and the EU has been covered by fossil fuels: **mineral oils, natural gas and coal**. ↘ CHART 67 LEFT In energy consumption, mineral oil is used especially in the form of fuels in the transport sector or in the form of heating oil for heat generation. Natural gas is mainly consumed directly in final consumption for heat generation (AGEB, 2021a). ↘ CHART 68 RIGHT On average, non-energy consumption in Germany accounted for about 7.4 % of total primary energy consumption from 2016 to 2020 (AGEB, 2021b) and about 13 % of final energy consumption in the manufacturing sector. It comprises in particular the **use of mineral oil and natural gas** in the **manufacture of chemical products** and accounts for over a third of energy consumption in this economic sector. ↘ CHART 68 RIGHT Overall, natural gas and electricity are most relevant for industrial final energy consumption (each accounting for about a third of energy consumption). ↘ CHART 68 LEFT

276. In line with the transformation pathway towards climate neutrality planned up to now, a **growing share of primary energy consumption** in Germany and the EU will come **from renewable energies**. ↘ CHART 67 RIGHT By 2030, the share of renewable energies used in gross electricity generation is to rise to 80 % (Bundesregierung, 2022a) and the share of renewables in **gross final energy consumption** from just under 20 % in 2021 to 30 % (AGEE-Stat, 2022; Bundesregierung, 2020). By then, a cumulative capacity of 360 gigawatts (GW) of onshore

↘ CHART 68
Energy consumption in Germany by sector and energy source





1 – Mining, quarrying and manufacturing. 2 – Non-renewable waste, waste heat, other gases. 3 – According to the Standard International Energy product Classification (SIEC). Differences in totals due to rounding. 4 – Solid fossil fuels; includes lignite and hard coal.

Sources: AG Energiebilanzen, Eurostat, own calculations
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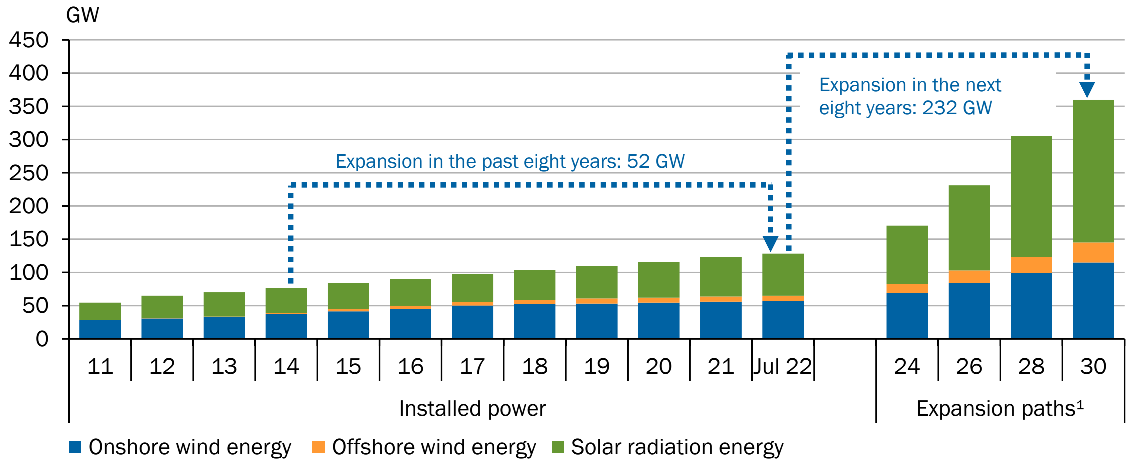
↘ CHART 69
Installed gross capacity of wind and solar radiation energy as well as expansion paths up to 2030 in Germany



1 – As the WindSeeG does not specify an expansion path for offshore wind energy in the years before 2030, the expansion path assumed here is based on a linear progression to the target value of 30 GW in 2030.

Sources: Bundesnetzagentur, Federal Government, own calcualtions
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and offshore wind energy and solar radiation energy needs to be installed (Bundesregierung, 2022b, 2022a). ↘ CHART 69 Based on the capacity already installed (around 128 GW), an additional 232 GW will need to be licensed and constructed by 2030. This corresponds to more than a quadrupling of the amount constructed in the past eight years. Improvements in planning and licensing procedures are likely to be key here. ↘ ITEM 338

In addition, 14 terawatt hours (TWh) of **hydrogen** are to be produced by electrolysis in Germany by 2030, which represents about 14 % of the envisaged demand of 90 to 110 TWh (BMWi, 2020). The remaining quantity is to be procured through imports (BMWi, 2020).

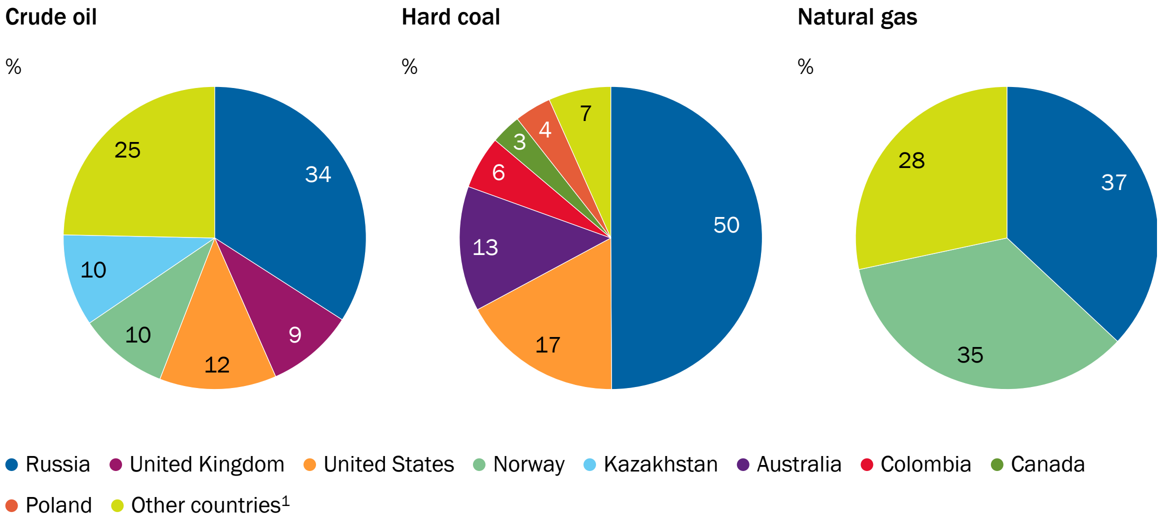
Sources of energy

277. Germany depends on energy imports to **cover its domestic energy consumption**. In 2020, **net energy imports accounted for 70 % of primary energy consumption**, which means that Germany is more dependent on imports than the EU as a whole (at 58 %). ↘ CHART 67 LEFT Energy is imported in particular in the form of material energy carriers. The most important imported energy carriers are crude oil, natural gas, coal and uranium.

278. The structure of **energy carrier imports** is relevant for **industrial end-user prices**. Especially in economic regions such as the EU, where domestic production is relatively limited, import prices have a considerable influence on wholesale energy prices, which, in turn, determine industrial end-user prices. For energy sources such as natural gas and coal, whose global markets are segmented, ↘ ITEM 300, a change in supply sources can therefore influence energy costs for industry.

↘ CHART 70

Germany's energy import dependence by supplier country before Russia's war of aggression
Imports in 2021



1 – The composition varies in the individual categories.

Sources: BAFA, BVEG, Federal Ministry for Economic Affairs and Climate Action, Federal Ministry for Economic Affairs and Climate Action (2022b), Norskpetroleum, Reuters, Verein der Kohleimporteure, own calculations

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279. About **a third of** Germany's **crude oil imports** in 2021 came **from Russia.** ↘ CHART 70 LEFT The conversion of crude oil into petroleum products largely takes place in Germany; only 11.5 % of sales of petroleum products were net imports in 2021 (BAFA, 2022a). In the EU as a whole, Russian imports made up 22.4 % of total imports of crude oil and petroleum products in 2021 (Eurostat, 2022a). While Germany is a net exporter of lignite, German **hard-coal mining ceased** in **2018**, so that domestic coal consumption has since had to be covered entirely by imports, 50 % of which came from **Russia** in 2021. ↘ CHART 70 CENTRE In 2020, the EU sourced 56 % of its coal imports from Russia (Eurostat, 2022b). In 2020, Germany's **demand for uranium** was met mainly from **stockpiles** and through long-term **supply contracts with Canada and the Netherlands** (BGR, 2022, p. 24). Other relevant uranium exporters to the EU are Nigeria (20 %), Russia (20 %), Kazakhstan (19 %) and Australia (13 %). Together with Canada, these countries covered more than 90 % of the EU's demand for uranium in 2020 (ESA, 2022, p. 19).

280. In 2021, Germany purchased 37 % of its **natural gas imports** from Russia, the EU 35.6 % (Eurostat, 2022a). ↘ CHART 70 RIGHT The remaining **imports** mainly come from **Norway**. The import infrastructure limits possibilities to switch from Russian supplies to other sources of supply at short notice. ↘ BOX 14 To date, Germany does not have **its own terminals** for the delivery and regasification of **liquefied natural gas** (LNG), and pipeline capacity with other suppliers is limited. ↘ BOX 14 Domestic production comprises 5 % of consumption.

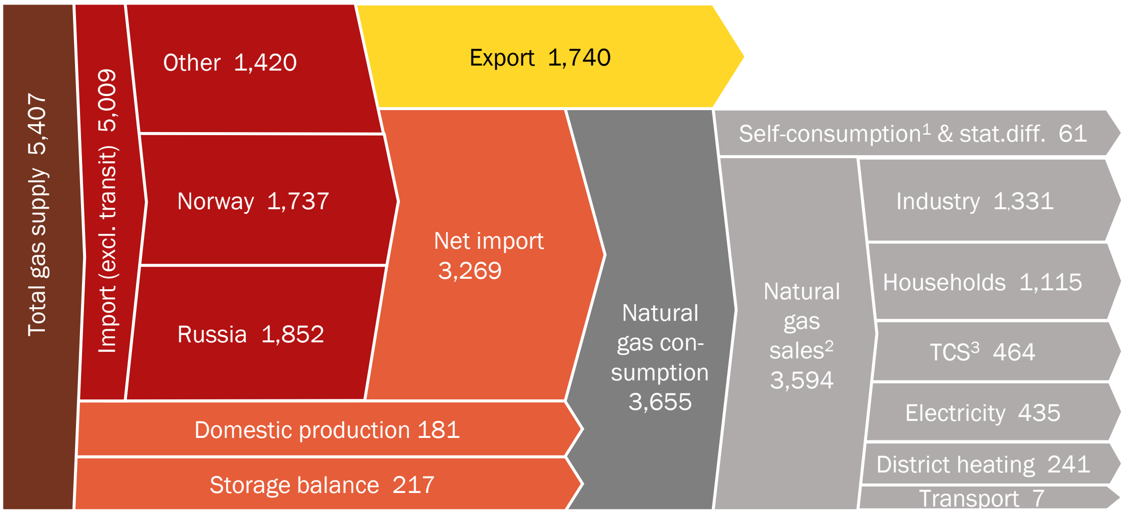
↘ BACKGROUND INFO 14

The relevance of Russian natural gas for supply security in Germany

In the discussion on the relevance of natural gas imports from Russia for German supplies, the volume imported from Russia is related to different key figures, which creates an inconsistent picture of dependence on natural gas from Russia. Relative to the **imported volume**, Russian natural gas imports accounted for 37 % in 2021. Relative to **total supply**, which includes imports, domestic production and withdrawal from storage, the Russian share was 34 %. ↘ CHART 71 Relative to Germany's **consumption**, Russian imports made up 51 %, but this includes quantities that are re-exported. Germany re-exports about a third of the imported gas volume to other EU member states, in particular to the Czech Republic (Bundesnetzagentur, 2022a). There is no publicly available data on whether Russian natural gas is predominantly consumed domestically or further exported.

↘ CHART 71

Natural gas flow chart in Germany in 2021
in petajoules



1 – Own consumption of the gas industry. 2 – Small differences between sources. 3 – Trade, commerce and services.

Sources: BAFA, BDEW, Federal Ministry for Economic Affairs and Climate Action, Norskpetroleum, Reuters, own calculations

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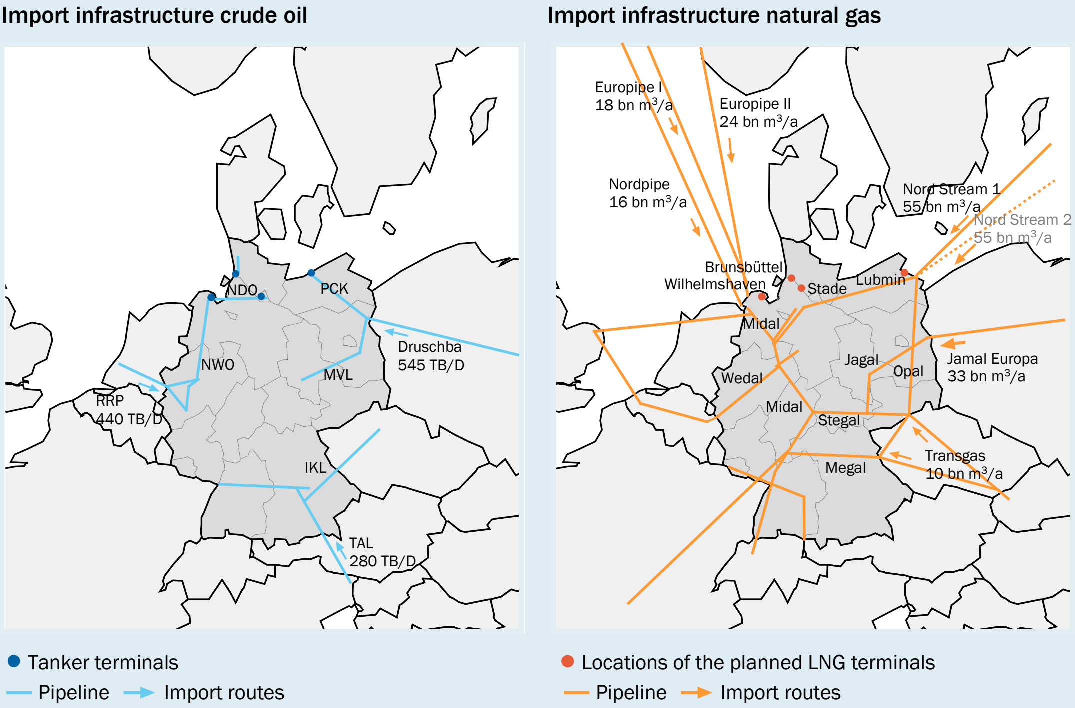
↘ BOX 14

Import infrastructure for energy carriers

On the one hand, **crude oil** is imported to Germany by **sea.** Connecting pipelines run from the seaports to the mineral oil processing industry. On the other hand, three **cross-border crude oil pipelines** are used for imports. ↘ CHART 72 LEFT Russian crude oil was imported via the Druzhba pipeline and routed to refineries in Schwedt and Leuna. Crude oil from North and West African states, the Middle East and the Caucasus is delivered to Trieste by sea and partly imported to

↘ CHART 72

Main infrastructure for imports of crude oil and natural gas[1]



1 – The chart shows approximate pipeline routes and connections and does not claim to be geographically correct. Capacities: TB/D - thousand barrels per day; bn m^3 /a - billion cubic metres per year.

Sources: EuroGeographics for the administrative boundaries, ENTSOG, IEA
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southern Germany via the Transalpine Oil Pipeline (TAL). Another pipeline connection is via the Rotterdam-Rhine Pipeline (RRP) between Rotterdam Europoort and German refineries in the Rhine-Ruhr area (IEA, 2020).

Much of Germany's hard **coal is imported by sea**. Another relevant import route is by **rail** from Russia, Poland and Ukraine (Bardt et al., 2014). In 2014, 46.3 % of hard coal imports was imported via inland river barges from Amsterdam, Rotterdam and Antwerp, 28.3 % by rail and 25.4 % via German seaports (VdKi, 2015).

Up to now, **natural gas** has been imported from Russia to Germany via three pipeline systems: the Nord Stream 1 pipeline, which has a direct connection with Russia and has the largest capacity, the Yamal-Europe pipeline from the Yamal Peninsula in Siberia to Germany, and the Transgas route (IEA, 2020). ↘ CHART 72 RIGHT Another three pipelines link Germany with Norway. In addition, **pipeline gas** can be traded via the pipeline network on the European mainland (ENTSOG, 2021). LNG cannot yet be imported directly into Germany but only via the pipeline connections with the LNG terminals in the Netherlands, Belgium and France (IEA, 2020).

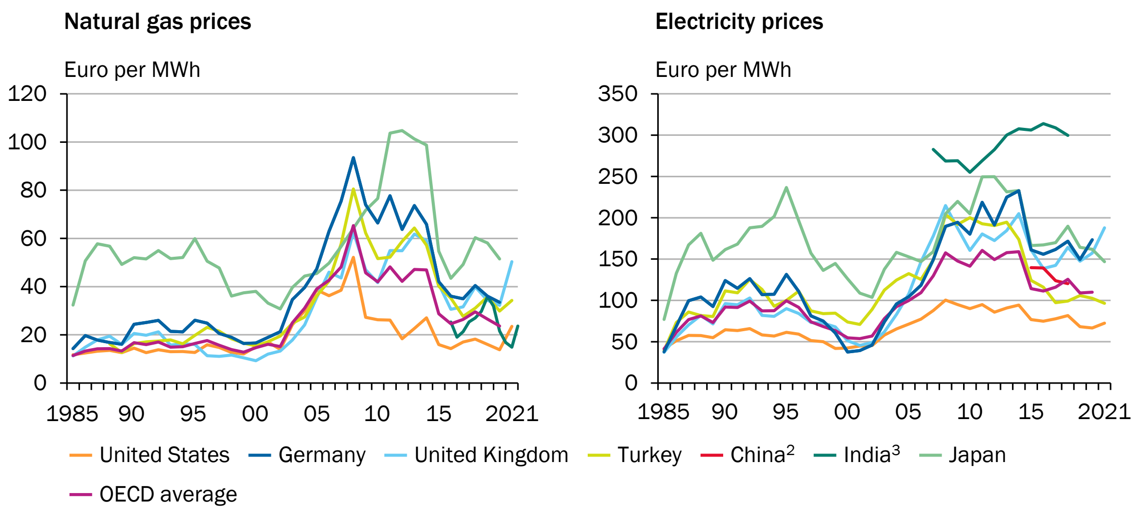
In response to the war of aggression on Ukraine, the **expansion of floating and land-based LNG terminals in Germany** has been accelerated. ↘ CHART 285 In order to replace Russian gas as quickly as possible, five floating LNG terminals are initially to be chartered by the government. As early as the turn of the year 2022/23, two terminals in Wilhelmshaven and Brunsbüttel and one private terminal in Lubmin are to be commissioned (BMWK, 2022a). The Federal Network Agency expects the planned LNG terminals to be able to replace more than 25 % of the 511 TWh imported from Russia in 2021 as of January 2023 (BMWK, 2022b; Bundesnetzagentur, 2022a). Three more terminals in Stade, Lubmin and Wilhelmshaven are to follow by the end of 2023. By 2026, the Brunsbüttel site is planned to be expanded into a land-based terminal and its capacity increased to 80 TWh (RWE, 2022). In addition, the Stade LNG terminal is expected to have a capacity of 130 TWh by 2026 (HEH, 2022). In total, Germany will have an LNG import capacity of around 500 TWh when all the planned floating and land-based terminals have been commissioned.

In order to connect Spain and Portugal to the European pipeline network, talks on the Midcat pipeline are ongoing – a pipeline which is to connect Spain and France (European Parliament, 2022). Algeria, Niger and Nigeria have also concluded an agreement to build a pipeline from Nigeria to Algeria and then to connect it with the existing Mediterranean pipeline to Italy (AHK Algeria, 2022). **Another planned pipeline** is to run from Nigeria along the Atlantic coast to Morocco and then on to Spain (ECOWAS, 2022). The pipelines from Nigeria are expected to take 10 years to complete.

Price developments before the start of the war

281. In an international comparison, **wholesale energy prices in the EU** were shown to have been **low for a long time** (Rademaekers et al., 2020), while **German and European final energy prices** were **relatively high** (European Commission, 2019; Rademaekers et al., 2020). This was mainly due to high non-refundable taxes and levies (Bundesnetzagentur and Bundeskartellamt, 2022). However, extensive exemptions applied to industry, especially large and energy-intensive firms, so that their energy prices were comparable to those in other world regions. ↘ CHART 73 Firms whose electricity consumption was less than 20 megawatt hours (MWh) did not benefit from these exemptions and have paid between 70 % and 150 % more per unit of electricity over the past two years than customers with an annual consumption of 150,000 MWh or more.

↘ CHART 73
Effective natural gas and electricity prices for industrial consumers until 2021[1]



1 – The figures represent average values, which are heterogeneous. 2 – No natural gas prices available. 3 – Natural gas prices correspond to the price cap; semi annual values.

Sources: Government of India, IEA, Ministry of Petroleum and Natural Gas, Refinitiv Datastream, own calculations
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2. Adjustment reactions as a result of the war

282. The **reduction of energy imports from Russia requires adjustments to the energy supply**. Alternative suppliers of fossil fuels will be needed as replacements as soon as possible. ↘ ITEM 285 In addition, energy savings by end users will be required in the short term. ↘ ITEM 293 Industry has already saved natural gas on a large scale, e.g. by fuel switches from gas to oil or by not switching from coal to gas (Menzel, 2022). A change in the energy mix and in energy consumption in Germany can already be observed. ↘ ITEM 293

283. In the case of **natural gas, Russia** stopped selling on the spot market as early as October 2021. Since the war began, Russia has increasingly restricted pipeline and liquefied gas deliveries to the EU. Until August, direct deliveries from Russia accounted for 30 % of the volume imported to Germany; since September 2022, no more gas has flowed directly from Russia to Germany (Bundesnetzagentur, 2022b). Whether and at what cost the damaged Nord Stream 1 and 2 pipelines can be repaired cannot be reliably estimated due to the officially imposed exclusion zone and the fact that the assessment of the damage has not yet been completed. (Nord Stream, 2022; Reuters, 2022).

284. In addition, other energy imports from Russia have declined due to **EU sanctions against Russia.** Among other things, these have targeted **imports of coal** since August 2022 (Council of the European Union, 2022a) **and crude oil** by sea from December 2022 (Council of the European Union, 2022a). With Poland and Germany also refusing oil imports via the Druzhba crude oil pipeline, ↘ BOX 14 about 93 % of Russian oil imports to the EU are likely to cease by the end of 2022 (CREA, 2022). Furthermore, British and US sanctions, as well as corporate initiatives, led many private actors, including some energy supply firms, to already partially renounce Russian energy imports at the beginning of the year.

285. As a substitute for Russian gas imports, pipeline imports from the Netherlands and Norway were initially increased and LNG imports via the Netherlands secured (BMWK, 2022a). In order to speed up the diversification of gas imports, the **LNG Acceleration Act** came into force on 1 June 2022. This law aims to accelerate the approval and authorisation process, and expedite awards of public contracts for the construction of floating and land-based LNG terminals in Germany (BMWK, 2022c). ↘ BOX 14 The procurement of sufficient LNG is to be achieved through new collaborations with partners such as Israel and Egypt (European Commission, 2022a).

286. In order to guarantee the **energy supply**, the operation of three nuclear power plants is to be extended until 15 April 2023. In addition, a temporary return of coal-fired power plants from the reserve to the electricity market by mid-2023 for lignite and by early 2024 for coal has been agreed (BMWK and BMUV, 2022a). Furthermore, it has been agreed that two lignite-fired power plant units would continue operating after the end of 2022 until spring 2024 (BMWK et al., 2022).

Longer-term adjustments to the energy supply

287. In May 2022, the European Commission presented the **REPowerEU plan**. In response to the Russian war of aggression, this plan aims to **end the EU's dependence on energy imports from Russia** and support the transformation towards climate neutrality. The plan includes four areas of action: energy saving, diversification of supply sources, accelerated expansion of renewable energy sources and investment in the energy infrastructure (European Commission, 2022b). Infrastructure investments such as the expansion of the LNG and hydrogen infrastructure are indispensable in this context. ↘ BOX 26 In addition, approval has been sought for the construction and operation of a platform for natural gas production in the North Sea between Germany and the Netherlands (LBEG, 2022; ONE-Dyas, 2022). With respect to investments in fossil fuel infrastructure, undesirable side effects – such as the delayed expansion of renewable energies, carbon lock-in effects and the devaluation of assets (stranded assets) ↘ GLOSSARY – should be taken into account (Löffler et al., 2019; Brauers et al., 2021). Care should therefore already be taken in the planning phase to ensure that, for example, new LNG terminals and the pipeline network required for them can be converted in time for the future increase in hydrogen imports.

288. **New procurement contracts** must be concluded to diversify sources of supply. ↘ BOX 14 ↘ ITEM 301 While Germany is seeking a short contract period in view of its decarbonisation goals, suppliers such as Qatar are demanding contracts for 20 years and more (Rashad, 2022). These different interests make it difficult to coordinate the **contract periods**. The design of supply contracts is of key importance and various clauses, including destination clauses and opting-out clauses, will play a role (Shi and Variam, 2016). ↘ ITEM 301 **Optimal supplier concentration** must also be given careful consideration. While it is true that supplier diversification improves supply security and allows future shocks to be better cushioned, a high degree of diversification of energy sources involves additional costs, such as higher transport costs and lower economies of scale. ↘ ITEM 303 **Joint European procurement** could leverage economies of scale and thus reduce costs. However, this raises additional coordination challenges and design issues (Boltz et al., 2022).

In the long term, new supply sources can be opened up, reducing dependencies on individual sources. The challenge will be to find a **portfolio of exporting countries** that offers **optimal insurance value** given the costs of diversification (Zhang et al., 2013; van Moerkerk and Crijns-Graus, 2016). Here, joint procurement of energy sources by the EU can offer additional advantages, since the increased bargaining power it generates can help reduce costs. ↘ BACKGROUND INFO 15

↘ BACKGROUND INFO 15

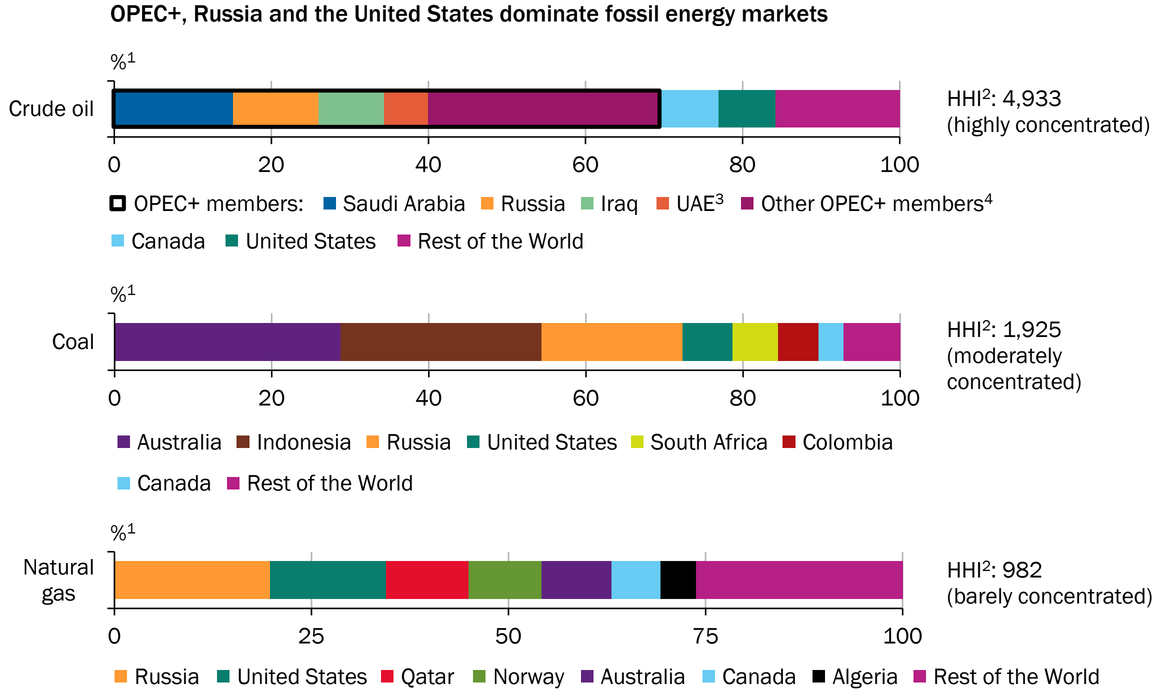
Concentration on the market for energy carriers

The production of fossil fuels is dominated by a group of resource-rich countries (GCEE Annual Report 2021 chart 134). This is reflected in the distribution of global fossil fuel exports: Russia, with approximately 26 exajoules, supplies almost 15 % of global trade, while the USA and Australia, with about 15 exajoules each, supply almost 9 % of global exports (BP, 2022). The concentration of supply on the world markets varies between the individual energy sources. ↘ CHART 74 Measured by the **Herfindahl-Hirschman Index (HHI**, with a minimum of zero for a large number of suppliers of the same size and a maximum of 10,000 points if there is only one supplier), the world market for natural gas is not very concentrated (HHI 982 points), the market for coal is moderately concentrated (HHI 1,925 points), and the world market for crude oil, counting the **OPEC+ countries** as a joint cartel, is highly concentrated (HHI 4,933 points).

289. Compared to the markets for energy carriers, it is even more difficult for individual states to avoid being **dependent** on **raw materials** that are needed for developing new technologies for energy production. China, for example, controls about 60 % of the global production of rare earths and is even in a quasi-monopolistic position in the processing of individual minerals (Brüggemann and Levinger, 2022). ↘ ITEMS 486 FF. This dominance continues along the value chain, for example for **components of photovoltaic systems and wind turbines**, especially since China, as the world's largest consumer, can also influence the market on the demand side (Brüggemann and Levinger, 2022).

This could make it more difficult in the coming years to achieve the expansion targets for renewable energies and thus also to ensure a secure energy supply.

↘ CHART 74
Exporters of coal, natural gas and crude oil on the world markets in 2021



1 – World market share in % of exports by energy content. 2 – Herfindahl-Hirschman Index: Calculated from the sum of squared shares (in % * 10,000); can reach a maximum value of 10,000 points. For the calculation of the HHI of the market for crude oil, the OPEC countries were treated as one supplier. 3 – United Arab Emirates. 4 – Algeria, Angola, Equatorial Guinea, Bahrain, Brunei, Gabon, Iran, Congo, Kuwait, Libya, Malaysia, Mexico, Nigeria, Oman, Sudan, South Sudan, Venezuela.

Sources: BP (2022), OPEC (2022), own calculations
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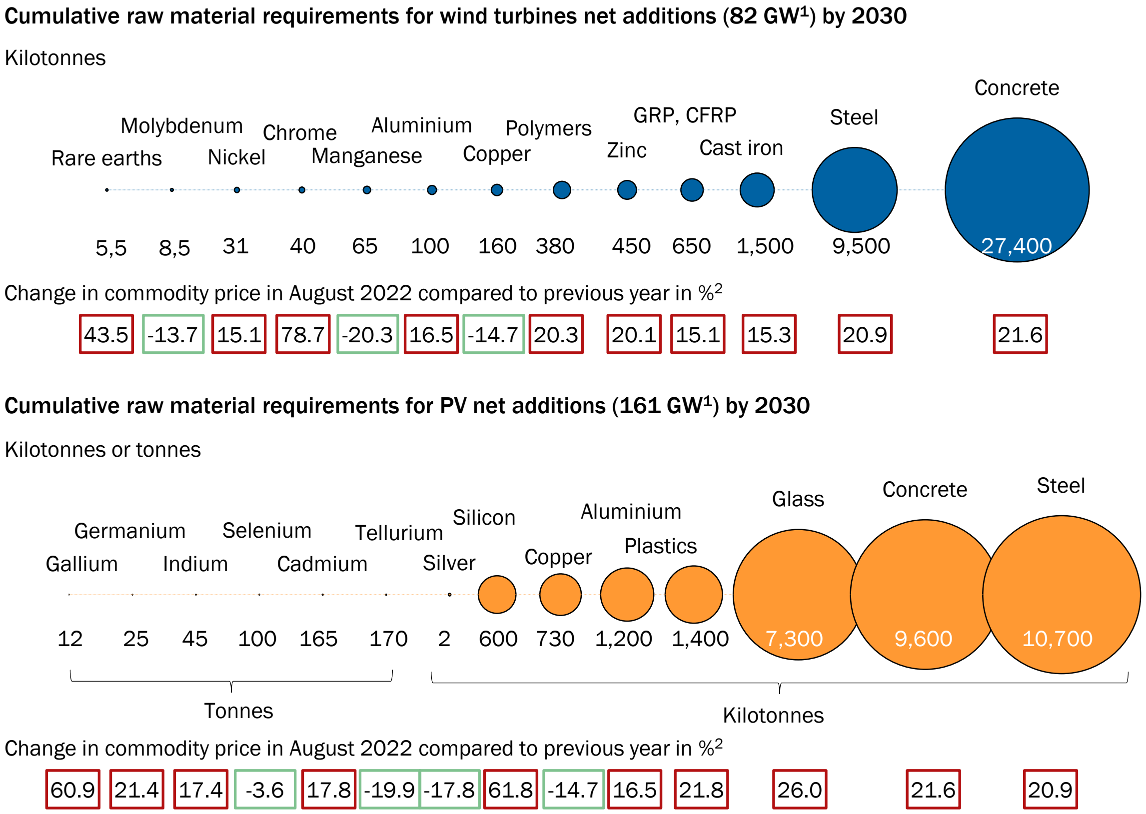
↘ CHART 75
Higher raw material prices increase the costs of expanding renewable energy



1 – Planned net additions between the years 2021 and 2030 according to EEG 2023. 2 – The numbers represent global commodity price developments with the exception of concrete, glass, cast iron, plastics, polymers and steel for which producer prices in Germany are shown.

Sources: BLS, DERA, Federal Statistical Office, Refinitiv Datastream, Trading Economics, own calculations
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Furthermore, price fluctuations, **geopolitical interference** and supply disruptions for rare minerals such as copper, lithium, nickel, cobalt and rare earths could **significantly slow down and increase the cost of the shift towards renewable energies** (IEA, 2021a). ↘ CHART 75 ↘ ITEM 486 On the other hand, the amendment to the Renewable Energy Sources Act passed in July 2022 has reduced many regulatory barriers to the expansion of renewable energy, e.g. in the field of nature conservation (Bundesregierung, 2022c). ↘ ITEM 338

290. Additional challenges in the transformation of energy systems arise from the growing number of decentralised generation plants and storage facilities as well as greater flexibility in consumption, which require the **optimisation, strengthening and further expansion of existing electricity grids** (acatech et al., 2020). The increasing networking between actors, for example via the Internet of Things and the application of artificial intelligence, makes a rapid **digitalisation of the energy system** indispensable (Mayer and Brunekreeft, 2021). As actors become more decentralised, the resilience of the overall system could decrease if they are insufficiently protected and therefore exposed to a higher potential risk from **cyber attacks.** However, once decentralised assets have been upgraded for semi-autonomous operation and appropriate security

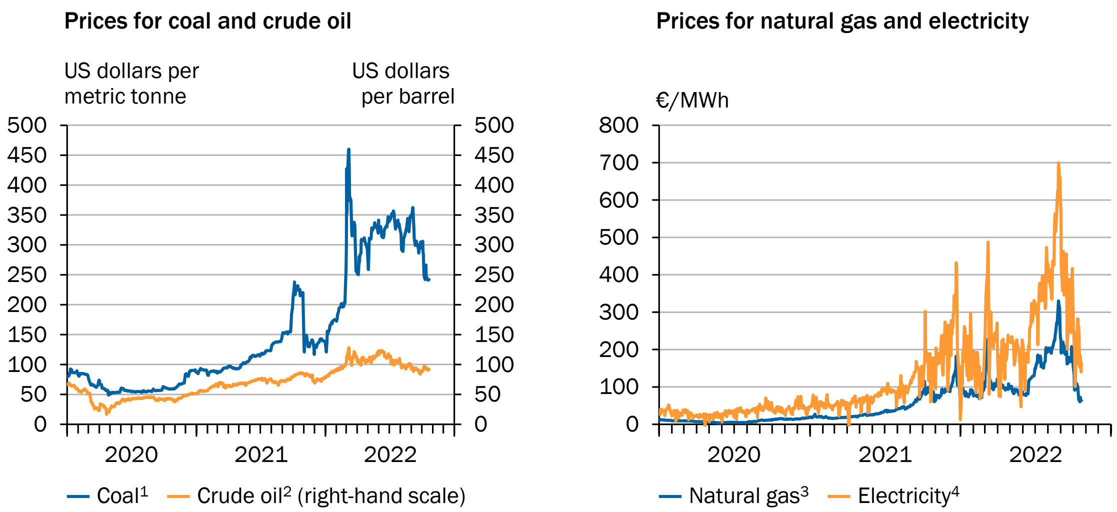
measures have been introduced, the resilience of the overall system could also be increased by decentralisation (Mayer and Brunekreeft, 2021).

Price developments since the start of the war

291. **Wholesale energy prices have risen in recent months**. After energy prices fell during the coronavirus pandemic in 2020 as a result of low demand, prices for natural gas, electricity and coal in particular have risen sharply in the course of 2022. ↘ CHART 76 ↘ BOX 15 This development is reflected in a 136.9 % increase in the cost of energy imports between January and July 2022 compared to the same period in 2021 (BAFA, 2022b, 2022c). Natural gas prices have fallen in recent weeks due to high storage levels and mild weather, while futures prices for winter delivery remain high.

↘ CHART 76

Development of wholesale prices for energy



1 – Price for thermal coal from South Africa (API4) delivered to the ports of Amsterdam, Antwerp and Rotterdam. 2 – Price for Brent crude oil. 3 – Day-ahead price for natural gas in the Title Transfer Facility (TTF). 4 – Daily price index for baseload on the electricity spot market for the market area Germany/Austria (Phelix base).

Sources: EEX, EIA, ICE, Refinitiv Datastream
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↘ BOX 15

How do electricity markets work?

Approximately 502.6 TWh of electricity were fed into the German grid in 2020 (Bundesnetzagentur and Bundeskartellamt, 2022). Before being fed into the grid, each unit of electricity is traded on electricity markets several times on average.

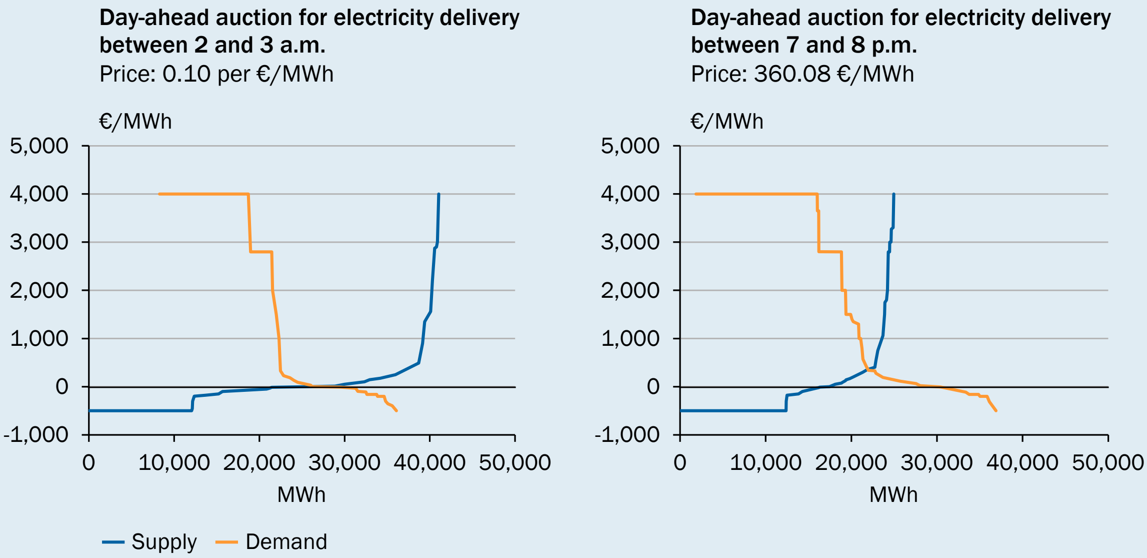
An important component of the electricity market is **exchange-based day-ahead trading**, in which energy products are traded for every hour of the following day with the help of centralised auctions. In 2020, the day-ahead trading volume for Germany was around 231.2 TWh. The principle used in the auction for determining prices is often referred to as the **merit order principle.** The volumes offered by power plants and other energy sources are ranked according to their bids, which in turn are largely determined by their marginal costs. The last bid taken up sets the uniform price for all traded energy units. Accordingly, the market clearing price for the individual hours results from the intersection of the amount demanded and the amount supplied. If the purchase prices of the primary energy sources change, parts of the supply curve shift and, with them, the market clearing price.

It is also possible to buy electricity on a power exchange on the day when deliveries start. In **intraday trading**, electricity is traded for quarter-hour to hourly blocks. In this process, a transaction is made as soon as a bid and an offer match (pay-as-you-bid price determination). In 2020, 68.52 TWh of electricity was traded in this way (Bundesnetzagentur and Bundeskartellamt, 2022).

↘ CHART 77

Merit order pricing on the German electricity market

Auction prices on 5 October 2022 for the next delivery day



Sources: EPEX SPOT, own presentation
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Participation in day-ahead and intraday trading entails a major price risk. As generation capacity and consumption vary seasonally and over the course of the day, electricity procurement costs are subject to sharp fluctuations. ↘ CHART 77 However, market players can use **numerous financial instruments** to **hedge against electricity price fluctuations**, even for several years in advance. The most popular electricity derivatives are futures (1,416 TWh traded in 2020 in Germany) – binding forward contracts that financially represent the trading of a certain amount of electricity at a fixed price and time. In addition to such general financial instruments, highly specialised products can be used, such as wind power futures, which can reduce both the price and volume risk that arises from the volatile generation of wind energy. Alternatively, parties can enter into direct sales agreements outside power exchanges (**over-the-counter, OTC**). These transactions are not publicly visible, but their volume significantly exceeds exchange trading. In 2020, for example, a total of around 5,702 TWh was procured by eleven brokers included in a data survey, 45 % of which were for 2021 contracts (Bundesnetzagentur and Bundeskartellamt, 2022).

The German electricity market is part of an overarching European system. For example, a market-coupling auction takes place on the day-ahead market, where a central auction algorithm calculates energy flows between different European zones in order to minimise the overall European cost of electricity procurement. As a result, German electricity exports to France, for example, jumped when French nuclear power generation ran low (ENTSO-E Transparency Platform). Since transport capacity has hitherto been a limiting factor for **cross-border electricity trade**, cross-border electricity flows can be expected to increase significantly in the future, given the target of doubling the capacity of international electricity power lines in Europe by 2030 (Dehaudt and Grouthier, 2022).

The sharp price increases in exchange-based electricity trading have triggered a discussion on market design and, in particular, the merit order as a price-determining principle (Moussu, 2022a; Liboreiro, 2022; von der Leyen, 2022; Le Maire, 2022). A **number of reform proposals for exchange-based trading** have been made, and some of the proposals have already been adopted (European Commission, 2022c, 2022d; Liebreich, 2022; Council of the European Union, 2022b). While the proposals differ slightly, they generally envisage a (partial) decoupling of the prices received by individual suppliers from the bids of other suppliers. For example, the EU will cap prices at €180 per MWh for some power plants, including those operated with renewables, coal and nuclear power, but not for others. If the prices received exceed the cap, the price difference will be skimmed off and credited to end customers (European Council, 2022). In Spain and Portugal, exchange prices are capped. However, fossil power producers receive subsidies to cover their energy carrier costs and thus remain profitable despite the electricity price cap.

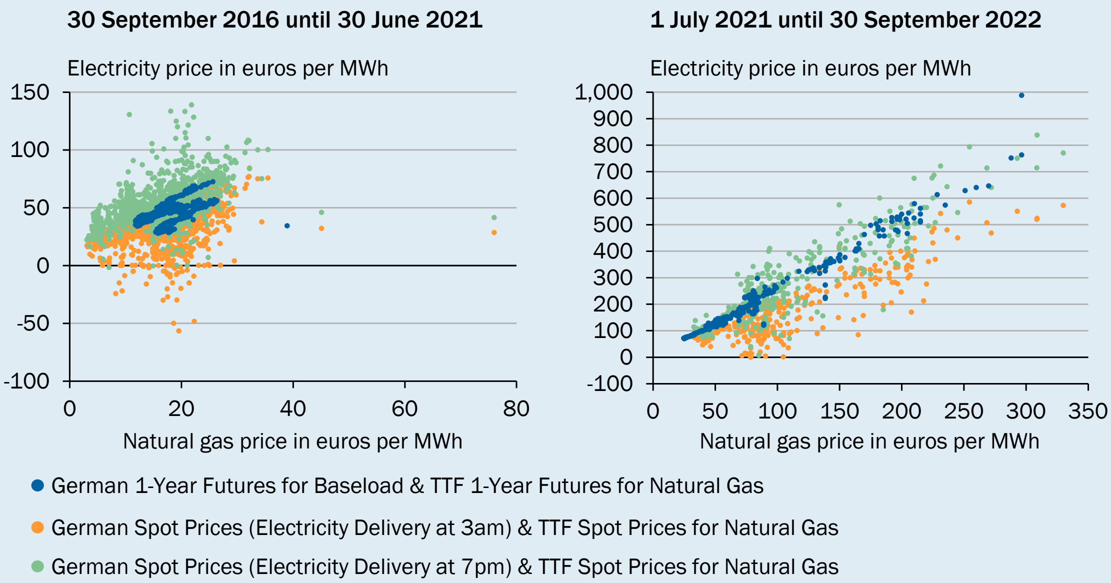
At the same time, there has been a proposal to introduce an additional tax on power plants with high profits (**excess profits tax**). Such a tax has already been implemented in Italy, Romania and Greece, while Germany is currently working on an implementation concept.

The discussion on the impact of potential interventions in the functioning of the electricity markets is controversial. Some studies point to the efficiency of the current European electricity market design and the merit order principle (Ockenfels et al., 2008; Tierney et al., 2008; ACER, 2022; Monopolkommission, 2022). The discussion is currently focusing in particular on whether the application of the merit order principle is the cause of the electricity price developments. However, similar prices are achieved in intraday trading, which uses the often proposed pay-as-you-bid principle, as in day-ahead trading. According to initial analyses, the current price increases can be largely explained by leaps in natural gas prices, combined with reduction in the electricity supply caused by weather factors such as the low water levels in many European rivers in the summer of 2022, as well as problems with the electricity supply in France (ACER, 2022).

Even if the **proposed interventions in the market** lowered prices in the short term, in the long term they would **suppress the signals efficient generation** and investment needs in capacity building. Moreover, – in the short term high prices signal the need to save electricity. Unilateral measures could also lead to an increase in electricity exports, which, in turn, increases the cost of the measures and exacerbates shortages. For example, the Iberian Peninsula saw approximately 60 % increases in electricity generation from gas-fired power plants after the introduction of the reforms, due to both increased domestic consumption and higher exports to France (Hirth, 2022). Furthermore, the market reforms target the day-ahead market. While this serves as an important reference point, it is relatively small compared to other electricity market segments. It is not yet possible to foresee how the proposals will interact with the OTC and futures markets, in particular how they might affect existing contracts.

In Germany, the **impact of gas price shocks on electricity prices** is particularly strong (Uribe et al., 2022). This is illustrated by the very high correlation between natural gas prices and electricity prices, especially for the times of day when electricity consumption is highest. ↘ CHART 78 This correlation was weaker before 2021. ↘ CHART 78 This may indicate that natural gas set prices less frequently at that time, e.g. because of the higher capacities of nuclear power plants, or because the relative costs of some gas-fired power plants were lower than those of other power plants, such as those powered by biomass, oil or coal.

↘ CHART 78
Correlations between electricity and natural gas prices in Germany



Source: Refinitiv Eikon
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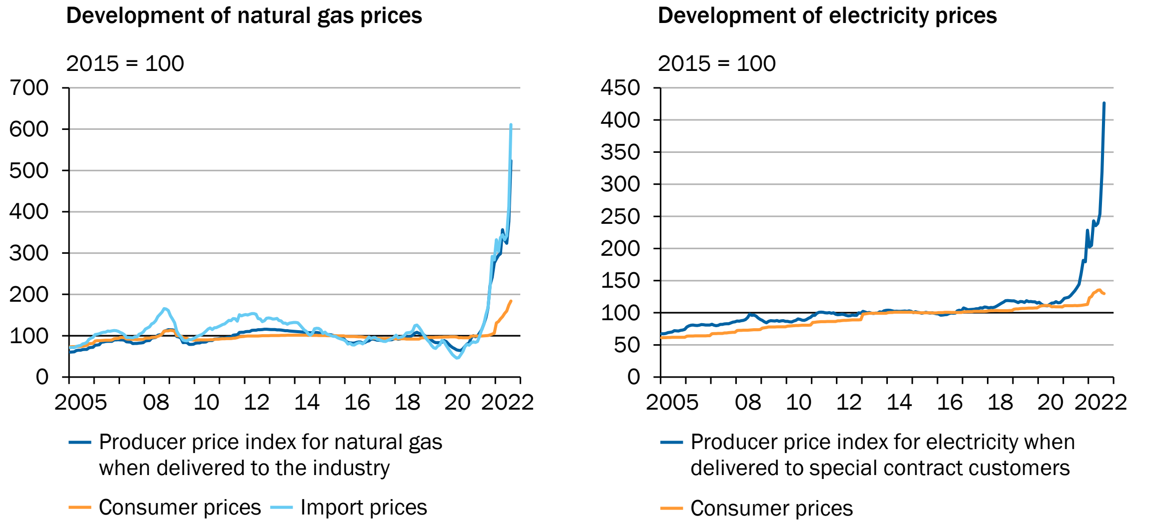
292. Up to now, the higher prices on the wholesale markets have only been **partially passed on to end users**. To date, industrial consumers in particular have been affected by the large increases in the price of natural gas. ↘ CHART 79 LEFT Some households, on the other hand, are still benefiting from long-term contracts. In addition, the share of procurement costs in end-consumer prices is lower for private households, so that changes in procurement costs have a smaller impact. A similar picture emerges in the development of electricity prices. Prices for industrial customers with very high consumption have more than doubled, while prices for households have risen much less, probably due to longer-term contracts. ↘ CHART 79 RIGHT

↘ CHART 79
The energy price increases have affected industry most strongly



Source: Federal Statistical Office
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Changes in energy consumption since the beginning of the war

293. The high energy prices, combined with energy policy measures such as the gas auction model and tenders for so-called Strategic Storage Based Options (SSBO), ↘ BACKGROUND INFO 16 as well as adjustment reactions by consumers, have already led to a **change in energy consumption**. Natural gas has been substituted by coal and all petroleum products – consumption of these energy carriers rose in H1 2022. ↘ CHART 80

The EU has set itself the target of reducing **natural gas consumption by 15 %** between 1 August and 31 March compared to the same period in the previous five years. This target was approved **for the period 1 August 2022 and 31 March 2023**. Possible measures include reducing gas-fired electricity generation, promoting fuel switching, national information campaigns and targeted commitments to reduce heating and cooling (Council of the European Union, 2022c).

↘ BACKGROUND INFO 16
Domestic instruments for avoiding shortages of natural gas

In addition to international efforts to secure new natural gas supplies, instruments have been used domestically to reduce the risk of natural gas shortages. For example, based on the **law on the introduction of minimum filling-level requirements for gas storage facilities,** a combination of instruments has been developed to ensure that gas tanks are filled. These include filling-level requirements (including mechanisms ensuring that unused storage capacities are made available), as well as measures on the market-based filling of storage capacities, e.g. inviting tenders for 'strategic storage-based options' (SSBOs), i.e. storage quotas (dena, 2022). The providers undertake to comply with predefined filling-level specifications and to keep a partial quantity of gas available on-demand at all times. The remuneration for gas storage operators is financed by a gas storage levy. Should regional –

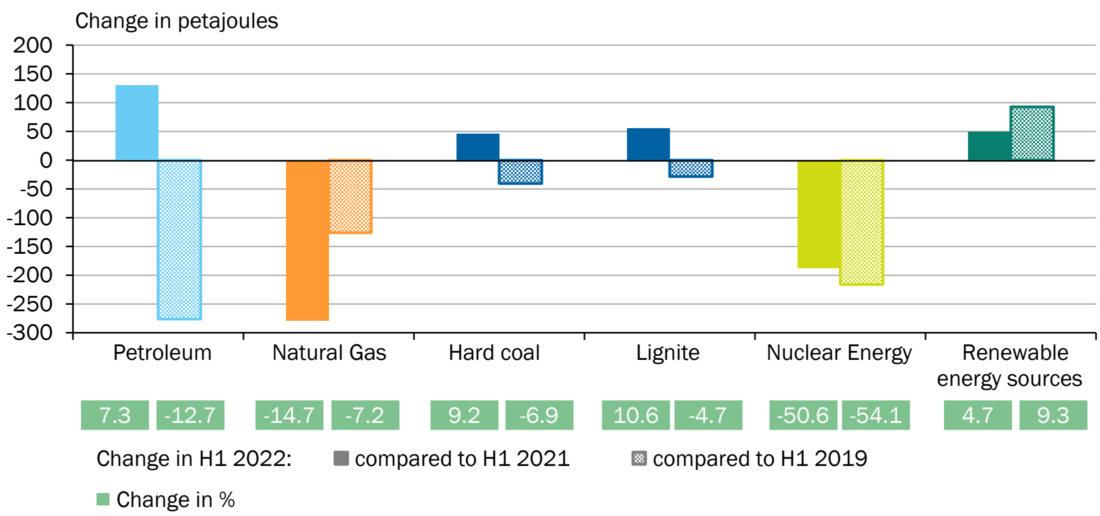
possibly short-term – shortages occur nevertheless, the **gas auction model**, which has been in operation since the beginning of October, can be used to counteract them. In the gas auction model, industrial customers submit a bid stating the price at which they are willing to temporarily reduce their gas consumption. The remuneration for the gas reduction is financed from the 'neutrality charge for balancing'.

294. According to the Federal Network Agency, natural gas consumption in Germany up to and including September 2022 was just under 10 % below the average for 2018 to 2021 for the same period. However, for the period from January to May 2022, almost half of the decline (6.4 % versus 14.3 %) was due to **milder weather** (BDEW, 2022a). The **largest contribution to natural gas savings** so far has come from **industry**, whose consumption in Germany in September 2022 was around 19 % below the September average for 2018 to 2021. In August, the savings were as high as 21 % (Bundesnetzagentur, 2022a). ↘ CHART 81

295. **Energy efficiency measures** and **fuel switch,** i.e. a shift away from natural gas to other energy sources, have helped reduce consumption. Furthermore, **production cutbacks**, especially in energy-intensive industries, have also contributed to the energy savings. ↘ CHART 59 However, the exact contribution of the individual measures cannot be quantified due to the lack of data.

296. Gas consumption by private households and commercial customers up to and including the end of September 2022 was 8 % lower than the average for the same period from 2018 to 2021. However, it is more difficult to make a comparison here, as consumption is highly dependent on the outside temperature. In addition, prices had not yet risen much in Q1 2022, when more heating was used. ↘ CHART 79 LEFT When the new heating season for households begins, it will become clear how large the savings will be in **private households and the commercial, trade and services sectors**. To ensure that Germany does not experience a gas shortage, at least 20 % (Bundesnetzagentur, 2022c) of natural gas must be

↘ CHART 80
Development of primary energy consumption in Germany by energy source



Sources: AG Energiebilanzen, BDEW, own calculations
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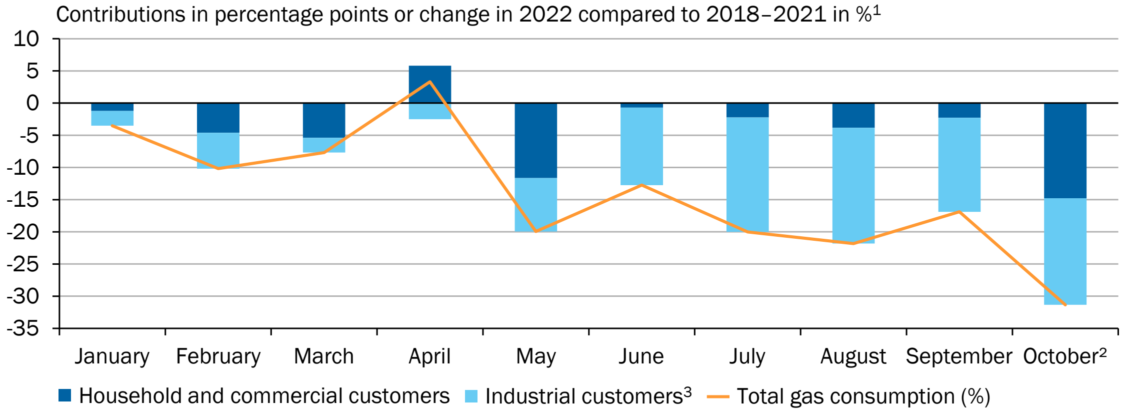
↘ CHART 81
Falling natural gas consumption in Germany



1 – Deviation from the average of the years 2018–2021. 2 – Based on the available weekly values up to week 42, an average consumption for October was estimated. 3 – Industrial customers are customers with a consumption of more than 1.5 GWh per year. Includes gas consumption by electricity generation.

Sources: Federal Network Agency, own calculations
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saved compared to the previous year. Alternatively, industry would have to make an even greater contribution to save gas. Initial estimates suggest that, after adjusting for weather conditions, customers in both the private and commercial sectors have been saving gas (DIW, 2022; Luderer et al., 2022).

III. NEW CHALLENGES FOR INDUSTRY

297. **German industry's energy supply was already in upheaval before Russia's war of aggression** as a result of the planned conversion to low-carbon energy sources. Most industries were looking towards electrification or a switch to hydrogen; some were preparing for carbon capture and storage ↘ GLOSSARY while continuing to use fossil fuels. ↘ BOX 16 At the same time, changes in energy prices were on the horizon, as the expansion of renewable energy would affect the fluctuation of electricity prices over the course of the day (Härtel and Korpås, 2021; Böttger and Härtel, 2022). However, whether the transformation would cause average end-user prices for electricity to rise (De Vita et al., 2021; Pototschnig et al., 2022) or fall (Böttger et al., 2021) in the short and medium term was controversial.

298. The sharp and abrupt price increases observed in Europe, particularly since last autumn, have raised **concerns** that industrial **competitiveness vis-à-vis other regions could be weakened.** ↘ CHART 79 ↘ ITEM 304 The high prices and reduced natural gas supply are forcing industry to markedly cut its energy consumption in the short term. Opportunities are therefore being sought to improve energy efficiency, expand fuel switching ↘ BOX 16 and make demand for energy more flexible. ↘ ITEM 313 Declines in production have been recorded in some industries. ↘ ITEMS 57 AND 59

↘ BOX 16

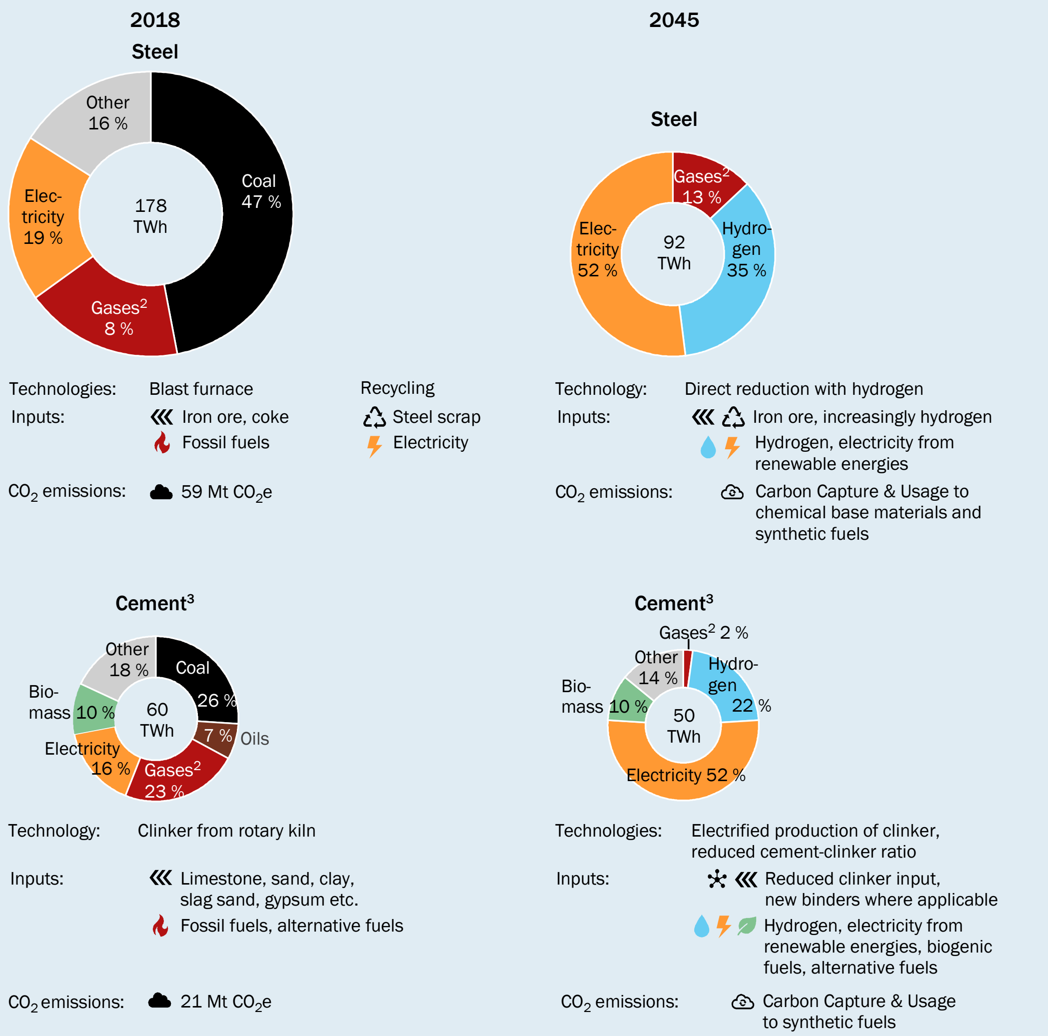
Has the war change industry's transformation pathways?

In view of industry's high carbon emissions – accounting for 24 % of Germany's total emissions in 2021 (UBA, 2022) – decarbonisation pathways have been developed that are compatible with the goal of climate neutrality in Germany in 2045 (EWI, 2021). ↘ CHART 82 The most important element of decarbonisation is the switch to **low-emission energy sources.** The envisaged transformation pathways rely on natural gas as a bridging technology in the short term,

↘ CHART 82

Decarbonisation in the steel and cement industry

Values shown inside the circle: Final energy consumption[1]



1 – Final energy consumption according to dena (2021) Leitstudie and EWI (2021) Gutachterbericht. 2 – Gases are methan-based, including synthetic and biogene components, and include liquefied gases. 3 – In the source, the associated industry sector is referred to as stone & earth and includes the production of lime and cement as processes.

Sources: dena (2021), EWI (2021), own calculations

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and on a market ramp-up of hydrogen in the long term (Somers, 2022). The steel industry plans to become a significant consumer of hydrogen as early as 2025 (ArcelorMittal, 2022; Salzgitter AG, 2022; thyssenkrupp, 2022). With an annual consumption of 9 TWh, this industry would already consume about 64 % of Germany's total annual hydrogen production (14 TWh) planned for 2030 (BMWi, 2020; EWI, 2021). From 2045 onwards, the German **steel industry** alone is expected to consume 32 TWh of hydrogen per year directly and an additional 40 TWh indirectly through its demand for electricity (EWI, 2021). The German **cement industry** is expected to consume 5.3 to 11 TWh of hydrogen per annum as from 2045 (VDZ, 2020; EWI, 2021). ↘ CHART 82

The planned transformation pathways also envisaged the **increasing electrification of production processes**, which could lead to a doubling of industrial electricity consumption in the future (BMWK, 2022d). For a complete decarbonisation of processes in which fossil fuels are particularly difficult or expensive to substitute, the remaining emissions are to be saved by **carbon capture and storage or by using the carbon** ↘ GLOSSARY. For example, CO_2 captured in the steel industry can be used to produce chemical feedstocks, or CO_2 captured in the steel and cement industries can be used to manufacture synthetic fuels (VDZ, 2020; Somers, 2022).

In view of the changed situation on the energy markets, the economic viability of the envisaged transformation pathways can be expected to change. On the one hand, rising electricity and gas prices increase incentives to expand **renewable energies**, improve **material and energy efficiency** and increase imports of **renewable energy carriers**, which could accelerate decarbonisation. On the other hand, it could prolong the use of other fossil fuels that have not increased in price to the same extent and are not subject to similarly low supply security (Luderer et al., 2022). In the case of reduction pathways in which **natural gas** was planned **as a transition technology**, decarbonisation could be carried out directly with hydrogen earlier if sufficient quantities of hydrogen are available. Were this not the case, natural gas would have to be used as a bridging technology despite higher prices, or production capacities would have to be shut down. In the steel industry, for example, a gradual replacement of natural gas with hydrogen has been expected until now (Somers, 2022). Furthermore, higher electricity prices increase the domestic production costs of hydrogen (Ariadne, 2022), while the deteriorating financial situation of firms and general uncertainty about the future could reduce corporate investment and thus **slow down the transformation.** In industries such as steel production, although **decarbonisation plans have been adhered to** up to now (thyssenkrupp, 2022), according to a BDI survey, around 40 % of companies feel compelled to **postpone investment decisions in the ecological and digital transformation** (BDI, 2022).

According to a scenario analysis conducted by the Potsdam Institute for Climate Impact Research (PIK) (Luderer et al., 2022), the need to reduce Europe's dependence on imports could lead to earlier decarbonisation despite the fall in carbon prices. Electrification, accelerated by early replacement of production equipment, is expected to play a decisive role in this process. In addition, the study forecasts **production cutbacks and a rise in imports** of synthetic naphtha and the hydrogen derivatives ammonia and methanol, which will reduce domestic demand for hydrogen. Nevertheless, there may be temporary negative emission effects, for example due to the increased use of heating oil and biomass in the steam and hot-water sector as a result of a fuel switch, or due to the slower decline in the use of coal. In the medium and long term, however, the transformation of production processes is likely to depend on the **lifespan of existing production facilities**, the **availability of skilled workers** in relevant professions, and the global **capacity of electrolysers** (Luderer et al., 2021, 2022).

1. Absolute and relative energy-price increases

299. Despite the adjustments in energy supply and consumption made up to now, **European wholesale energy prices** for both **natural gas** and **coal** are **high** – both historically and relative to other economic regions. ↘ ITEM 291 These international differences can be partly explained by the different sanctions regimes against Russian imports. Crude oil imports from Russia to the EU, as well as to the US, Japan and the Republic of Korea, had fallen by two-thirds by July 2022 (IEA, 2022). On the other hand, other countries have increased oil imports from Russia, e.g. India between March and August 2022 to thirty times the level of the previous year (Verma, 2022). This is not least due to the fact that the price difference between Brent oil from the USA and Russian Urals oil was at times 35 US dollars per barrel or 35 % (Gornostay, 2022).

300. **The different price developments in the European and US natural gas markets** are particularly striking. Energy markets, even when geographically separated, can be coupled via the available transport infrastructure, so that prices converge due to arbitrage (Oglend et al., 2020; Li et al., 2014). The natural gas markets have become more integrated in recent years (Garaffa et al., 2019), which would actually lead one to expect greater price coupling. However, the shock associated with the restriction of Russian natural gas supplies is so strong that the existing infrastructure is limiting arbitrage opportunities and prices have diverged sharply in recent months.

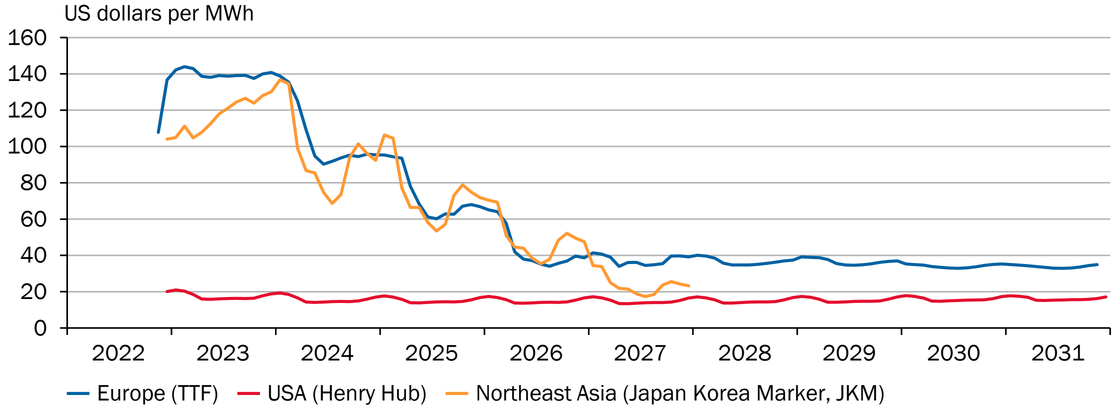
301. This is due to **limited export capacities** in the countries with large, available natural gas deposits, especially to the lack of gas liquefaction facilities, which are needed for LNG exports. ↘ BOX 14 At present, therefore, wholesale prices are lower especially where gas is extracted and export opportunities are limited. This is the case in the USA, but price differences can also arise within Europe. For example, transport possibilities between regions located in areas served by different gas hubs ↘ GLOSSARY – for example between Germany and Spain – are severely limited. In addition, a large proportion of liquefaction plants are tied up for several years by existing long-term LNG supply contracts – in 2021, 63.4 % of world trade was determined by long-term contracts – so adjustments are slow. These contracts generally do not include exit clauses to redirect supplies to countries with higher prices in the short term (GIIGNL, 2022). However, contractual exit clauses allowed at least ten LNG cargoes heading for ports in Asia to be diverted to Europe during December 2021 (Rashad, 2021).

302. Developing export and transport infrastructure is very time-consuming – the entire planning and construction period for Nord Stream 1 was about 6 years. Therefore, although **natural gas prices are expected to fall in the medium term**, they will still be **significantly above pre-crisis levels**. Because of the close interconnections between the electricity and natural gas markets, **higher electricity prices are also expected**. This is suggested by both futures prices and scenario calculations (Egerer et al., 2022b; EWI, 2022; Mier, 2022; Prognos, 2022a). ↘ CHART 79 **Regional price differences** are also likely to **narrow, but not disappear.** ↘ CHART 83 How quickly this will happen depends on how quickly

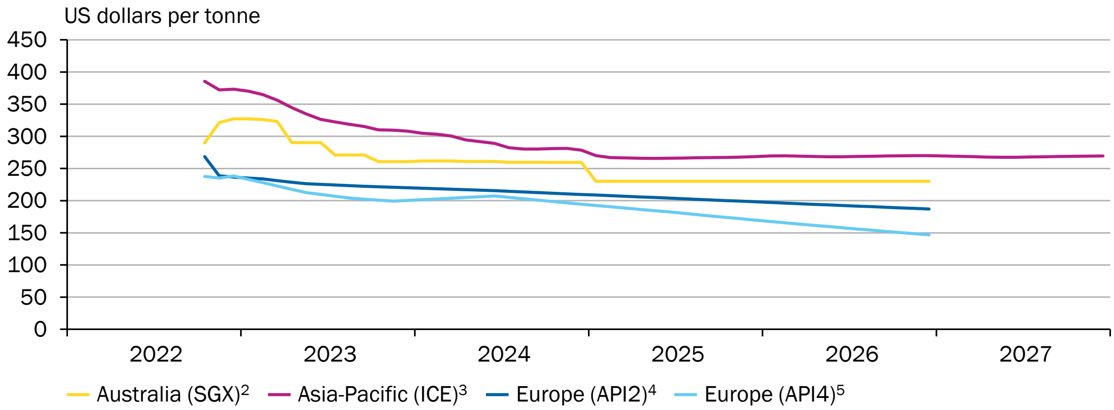
↘ CHART 83

Market expectations of future prices for natural gas, electricity and coal compared to other world regions

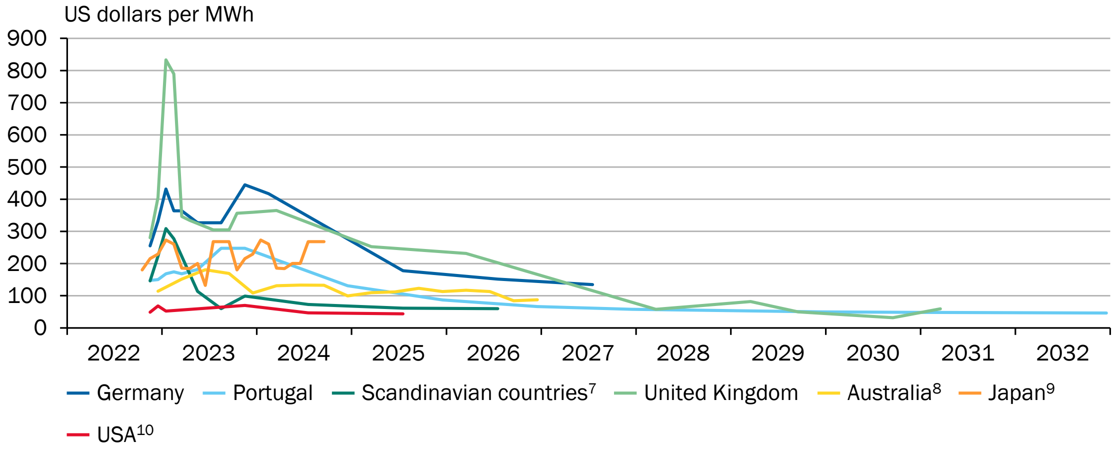
Futures prices for natural gas[1]



Futures prices for coal[1]



Futures prices for electricity[6]



1 – As at 27 October 2022. 2 – FOB Australia Premium Coking Coal. 3 – Newcastle Coal: Thermal coal by sea from the Asia-Pacific region. 4 – Amsterdam, Rotterdam, Antwerp delivered coal from South America. 5 – Amsterdam, Rotterdam, Antwerp delivered thermal coal from South Africa. 6 – Status: for Germany 28 October 2022 and the other states 27 October 2022. 7 – Nord Pool system price. 8 – SFE-NSW Base-Load. 9 – Japanese Power (Day-Ahead) Tokyo Base-Load. 10 – US Electricity PJM Off Peak.

Sources: CME Group, Intercontinental Exchange (ICE), Refinitiv Datastream, Refinitiv Eikon, own calculations
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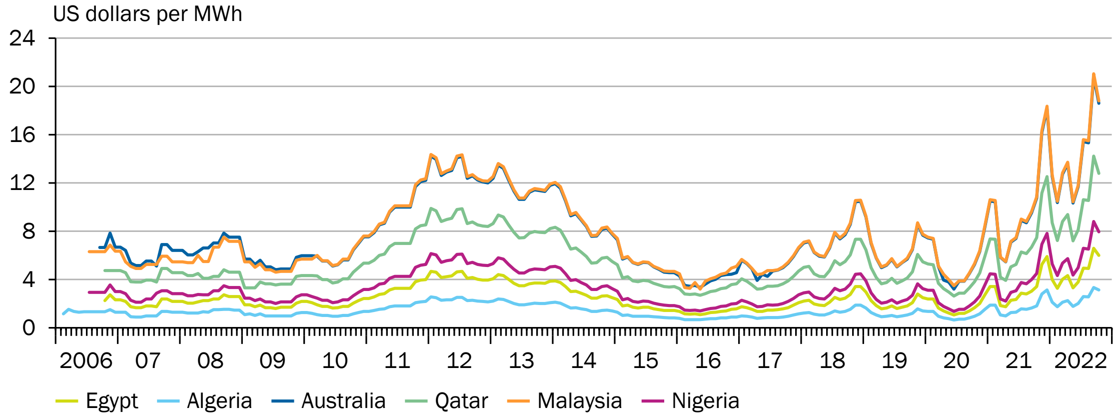
↘ CHART 84
Heterogeneity of freight costs for LNG imports[1]



1 – Freight costs for LNG imports to Belgium depending on the country of origin. Price in US dollars per MMBtu (1 million British thermal units) converted into US dollars per MWh.

Source: Refinitiv Datastream
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surplus demand in Europe can be reduced, i.e. by a reductions in demand, ↘ ITEM 306 as well as on the development of new energy sources and the expansion of transport and generation capacities. ↘ ITEMS 282 FF. It should be noted that the European markets remain closely interconnected and that the EU is vigilant concerning the principle of solidarity (European Commission, 2022e). This is because the situation not only in Germany but also in the EU as a whole is decisive for price convergence.

Futures suggest that US natural gas prices will return to pre-2020 levels in the coming years, while **European natural gas prices will settle down at a level of around €40 per MWh by 2026**. ↘ CHART 83 This is significantly higher than the price level of €5 to 30 per MWh between 2010 and 2021. A similar situation can currently be observed in the case of coal. According to market expectations, hard coal prices in the EU in 2026 would exceed the level of import prices from South America and South Africa in the past decade by about 143 %, while remaining about the same in the USA.

303. The expected high prices can be explained, for example, by the **additional costs** of **switching from** natural gas imports via **pipelines to LNG deliveries** because of the liquefaction and regasification processes. These have historically been around 3 to 6 US dollars per MWh (Team Consult, 2017; Tsafos, 2019). In addition, transport costs are higher when suppliers are more distant. ↘ CHART 84 For **natural gas in particular, transport costs are crucial**, but also highly volatile due to variation in vessel capacity. In the past, these costs have accounted for up to 50 % of total procurement costs (Hafner and Luciani, 2022, p. 23).

304. The different wholesale prices in the economic regions contribute significantly to the **internationally different end-consumer prices for energy**. For example, the price increases estimated by the EIA that industrial customers in the USA have had to accept in recent months (EIA, 2022) are much smaller than the cor-

responding price increases in Germany. ↘ ITEM 292 The energy crisis therefore presents German and European **industry with a double challenge**. Production costs have not only risen in absolute terms, which reduces sales if the costs are passed on; costs have also risen far more relative to many international competitors, which may mean reduced competitiveness. This relative disadvantage will decline in the coming years, but will not disappear entirely. ↘ ITEM 314

2. Increased need for energy saving

305. Price signals and potential shortages in energy markets increase the pressure on firms to become more energy-efficient. Furthermore, reducing energy consumption can **reduce firms' vulnerability to energy supply shocks** and thus is in their long-term interest. Acurio Vásconez et al. (2015) and Katayama (2013) show that improvements in energy efficiency happening since the 1970s have reduced the macroeconomic impact of oil price crises. Similar effects could be expected at the firm level.

306. **Energy savings** can be achieved by reducing consumption or increasing efficiency. ↘ BACKGROUND INFO 17 Either the same amount of products and services can be produced for a given level of demand by improving energy efficiency, for example by using new production technologies; or, alternatively, if a certain level of efficiency is given, a shift in demand towards less energy-intensive products and services or reduction in consumption can lead to a reduction in consumption.

↘ BACKGROUND INFO 17

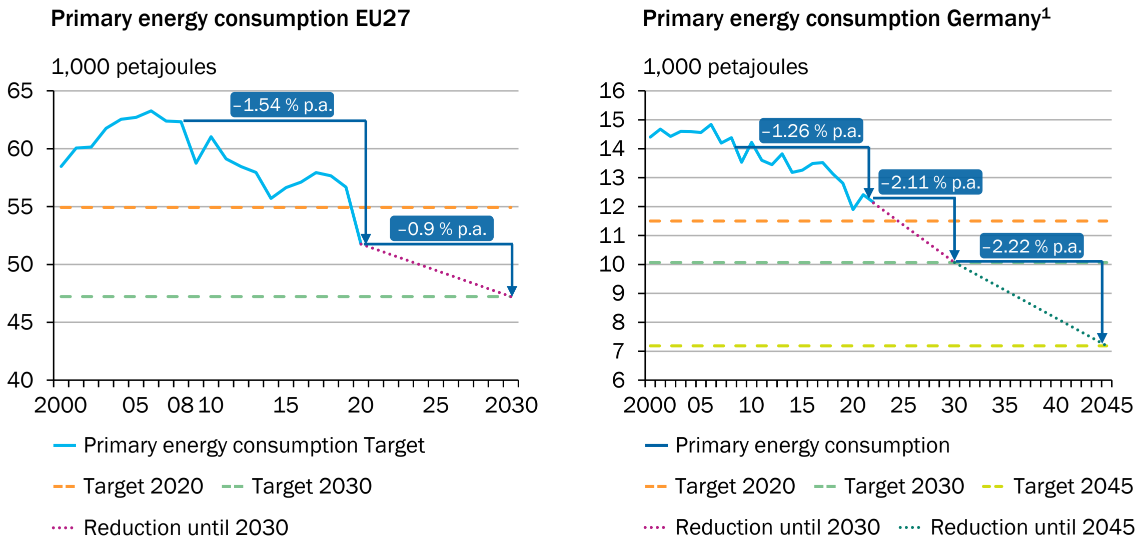
Energy efficiency

Energy efficiency is defined in the literature as the **energy input required to achieve a certain benefit**, i.e. the energy service. However, an increase in energy efficiency does not necessarily lead to energy savings. If the costs for energy services fall as a result of higher efficiency, total consumption can remain constant or even increase (**rebound effect**). Estimates of the size of the rebound effect differ (Gillingham et al., 2016). While increasing energy efficiency is essential both in the current energy crisis and for decarbonisation (IEA, 2021b), minimising the amount of energy consumed is not an economically meaningful aim in itself. The **economically efficient solution** is the one that is cost-effective, not necessarily the one that consumes the least energy. For example, the use of lithium batteries and other storage devices increases demand for primary energy due to losses that occur during charging. Nevertheless, the use of storage can make economic sense for certain applications.

Energy efficiency improvements in Germany

307. **Increasing energy efficiency** is one of the five dimensions of the EU Energy Union strategy. These also include energy-supply security, the internal energy market, decarbonisation, and research, innovation and competitiveness (European Parliament and Council of the European Union, 2018a). The EU adopted its first energy efficiency targets back in 2007. In 2018, a new target was set to

↘ CHART 85
EU and German targets for energy consumption



1 – Value for 2022 was extrapolated.

Sources: AG Energiebilanzen, Eurostat, own calculations
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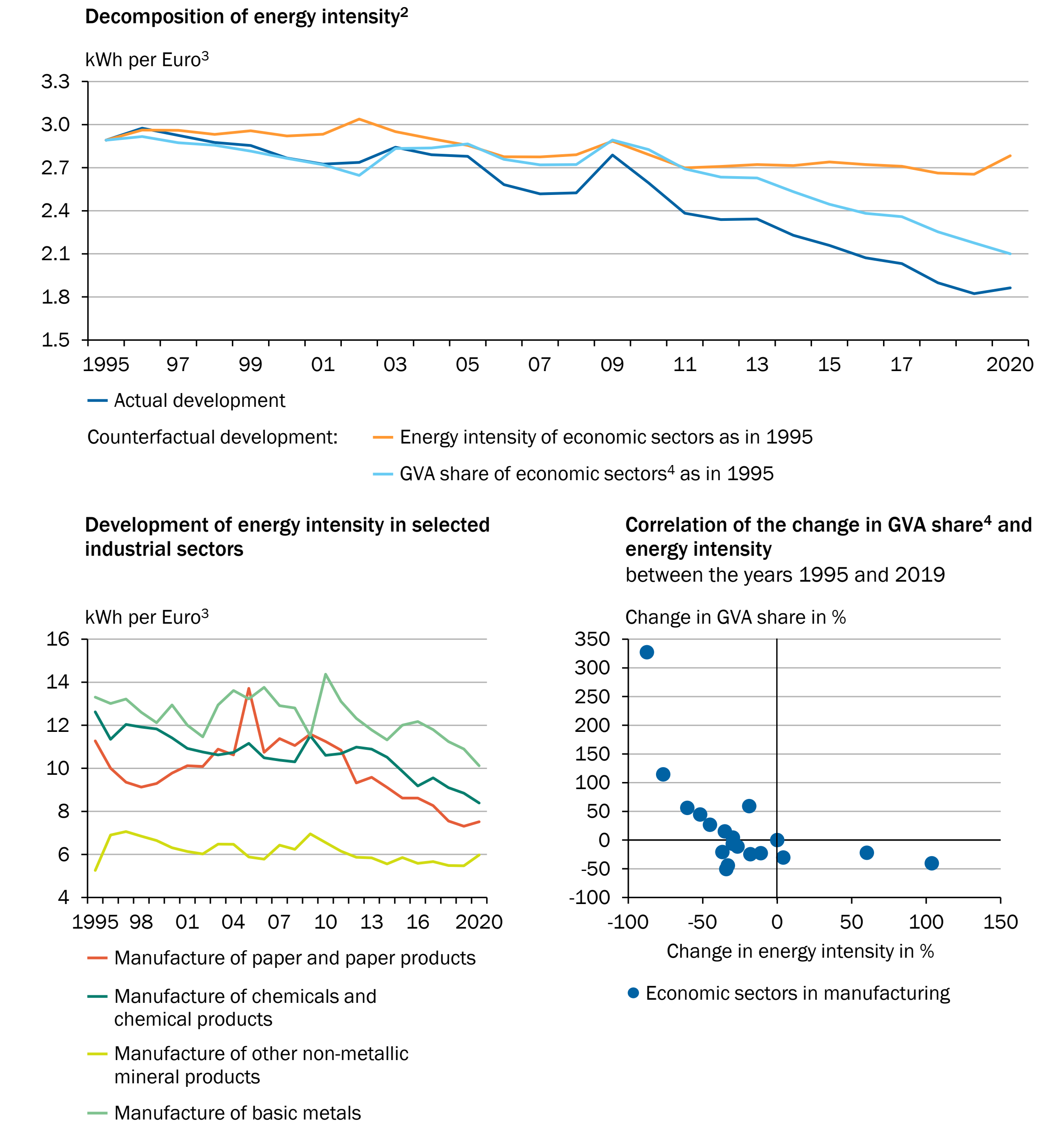
achieve a 32.5 % reduction in primary energy consumption by 2030 compared to the projection of future consumption made in 2008 (European Parliament and Council of the European Union, 2018b). The new European **Energy Efficiency Directive** envisages raising the **reduction target** for primary energy consumption to 39 % by 2030, which would represent a 9 % reduction compared to 2020. The EU27 met its 2020 target, not least because of the decline in primary energy consumption during the coronavirus pandemic. ↘ CHART 85 LEFT Overall, EU member states have reduced their consumption by 17 % compared to 2008. At the EU level, Germany committed to a 14 % reduction to meet the European target.

308. In addition to the EU-level targets, the member states have additional national savings targets. The Federal Government set itself the more ambitious 2020 target of reducing **primary energy consumption in Germany** by 20 % compared to 2008, which went beyond the pledge made to the EU. With a saving of 17 %, the Federal Government's national reduction target was missed despite lower energy consumption due to the pandemic. In 2021, primary energy consumption rose again and was 6 % above the 2020 target. The German **Climate Protection Act** of 2021 envisages a 30 % (50 %) reduction by 2030 (2045) compared to 2008. To achieve these targets, an annual reduction in primary energy consumption of just over 2.1 % (2.2 %) would be required from 2021 (2030) onwards. ↘ CHART 85 RIGHT From 2008 to 2020, the annual reduction was 1.26 %. When assessing the development to date, it should be noted that a large proportion of the decline in primary energy consumption to date has been due to conversion measures and not to technical, organisational or structural efficiency improvements (EWK, 2021). When fossil fuels are burned and converted into electricity, part of the energy is lost as waste heat. The lignite-fired power plants operate near

↘ CHART 86

Energy intensity in the manufacturing sector in Germany[1]



1 – Includes economic sectors 10-18 and 20-32 according to the Classification of Economic Activities, 2008 edition (WZ 2008). Analysis at 2-digit level. 2 – The actual development of energy intensity in manufacturing can be broken down into two effects. The pure structural effect indicates how the energy intensity of manufacturing would have developed if only the gross value added shares of the individual economic sectors had changed, but their energy intensity had remained at the 1995 level. The pure energy intensity effect indicates how the energy intensity of manufacturing would have developed if only the energy intensity of the individual economic sectors had changed, but their share of gross value added had remained at the 1995 level. 3 – Ratio between final energy consumption and gross value added in constant 2015 prices. 4 – Share of the gross value added of the indicated economic sector in the gross value added of all economic sectors.

Sources: Federal Statistical Office, own calculations

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45 % efficiency (DIW et al., 2018). For renewable energies, by contrast, an efficiency of 100 % is regarded as standard, i.e., 1 kilowatt hour (kWh) of electricity is generated with 1 kWh of primary energy.

309. **Energy intensity** in **manufacturing** (excluding coking plants and petroleum refining) has decreased since 1995. ↘ CHART 86 TOP There are two possible drivers for this development. On the one hand, the **composition of** the individual **economic sectors** may have changed. On the other hand, the reduction may be driven by a **decrease in energy intensity** in the individual economic sectors.

A hypothetical consideration of the development on the assumption that the energy intensity of the individual economic sectors would otherwise have remained constant shows that there **was a shift in gross value added towards less energy-intensive economic sectors**. For instance, the percentage of gross value added accounted for by the manufacture of motor vehicles has increased, while that for chemical products has decreased. These shifts between sectors have slightly reduced energy intensity.

A hypothetical consideration of the development under the assumption that the composition of the economic sectors would otherwise not have changed shows that the manufacturing industry (excluding coking plants and petroleum refining) has become less energy intensive overall. ↘ CHART 86 TOP **Energy intensity** has fallen in the **energy-intensive sectors** – the manufacture of chemical products, paper, cardboard and paper products – as well as in metal production and processing. On the other hand, energy intensity has remained constant in the manufacture of glass, glassware and ceramics and in non-metallic mineral processing. ↘ CHART 86 BOTTOM LEFT

310. The change in contributions to gross value added and the change in energy intensity show a **negative correlation**. ↘ CHART 86 BOTTOM RIGHT The economic sectors that reduced their energy intensity particularly strongly between 1995 and 2019 tended to have contributed more to gross value added in 2019 than in 1995.

Lutz et al. (2017) show that there is **still room for improvement** in the German manufacturing sector despite a reduction in **energy intensity.** In some industries, many firms are far from reaching the benchmark of efficient consumption. Export-oriented and innovative firms have the highest efficiency.

↘ BOX 17

Experience from past energy crises

The oil crises of the 1970s

In the autumn of 1973, the Organisation of Arab Petroleum Exporting Countries (OAPEC) significantly cut oil production (GCEE Annual Report 1974 item 2), which led to the **first oil price shock.** The global oil price rose within a few months from around three US dollars per barrel in July 1973 to more than three times that in April 1974 (World Bank, 2022). During the 1970s, oil prices normalised only to a small extent before rising even more sharply in the wake of the **second oil price shock in 1979-1980** (GCEE Annual Report 1980 item 4). ↘ CHART 87 TOP LEFT Both shocks plunged countries that were dependent on oil imports, such as Germany, the United States and Japan, into a deep **economic crisis** (GCEE Annual Report 1974 items 1 ff.; GCEE Annual Report 1980 items 1 ff.). ↘ CHART 87 TOP RIGHT

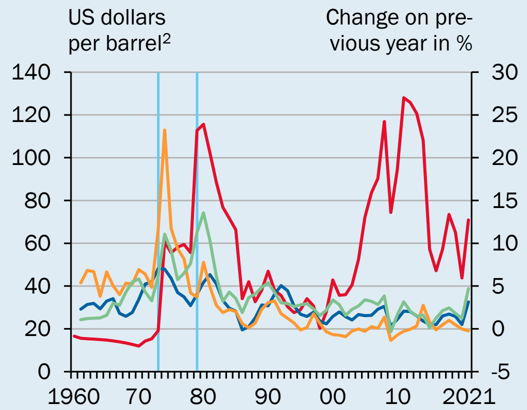
Many affected countries took **drastic measures.** In the Federal Republic of **Germany,** the

Energy Security Act was passed after the first oil crisis, which led, among other things, to general driving bans on selected Sundays, speed limits and the annual switch to daylight saving time. In the **United States**, fuel was rationed, speed limits were imposed and weekend driving was restricted. The U.S. has since invested heavily in energy efficiency research, and introduced

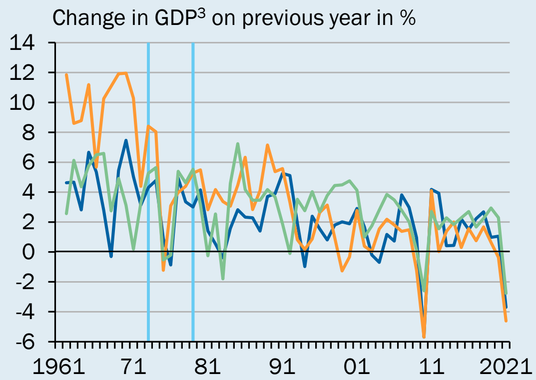
↘ CHART 87

Development of energy indicators and economic indicators after the oil price crises of the 1970s in Germany[1], Japan and the United States

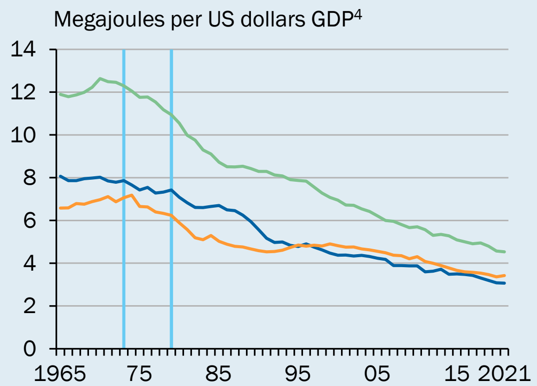
Development of oil and consumer prices since 1960



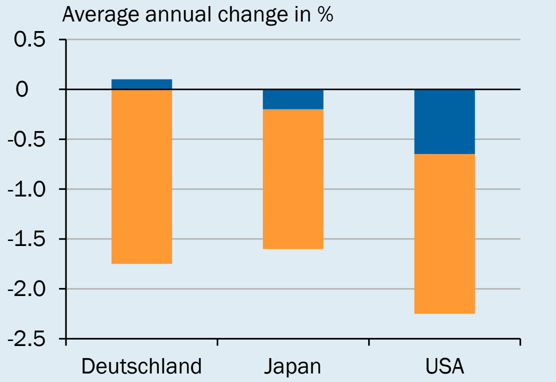
Economic collapse during the oil price crises of the 1970s



Energy intensity of GDP has fallen significantly since the 1970s
Primary energy consumption relative to GDP



Decomposition of the change in energy intensity of GDP between the years 1973 and 1998 into change in energy services/GDP and energy intensity effect[5]



1 – Until 1990 former territory of the Federal Republic of Germany. 2 – Deflated by the consumer price index of the USA (2021 = 100). 3 – In 2010 prices. 4 – In constant 2015 prices and purchasing power parities. 5 – For explanations of the decomposition, see OECD and IEA (2004, p. 46).

Sources: BP (2022), European Commission, IEA, OECD, own calculations
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energy efficiency standards for many products and processes (Geller et al., 2006). The Corporate Average Fuel Economy (CAFE) Act of 1975 limited the fleet-fuel consumption of motor vehicles in the U.S and helped make them more fuel efficient by reducing weight and vehicle size and making engines more efficient. Between 1975 and 1984, fuel consumption was reduced by 62 %, while maintaining the vehicle performance (Transportation Research Board and National Research Council, 2002). Thus, in the aftermath of the crisis, drastic and long-term measures were taken that permanently reduced energy intensity in the economy. ↘ CHART 87 BOTTOM

Japan was especially hard hit by the oil crisis in 1973 because it had hardly any fossil fuels of its own and was particularly dependent on oil imports. Oil imports accounted for 15 % of Japan's imports by value before the 1973 crisis, compared to about 10 % in other industrialised countries (Yamakoshi, 1986, p. 55). Since electricity was largely generated in oil-burning power plants in Japan before the first oil crisis, electricity prices rose more during the crisis than in other advanced economies (Mihut and Daniel, 2012). Inflation was also significantly higher in Japan than in the U.S. and Germany. ↘ CHART 87 TOP LEFT In addition to correcting its foreign policy stance in favour of the Arab states, the Japanese government responded with extensive **measures to reduce energy consumption and increase energy efficiency.** The **Energy Conservation Act** (initially the Law on the Rational Use of Energy) was enacted for this purpose in 1979. The law has been revised several times since then and still plays a key role in Japan's energy efficiency policy today (Geller et al., 2006; IEA, 2016). Under this law, the first **minimum energy efficiency standards** were introduced, e.g., in 1983 for refrigerators and air conditioners. In the 1990s, this was extended to other areas such as television sets, photocopiers and computers, and **penalties** for non-compliance were added. As a result, the average electricity consumption of new refrigerators fell by 15 % between 1979 and 1997, even though their average size increased by 90 % (Geller et al., 2006). Furthermore, 1998 saw the introduction of the Top Runner Programme, under which new products had to reach the efficiency level of the most efficient product in that product class. In some cases, the required efficiency improvement was over 50 % (Geller et al., 2006).

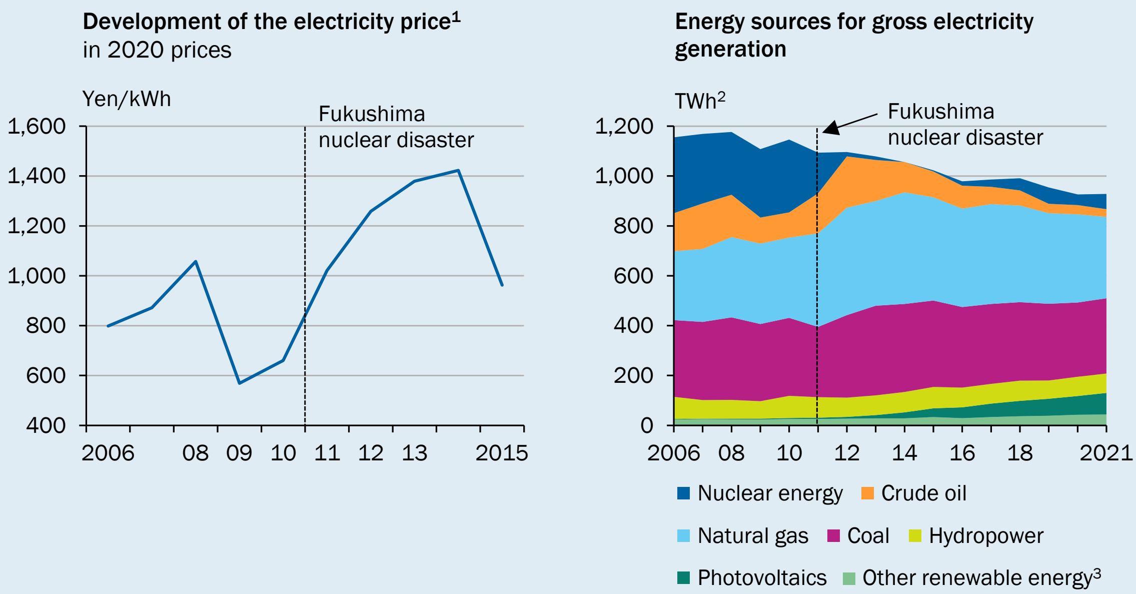
After the oil price crises, **value added in Japan shifted away from industry and towards services** (Yamakoshi, 1986, p. 66), although it is not possible to quantify how much of this was directly caused by the oil price shock and how much by the secular trend that was generally observed in advanced economies. At the same time, Japan's **industrial structure changed** in such a way that industries that were heavily dependent on oil, such as the petrochemical industry, aluminium production and shipbuilding, declined, while the automobile and electronics industries, for example, experienced a lasting upward trend (Yamakoshi, 1986). Here, demand for small, economical Japanese cars rose abroad, which strengthened Japan's exports (Yamakoshi, 1986, p. 65).

Overall, the **energy intensity of gross domestic product (GDP)**, i.e., energy consumption per unit of value of GDP, has **fallen considerably** in advanced economies such as Japan, Germany and the U.S. since the oil crises, albeit to varying degrees. ↘ CHART 87 BOTTOM LEFT Energy consumption relative to GDP depends not only on the energy efficiency of processes, but also on factors such as economic structure, the floor area of buildings per unit of value added in the service sector, transport of goods (which in turn is related to the size of the country's land area), living space per capita and a country's climate. A **decomposition analysis** can be used to estimate the extent to which the decline in the energy intensity of GDP in a country is due to changes in energy intensity and the extent to which it is due to a change in the demand for energy services (OECD and IEA, 2004). The **demand for energy services** is determined by the level of activity (measured, for example, in tonne-kilometres of goods transported) and the structure (for example, the share of different means of transport). **Energy intensity** is the final energy consumption per unit of activity in the individual subsectors (for example, the energy consumption per tonne-kilometre in transportation by truck). **Energy intensity is thus more interpretable as an efficiency indicator than energy consumption per unit of GDP.** A comparison between countries shows that the demand for energy services relative to GDP has fallen in Japan and the U.S., thus contributing to the lower energy intensity of GDP (OECD and IEA, 2004). ↘ CHART 87 BOTTOM RIGHT To a larger extent, however, the lower energy consumption per GDP is due to lower **energy intensity.** In Germany, the use of energy services has increased relative to GDP, and the decrease in energy consumption per GDP is (more than) entirely due to a decrease in energy intensity.

The 2011 Fukushima nuclear disaster in Japan

After the oil crises, nuclear energy gained importance for power generation in Japan. In March 2011, however, the energy supply in Japan experienced another crisis as a result of the nuclear disaster at **Fukushima.** All of Japan's nuclear power plants had to successively cease operations, leading to a gap in the electricity supply of about 30 % (IEA, 2016). This gap was mainly covered by more expensive fossil fuels such as LNG, oil and coal (IEA, 2016; Kiso et al., 2022). ↘ CHART 88 RIGHT Since the energy crisis affected only Japan and only one region within Japan,

↘ CHART 88
Effects of the Fukushima nuclear disaster on the power supply in Japan



1 – Annual average of daily prices on the Japan Electric Power Exchange (JEPX) for electricity 24 hours in advance deflated by the consumer price index (2020 = 100). 2 – Terawatt hours. 3 – Biomass, geothermal, wind energy and other energy sources.

Sources: BP (2022), JEPX, own calculations
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LNG supplies could be diverted within Japan and on the global market, e.g., from the Republic of Korea (Miyamoto et al., 2012). Overall, the LNG market developed strongly during this period (Yep and Foo, 2021). Power-saving appeals (the Setsuden 'saving electricity' movement), supported by the government and the media, made recommendations such as avoiding standby modes, using fans instead of air conditioners, and installing energy-saving light bulbs. From July to September 2011, mandatory electricity savings targets of 15 % relative to the previous year were set for large enterprises and office buildings for certain times of the day and in certain regions to avoid blackouts in summer. Many firms adjusted their working hours so that days off were spread evenly throughout the week, thus reducing peaks in electricity consumption. Workers were encouraged to wear weather-appropriate, and therefore less formal, clothing to work so that room heating and cooling could be reduced (BBC, 2011). Public transport was slowed down, escalators and illuminated advertisements were switched off. The power cuts feared for the summer of 2011 were avoided (Golden, 2013) and electricity price rises in the years following the disaster have provided a continuing incentive to save power (Kiso et al., 2022). ↘ CHART 88 LEFT Significant **efforts** have been made to further **increase energy efficiency and promote renewable energy** (Zhu et al., 2020). For example, the Japanese government worked with academia and industry to develop a strategy to promote innovation in energy technologies (2016 National Energy and Environment Strategy for Technological Innovation towards 2050 – NESTI 2050) (IEA, 2016). The Top Runner Programme was extended to the field of building materials in 2013 (IEA, 2016, p. 45). After the Fukushima disaster, the government also promoted energy management systems in office and residential buildings that provide real-time information on energy consumption and costs, as well as energy-saving recommendations. Firms received financial incentives to purchase such systems (IEA, 2016, p. 46).

Energy saving potential in industry

311. The increased energy prices are expected to lead to a reduction in industrial energy consumption. In the short term, this reduction is likely to take place as a result of **behavioural changes** as well as through a **reduction in production** (Prognos, 2022b). The latter is already taking place in some energy-intensive activities. ↘ ITEM 59

312. In the medium and long term, further savings can be achieved by means of optimised production processes, more energy-efficient plant and equipment, and energy-saving technologies. **Energy prices** have been empirically identified as **the most important determinant of energy intensity in European industry** (Ajayi and Reiner, 2020). However, it is foreseeable that this effect is caused not only by efficiency gains within individual firms, but also by the least efficient firms leaving the market in periods of high energy prices. In 2021, the European Commission estimated that final energy consumption in German industry could be reduced by 23.5 % by 2030, with measures that would be economically beneficial to firms, in particular by using process heat (Strug et al., 2021). The current price hike further increases the incentive to invest in energy efficiency measures. ↘ BOX 17

However, **estimates of energy saving potential** in industry **vary widely** (BDEW, 2022b; Prognos, 2022b). It is also unclear how quickly energy efficiency can be significantly increased. Many industries are already facing a fundamental technological shift due to decarbonisation, which on the one hand could reduce the willingness to invest in improving terminating technologies in the short term, but on the other hand could accelerate the switch to new technologies. ↘ BOX 16

313. **Making energy consumption**, especially electricity consumption, more **flexible over time** can also **reduce** industrial **energy costs** and thus contribute to overcoming the energy crisis. The electricity market design must provide price signals to create incentives to consume electricity when it is abundant, and ensure

that the investment in flexibility and storage required for this is worthwhile. ↘ BOX 18

↘ BOX 18

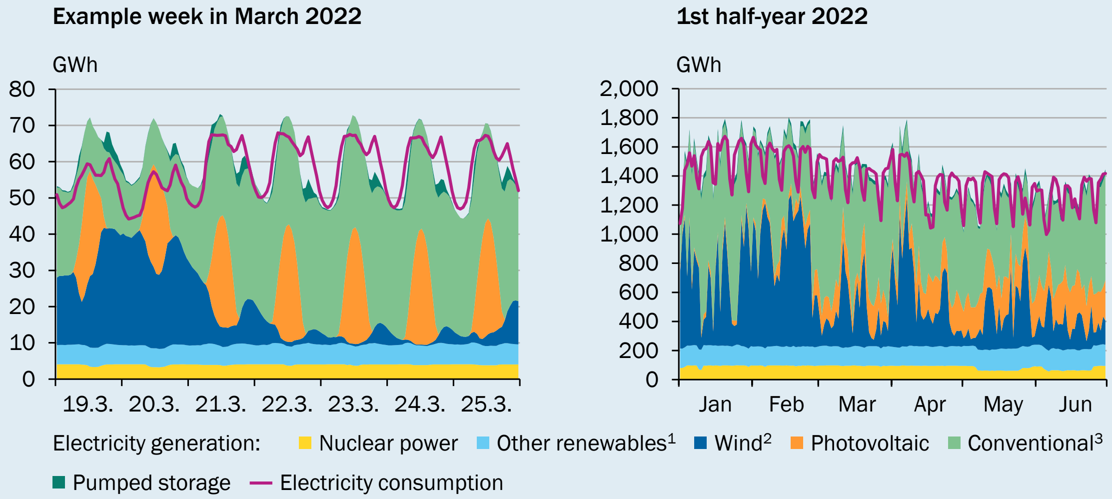
Flexibilisation of electricity demand

In Germany, the demand for electricity for final consumption is expected to increase by more than 30 % by 2030 compared to 2021, from 588 TWh to 750 TWh (Bundesregierung, 2022a). The share of renewable energies in electricity generation is expected to rise from 42 % to 80 % in the same period. Electricity demand is expected to increase further after 2030 (Wuppertal Institute et al., 2021). The increase in electricity demand from 2021 onwards is mainly driven by the production of hydrogen and by further electrification, for example through the use of heat pumps, electromobility and especially by the electrification of industrial processes (Lechtenböhmer et al., 2016). ↘ BOX 16 **The simultaneous increase in electricity demand and renewable electricity generation requires new measures to ensure a reliable electricity supply.** In addition to the expansion of electricity grids and storage capacities, the improvements in demand-side flexibility are also recommended (Bundesnetzagentur, 2017).

Up to now, the electricity market has been structured in such a way that electricity generation adjusts to demand. In times of high demand, additional power plants are ramped up to produce the amount of electricity needed. **However, electricity production from renewable energies is volatile and inflexible both in the course of a day and the course of a year.** As a rule, more electricity can be generated by photovoltaics in summer and by wind energy in winter. However, the daily amount of power generated by renewables is **difficult to plan because it depends on weather conditions.** ↘ CHART 89 Electricity generating plants using renewables are built as a decentralised generation system, i.e., they are much more geographically dispersed. Together, the spatial and temporal divergence of supply and demand necessitates an increase in transport and distribution capacity (Guidehouse et al., 2022).

↘ CHART 89

Electricity generation and consumption in Germany



1 – Biomass, hydropower, geothermal, landfill gas, sewage treatment plant gas and mine gas. 2 – Offshore and onshore. 3 – Lignite, hard coal, natural gas, derived gas from coal, petroleum, waste, blast furnace gas, refinery gas, gas with high hydrogen content, other residues from production and mixture of several fuels.

Sources: Federal Network Agency | SMARD.de, own calculations
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Increasing demand-side flexibility can make an important contribution to **ensuring a stable electricity supply** and **keeping supply costs low**, as fewer assets need to be kept as grid reserves and the need to expand transport capacity is reduced (Ambrosius et al., 2018; WIK et al., 2019). This would require the creation of appropriate framework conditions, for example by removing regulatory uncertainty and improving grid technology (Navigant Energy Germany et al., 2020).

In order to create incentives for firms to **invest in making their demand more flexible**, a reform of grid charges, surcharges and levies is required. Cost-reflective tariffs could create incentives to purchase electricity when demand for power is low (Leopoldina et al., 2020).

According to the meta-study by Eisenhauer et al. (2018), industry has the potential to flexibly increase its consumption by up to 600 megawatts (MW) and reduce it by up to 1,630 MW. **Transparency in pricing and planning certainty** are needed to give **industrial customers a sufficient incentive** to invest in demand-side management – e.g. by using periods when electricity costs are low to produce in reserve and build up stockpiles (Ambrosius et al., 2018).

IV. IMPLICATIONS FOR STRUCTURAL CHANGE IN INDUSTRY AND INDUSTRIAL POLICY

314. What effects will the current internationally asymmetric energy price increases have on the future economic structure in Germany? Will there be only **temporary production cutbacks** in some firms, or are plant closures on a larger scale to be expected? Although natural gas prices can be expected to fall well below their current level, they will not return to pre-crisis levels. At the same time, industry is undergoing a transformation towards the increased use of low-emission energy sources. ↘ BOX 16 Electricity prices are also expected to remain high in the medium term. Uncertainty about future economic developments could make private investors more reluctant to provide finance.

1. Relevance of energy prices for German industry

315. The degree to which individual **firms and products** will be **affected by rising energy costs** will depend largely on **their energy cost share** (Kahn and Mansur, 2013). To gain **insight into the relevance of energy costs for manufacturing firms**, the GCEE reviewed **empirical studies** based on Official Firm-Level Data for Germany data ↘ BACKGROUND INFO 18, in particular Lutz et al. (2017), Rottner and von Graevenitz (2020), Berner et al. (2022), Rottner and von Graevenitz (2022a, 2022b), and Mertens et al. (2022). In addition, the GCEE conducted **its own evaluation of using that dataset**.

In order to be able to estimate the **influence of current price developments at the product level**, the GCEE also commissioned an **expert report** from **Müller and Mertens** (2022).

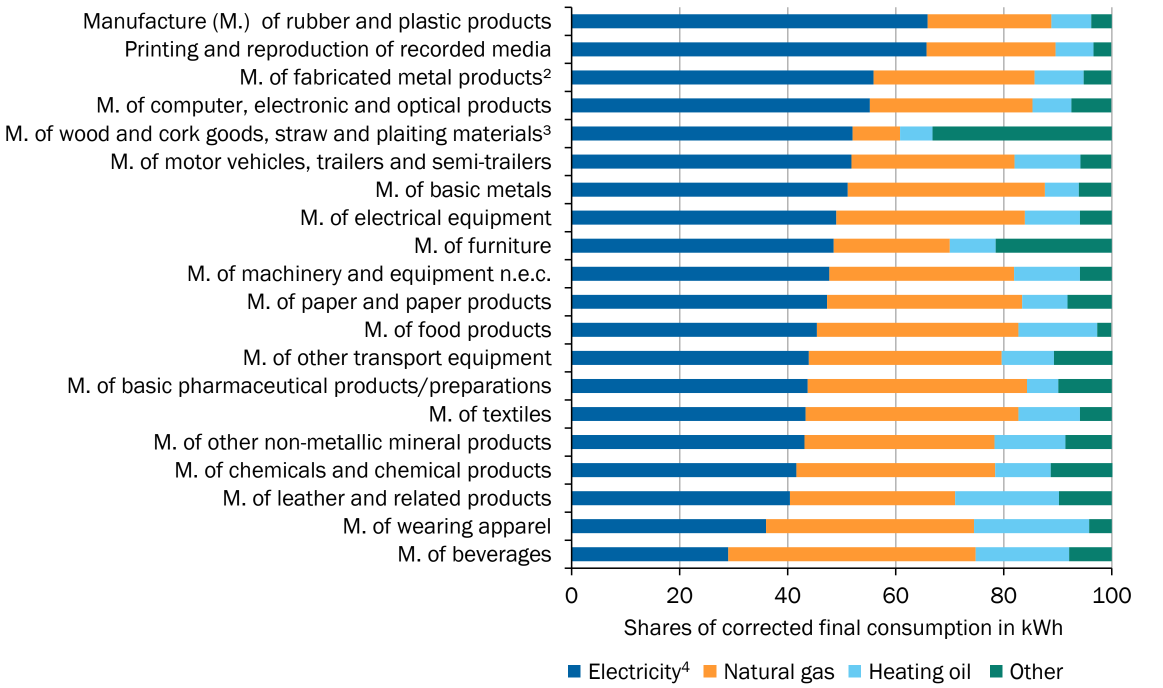
↘ BACKGROUND INFO 18

Official Firm-Level Data for Germany

Detailed information on the **consumption of the different energy carriers** by German industry is provided by the Official Firm-Level Data for Germany ('AFiD data'). These data are collected by the Federal Statistical Office for **all manufacturing companies in Germany** with more than 20 employees, and are currently available up to 2018. In addition, the AFiD dataset's cost-structure module provides information on turnover, the production inputs used and value added for a sample of up to 18,000 (depending on the year) firms in the manufacturing sector (Federal Statistical Office, 2019). In our own analysis, we looked at firms from the manufacturing sector that took part in the cost structure survey in the years 2016 to 2018. The sample analysed comprises around 12,000 firms. The survey on energy use is conducted at the plant level and aggregated at the firm level. Energy use was analysed according to the methodology of Rottner and von Graevenitz (2022b) to correct conversion losses and avoid double counting. In the case of firms that use fuels to generate electricity, the fuels and the resulting self-generated electricity would otherwise be counted twice.

↘ CHART 90

Energy consumption by companies for selected economic sectors in manufacturing[1]
Based on average values from the years 2016-2018



1 – According to classification of economic activities, 2008 edition (WZ 2008). 2 – Except machinery and equipment. 3 – Manufacture of wood and of products of wood and cork, except furniture; Manufacture of articles of straw and plaiting materials. 4 – The electricity share includes an estimate for the self-generated electricity of individual companies.

Sources: FDZ der Statistischen Ämter des Bundes und der Länder, AFiD-Panel Industrieunternehmen 2001–2018 sowie AFiD-Modul Energieverwendung 2005–2018, own calculations

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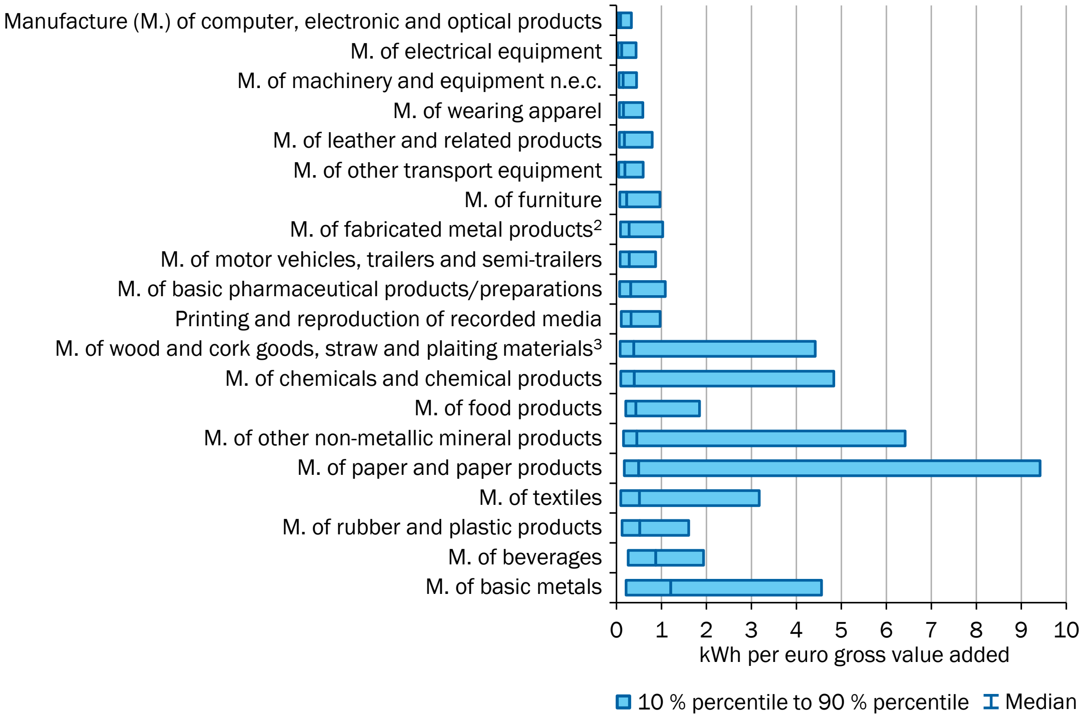
↘ CHART 91

Energy intensity by selected economic sectors in manufacturing[1]

Based on average values from the years 2016–2018



1 – According to classification of economic activities, 2008 edition (WZ 2008). 2 – Except machinery and equipment.
3 – Manufacture of wood and of products of wood and cork, except furniture; Manufacture of articles of straw and plaiting materials.

Sources: RDC of the Federal Statistical Office and Statistical Offices of the Länder, AFiD-Panel Industrieunternehmen 2001–2018 and AFiD-Modul Energieverwendung 2005–2018, own calculations

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Importance of different energy carriers for industry

316. The energy data on which the GCEE's analysis is based show that **electricity is of outstanding importance** for industry. ↘ CHART 90 In all industries, with the exception of beverage production, electricity accounts for 35 % or more of the energy used, whereby electricity is often generated directly by the firms themselves. The share of self-generated electricity rose from 14 % to 21 % between 2003 and 2014 (Rottner and von Graevenitz, 2020). About 70 % of the firms use natural gas, and the share of natural gas in total energy consumption exceeds 22 % in all industries except the production of wood and wood products. One third of the firms use heating oil.

317. **Energy intensity** – measured as energy used in kWh per euro of gross value added (GVA) – **varies greatly** within manufacturing, **both between industries and within an industry**. ↘ CHART 91 The lowest energy intensity is in the manufacture of data-processing equipment, electronic and optical products. The highest intensity is in energy-intensive metal production and processing. There are large differences within the chemical industry. The median energy intensity in the basic chemicals industry is 1.3 kWh per euro of GVA, whereas in the production of paints, printing inks and adhesive cements it is only 0.3 kWh per euro of

GVA. In the paper industry, energy intensity is highest in the production of pulp, paper, cardboard and paperboard, at 6.8 kWh per euro of GVA.

Energy cost intensity of different economic sectors

318. The **importance of energy costs** can be illustrated by their share of **a firm's total costs** (material input, personnel costs, depreciation and other costs) **or** by **how high energy costs are compared to turnover**. On average, these two measures are 8.5 % and 2.3 % respectively for the firms studied. However, energy consumption is very heterogeneous and skewed across the firms: average consumption is higher than consumption in the 90th percentile, ↘ GLOSSARY i.e., average consumption is strongly driven by the 10 % of firms with the highest consumption. For the median firm, ↘ GLOSSARY energy costs account for only 4.7 % (1.6 %) of costs (of turnover).

The share of energy costs is particularly high in sectors such as beverage production, metal production and processing, glass and glassware manufacture, ceramics, and non-metallic mineral processing. Ceramics firms have the highest energy cost share at 8.7 %; its share of turnover is 8.1 %. In chemical products, basic chemicals reveal the highest figure with an energy cost share of 7.5 %. By contrast, industries such as the manufacture of electrical equipment or mechanical engineering have only low energy costs.

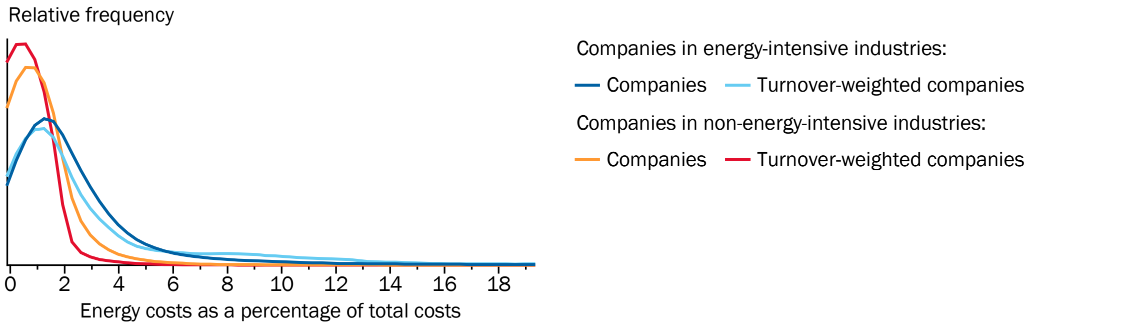
319. The **heterogeneity between and also within the industrial sectors** becomes especially clear when considering the whole distribution of cost shares. While energy costs constitute 1 % of total costs or less for many firms, there are individual firms in each industry where the corresponding share is 8 % and, in some cases, even exceeds 15 %. ↘ CHART 92 BOTTOM The 300 firms with the highest energy costs as a share of total costs are responsible for 40 % of the gas consumption in the industry sample studied.

Relative energy costs also depend on firm size. The firms with the highest turnover in energy-intensive industries tend to use relatively more energy, while the relationship is reversed for non-energy-intensive industries. ↘ CHART 92 TOP This may be partly due to **different technologies used by firms of different sizes**. For example, smaller firms in the steel industry specialise in secondary steel, which is based on recycled steel and therefore requires less energy than primary steel. ↘ CHART 92 MIDDLE

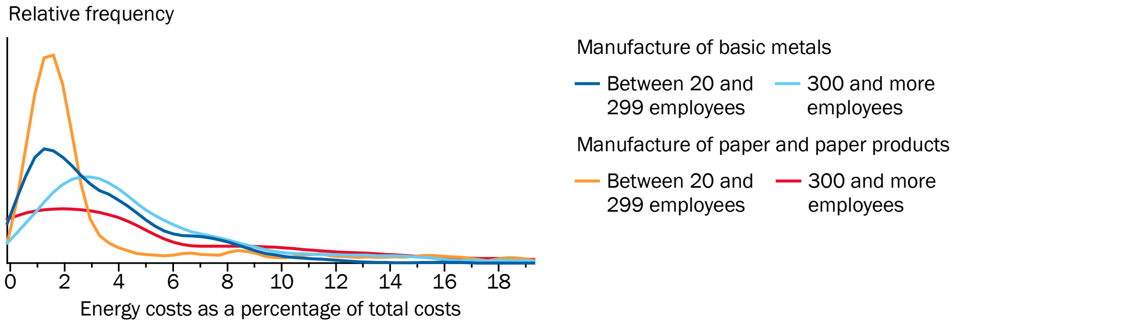
↘ CHART 92

Industrial companies in Germany have very different energy intensities[1]

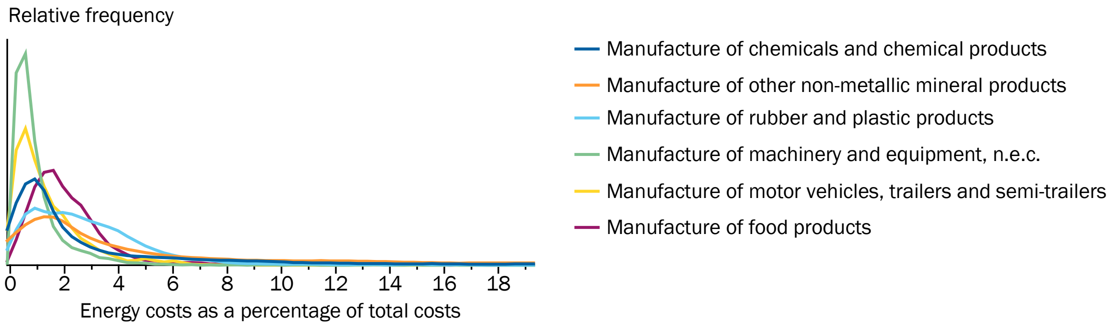
Energy intensity of companies[2]



Companies from the manufacture of basic metals sector and from the manufacture of paper and paper products sector



Companies in other selected economic sectors



1 – The charts show the distribution of energy cost shares of companies in the manufacturing sector according to the Classification of Economic Activities, 2008 edition (WZ 2008). The distributions are based on kernel density estimates. 2 – The non-energy-intensive companies comprise the economic sectors 14, 26, 27, 28, 29 and 30. The energy-intensive companies are the economic sectors 10, 11, 13, 15, 16, 17, 20, 21, 22, 23, 24, 25 and 31. The breakdown is based on the average energy efficiency in the respective economic sectors

Sources: RDC of the Federal Statistical Office and Statistical Offices of the Länder, AFiD-Panel Industrieunternehmen 2001–2018 and AFiD-Modul Energieverwendung 2005–2018, own calculations
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Gas intensity of different products

320. The differences in energy costs within the individual economic sectors are also due to the fact that individual plants manufacture products characterised by widely differing energy intensities. In an expert report for the GCEE, Müller and Mertens (2022) show that the **300 most gas-intensive products per euro of turnover** in the years from 2015 to 2017 were responsible for **90 % of total gas consumption** in the German manufacturing sector and account for 45 % of

↘ TABLE 17

Gas consumption of the 300 most gas-intensive products at 6-digit level[1]
Based on average values from the years 2015 and 2017

	Observations	Mean value	Standard deviation	Minimum	Maximum
Gas consumption (TWh)	300	1.03	1.15	0.19	6.58
Turnover (€ billion)	286	2.70	6.59	0.02	69.30
Gas intensity (kWh/€)	286	1.50	2.75	0.02	26.60
Inverse import substitutability (domestic consumption/world trade without Germany)	249	0.23	0.51	0	5.85
Inverse import substitutability (domestic consumption/world trade without EU)[2]	249	0.43	1.01	0	8.86

1 – According to the list of products for the production statistics, edition 2009 (GP2009). 2 – Exports adjusted for re-exports from the EU. Data on re-exports are incomplete, but play a minor role overall.

Source: Müller and Mertens (2022)
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manufacturing turnover. The production of these products used 310 TWh of gas per year. The gas intensity of the 300 products range from 0.02 kWh to over 26 kWh per euro of turnover. ↘ TABLE 17 The products with the highest gas intensity are in the basic chemicals sector. To estimate how high the loss of sales would be if production were curtailed, sales and gas intensity must be considered together. Müller and Mertens (2022) show that high-turnover products have a relatively low gas intensity, so that the direct sales losses would not be particularly high if gas-intensive production were to be restricted. However, they do not consider other consequences in the supply chain, which can have potentially serious impacts.

2. Effects of rising energy costs

321. Energy costs have increased significantly in recent years. If the firms had had the same energy consumption in 2021 as in 2017, the higher prices for natural gas and electricity observed between the first and second half of 2021 would have caused additional costs of **€1.79 billion** for the firms studied. The increases were particularly high for large firms: while customers with the smallest energy consumption had to pay around 3 % more per kWh in the period under review, prices for customers with a consumption of over 150 gigawatt hours (GWh) rose by 50 %.

Implications of higher energy costs for gross margin and product mix

322. In order to understand the extent to which firms are affected by higher energy prices, the GCEE carried out **simulations**. They show how high the **additional burden is relative to the gross margin**, the estimated EBITDA, ↘ GLOSSARY depending on the potential electricity and gas costs increases. A highly simplifying assumption is made here that the cost increase cannot be passed on to consumers

↘ TABLE 18

Share of cost increase in gross margin in the manufacturing sector[1]

%

		Increase in the cost of gas						
		+ 100 %	+ 200 %	+ 300 %	+ 400 %	+ 500 %	+ 600 %	+ 700 %
Increase in the cost of electricity	+ 100 %	32	37	42	47	52	58	63
	+ 150 %	45	50	55	60	66	71	76
	+ 200 %	58	63	69	74	79	84	89
	+ 250 %	72	77	82	87	92	97	103
	+ 300 %	85	90	95	100	105	111	116
	+ 350 %	98	103	108	114	119	124	129

1 – Based on average values from 2016–2018. Red indicates a greater increase in costs relative to the gross margin, yellow a medium increase and green a smaller increase.

Sources: RDC of the Federal Statistical Office and Statistical Offices of the Länder, AFiD-Panel Industrieunternehmen 2001–2018 and AFiD-Modul Energieverwendung 2005–2018, own calculations

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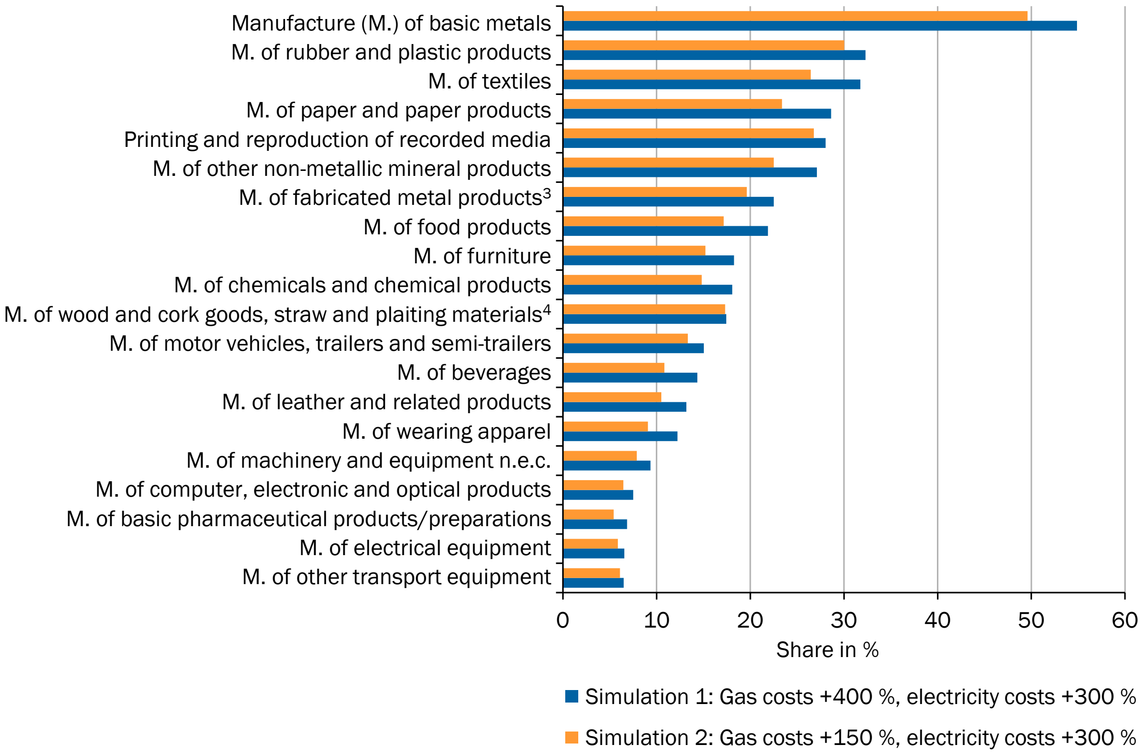
through price increases. The simulations thus represents a worst-case consideration of the direct effects of the energy price increase. In the first simulation, an increase in electricity costs of 300 % and gas costs of 400 % is assumed based on the development of the price indices for industrial customers. ↘ CHART 79 In this case, the additional costs would represent on average 100 % of the gross margin for all the firms studied. ↘ TABLE 18 Looking at the different economic sectors, it becomes clear how differently the firms would be affected by such an increase. In **metal production**, such a cost increase without passing on costs would mean that **55 % of the firms** that previously had a positive gross margin **would have a negative gross margin**. ↘ CHART 93 The energy-intensive industries manufacturing glass and ceramics, paper and textiles would be equally seriously affected. In a direct comparison, the **second simulation** assumed an increase in gas costs of only 150 %, simulating the introduction of a cap on gas price of around 12 cents per kWh. Electricity costs are simulated with an increase of 300 %. Compared to the first simulation, this shows a reduction in the number of firms with a negative gross margin. The simulation makes it clear that an increase in electricity prices places a heavy burden on firms in the manufacturing sector.

323. At the product level, Müller and Mertens (2022) estimate that quadrupling of gas prices compared to the years 2015 to 2017 would increase **gas costs** by an average of **12 euro cents per euro of turnover**. For products that can easily be replaced by imports, cost increases of this magnitude would lead to declines in production. A complete **production stop of the most gas-intensive products that can be easily substituted by imports** would lead to a 26 % fall in **total gas consumption in** industry. However, **sales** would only fall by 3 %. Such a production stop could involve considerable frictions because import substitution would cause search and transaction costs.

↘ CHART 93

Share of companies[1] in selected manufacturing industries[2] with a negative gross margin due to the simulated cost increase

Based on average values from the years 2016–2018



1 – Of companies that had a positive gross margin on average in 2016–2018. 2 – According to classification of economic activities, 2008 edition (WZ 2008). 3 – Except machinery and equipment. 4 – Manufacture of wood and of products of wood and cork, except furniture; Manufacture of articles of straw and plaiting materials.

Sources: RDC of the Federal Statistical Office and Statistical Offices of the Länder, AFiD-Panel Industrieunternehmen 2001–2018 and AFiD-Modul Energieverwendung 2005–2018, own calculations

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324. It is clear from the data that the current development of energy prices can drive up production costs, especially in the **metal production and the manufacture of glass and ceramics, paper and textiles**. In the short term, costs can be stabilised by hedging transactions. Data from the Federal Office for Economic Affairs and Export Control (BAFA) show that average gas import prices – at €64 per MWh in June and around €104 per MWh in July – were well below the spot price (BAFA, 2022c). However, the longer prices remain high, the smaller the percentage of firms protected by long supply contracts. The extent to which cost increases will affect the competitiveness of individual firms will depend on the situation of their competitors. If they are exposed to similar price increases, the competitive situation may remain unchanged.

International competitive environment

325. Since energy **prices within the EU** are **relatively strongly linked, unlike between Germany and the USA** for example, the effects of current price developments on competition within the EU are likely to be relatively moderate. Nevertheless, a relocation of production among the EU member states cannot be

ruled out. For example, French aluminium producers have complained about a competitive disadvantage relative to Spanish producers due to changes in pricing on the Spanish electricity market (Moussu, 2022b).

↘ BACKGROUND INFO 19

Competitive environment

In order to understand the competitive environment in individual sectors of the economy, the GCEE used Eurostat data to identify the **countries of origin of imports to Germany**. In addition, it identified the **export markets of the German firms** and determined the origin of the other exporters active in these markets. A distinction was made as to whether the competitors came from the EU or from non-European countries. The exposure to non-European competitors was quantified as the aggregate market share of non-European competitors (in the case of exports weighted by the volume of the German firms' exports to the individual foreign markets). ↘ TABLE 19

326. **Core factors influencing** potential **exposure to current energy price shocks** are: energy efficiency, relevance of natural gas consumption (measured in terms of natural gas costs as a percentage of energy costs), margin for covering additional costs (measured as gross margin), and exposure to non-European competitors. ↘ TABLE 19 The cells highlighted in red in the table mark the industries facing the highest risks based on the individual factors. The table also shows the economic relevance of the individual industries, measured by their annual turnover as well as the number of firms. Industry-specific features, such as the impact of integrated production facilities (chemical products) or overcapacities (steel industry) on the degree to which firms are affected by the energy crisis, cannot be taken into account here.

327. Looking exclusively at **energy efficiency** and the share of **natural gas costs in** total energy costs, we can see that firms in energy-intensive industries – such as the production of beverages and food, the manufacture of chemical products, paper, glass and ceramics as well as metal production and processing are currently expected to experience particularly sharp cost increases. They could thus be classified as particularly affected.

In principle, firms can try to pass on these additional costs to their customers. This is especially important for firms with low **margins** that would otherwise incur immediate losses. The degree of **exposure to non-European competitors** in particular can be expected to limit the scope for cost pass-through in the current situation. There are industries that are affected by high energy costs but may be able to pass on the costs without losing market share to non-European competitors. For example, the production of beverages and food, while potentially severely affected due to low energy efficiency, is not subject to high competitive pressure at home or abroad. It can therefore be assumed that it will be able to pass on most of the increased costs to end customers. By way of contrast, relatively high margins can be observed in the manufacture of chemical products. However, firms in this industry are highly exposed to non-European competitors.

↘ TABLE 19

Indicators for the potential impact in the manufacturing sector in Germany[1]

Economic sector in the manufacturing industry[2]	Turnover Euro billion (number of companies)[3]		Energy intensity[4]	Share of natural gas costs in energy costs[5]	Gross margin[5,6]	Exposure to non-EU competitors[7]	
						Foreign markets[8]	Domestic market[9]
			kWh / Euro GVA	%			
Manufacture of food products	168.13	(5,070)	0.43	20.0	14.8	33.9	20.9
Manufacture of beverages	22.64	(472)	0.87	30.3	23.4	27.1	13.2
Manufacture of textiles	12.14	(670)	0.51	26.7	13.4	47.5	48.8
Manufacture of wearing apparel	7.49	(226)	0.16	25.0	20.4	37.9	51.5
Manuf. of leather, related products	3.89	(119)	0.18	28.6	16.1	37.7	36.3
Manuf. of wood and of products[10]	21.45	(1,022)	0.39	2.1	11.0	35.5	23.5
Manuf. of paper and paper products	43.57	(771)	0.48	22.5	15.6	23.3	15.5
Manuf. of chemicals, chemical products	166.21	(1,288)	0.39	20.0	30.3	41.2	28.4
Manuf. of basic pharmaceut. products[11]	62.53	(287)	0.31	18.8	28.3	32.4	26.5
Manuf. of rubber and plastic products	90.04	(2,976)	0.52	7.1	17.9	36.4	31.9
Manuf. of other n.-met. min. products[12]	47.69	(1,576)	0.45	31.7	17.3	42.4	37.2
Manufacture of basic metals	108.00	(922)	1.19	20.9	7.5	43.9	31.5
Manuf. of fabricated metal products[13]	124.32	(7,388)	0.28	17.4	13.8	38.9	37.7
Manuf. of computer, electron. products[14]	89.14	(1,738)	0.09	9.1	19.5	50.5	40.9
Manufacture of electrical equipment	121.21	(1,974)	0.12	11.1	21.1	55.1	47.2
Manuf. of machinery, equipment n.e.c.	289.03	(5,542)	0.15	10.0	17.0	40.1	42.9
Manuf. of motor vehicles, trailers[15]	509.37	(1,054)	0.28	14.3	29.6	41.5	22.7
Manuf. of other transport equipment	49.81	(296)	0.18	21.4	9.0	44.5	49.6
Manufacture of furniture	19.49	(949)	0.23	4.5	10.9	33.2	32.5

1 – The colour scheme is based on the distribution of the individual variables between the sectors and was conducted based on terciles, whereby red/yellow/green corresponds to a division of the affectedness of a strong/medium/low effects. Data, with the exception of exposure to non-EU competitors, refer to the arithmetic mean of the individual economic sectors. 2 – According to the classification of economic activities, 2008 edition (WZ 2008). 3 – As of 2018. 4 – Median values from 2016 to 2018. 5 – Average values for the years 2016 to 2018. 6 – Ratio of EBITDA to revenue. 7 – As of 2021. 8 – Average across all countries: Share of imports from non-EU27 countries in total imports, weighted by the respective imports from Germany. 9 – Share of imports from non-EU27 countries in total imports of Germany. 10 – Products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials. 11 – And pharmaceutical preparations. 12 – Manufacture of other non-metallic mineral products. 13 – Except machinery and equipment. 14 – And optical products. 15 – And semi-trailers.

Sources: Eurostat, Federal Statistical Office, RDC of the Federal Statistical Office and Statistical Offices of the Länder, AFiD-Panel Industrieunternehmen 2001–2018 sowie AFiD-Modul Energieverwendung 2005–2018, UN Comtrade, own calculations
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328. **Metal production and processing, the manufacture of glass and ceramics** and, to a slightly lesser extent, the manufacture of fabricated metal products are strongly affected in **all** dimensions. In the case of metal production and processing, there are three sectors: ferrous metals, especially steel; non-ferrous metals, such as aluminium, copper or zinc; and foundries. Foundries in particular use a large amount of energy. Gross margins in this sector are particularly low and

competitive pressure is high both at home and abroad. A similar picture emerges in the manufacture of glass and ceramics. In addition to glass production, this includes in particular the manufacture of ceramics and porcelain as well as products made of cement, gypsum and concrete. The industry's energy efficiency is particularly low and it is under relatively high competitive pressure from non-European competitors. The manufacture of textiles is also strongly affected in all areas, but its turnover is comparatively small.

329. When assessing Germany's future attractiveness as a location for manufacturing, it must be taken into account that energy prices are **only one of many location factors** and that other factors, such as proximity to customers, can be decisive in the case of highly specialised products. This may be one reason for the weak correlation between energy prices and competitiveness found in the economic literature. ↘ BOX 19 In addition, the prices of energy carriers can be expected to converge internationally in the long term, and industry could switch to decarbonised technologies. ↘ BOX 16

↘ BOX 19

Findings from empirical studies on the correlation between energy prices and the competitiveness of firms

The relationship **between energy prices and** various **indicators of competitiveness has been the subject of numerous empirical studies.** For example, studies have examined how energy prices affect profitability (Rentschler and Kornejew, 2017), investment (Ratti et al., 2011), productivity (Marin and Vona, 2021) and employment (Hille and Möbius, 2019; Marin and Vona, 2021; Bijnens et al., 2022). These studies often show a **negative relationship**, **that is, however, usually very small or even insignificant** (Venmans et al., 2020).

A **shift in economic activity** as a result of energy costs has only been investigated in a few empirical studies to date. Again, however, energy prices do not appear to be among the main drivers of global trade flows. For example, Sato and Dechezleprêtre (2015) show that a 10 % increase in the difference between energy prices in two countries only led to a slight increase in imports (by 0.2 % on average) in the individual manufacturing sectors.

However, the **estimated effects are very heterogeneous**, with particularly strong effects in energy-intensive industries (Sato and Dechezleprêtre, 2015; Hille and Möbius, 2019; Marin and Vona, 2021; Bijnens et al., 2022; Rottner and von Graevenitz, 2022a). For example, Manderson and Kneller (2020) show that closures of manufacturing plants as a result of a relative increase in energy prices in the UK have occurred mainly in the most energy-intensive industries.

In many studies, it remains unclear whether only the price developments in the countries in the analysed sample were considered or whether the price level of competitors was also controlled for. In analyses that clearly take **asymmetric energy price changes into** account, the estimated effects tend to be more negative. For example, Marschinski et al. (2020) show that oil refinery closures in the EU between 2009 and 2013 were mainly due to the increase in energy prices in Europe relative to the rest of the world. Garsous et al. (2020) estimate that for firms listed on the stock exchange, a relative increase in domestic energy prices of 1 % is associated with an absolute increase in foreign assets of just under 0.7 %. Since the foreign direct investments of these firms have been relatively small up to now, the shift in economic activity is also relatively small.

When interpreting the study results, it must be noted that the estimation models **assume**

linear effects. Should the effects increase disproportionately with the price change, the empirical studies would therefore depict a lower limit of the possible effects. Furthermore, the variations in energy prices in the years to which most of the studies refer were moderate compared to the current price asymmetries.

Another caveat is that the studies to date predominantly **do not distinguish between transitory and persistent price increases**, yet these can have different degrees of effect. Given that current developments are expected to result in longer-lasting price increases, the studies may tend to underestimate the impact of price increases. ↘ ITEM 302

330. By making changes in manufacturing processes, changing technology or switching fuels, firms can partially **cushion the rise in costs** associated with the energy price increase and thus counteract the decline in their competitiveness. For example, Rottner and von Graevenitz (2022a) show empirically that when grid charges rise, German firms shift their production to plants that are less affected by cost increases. In addition, plants are increasingly generating their own electricity. A one-cent increase in grid charges reduces industrial electricity purchases from the grid by 3 %.

Adjustments can also be made to the **composition of production factors**. Especially in the long run, fossil energy is substituted by capital and labour, as models on the oil crises of the 1970s illustrate (Hassler et al., 2021). Firms can also compensate for rising energy costs by cutting other costs. For example, using AFiD data, Mertens et al. (2022) estimate that a 10 % increase in energy prices in German firms is associated on average with a 2.7 % reduction in average salaries.

331. **In the long term, research and development** and the **innovations** they trigger can **improve adjustment options**. A large number of studies show a positive correlation between energy prices and innovations, especially in the field of energy efficiency (Popp, 2002) and in the building sector (Constantini et al., 2017). This is reflected, among other things, in higher patent activity – an effect that is consistent across different industries and countries (Ley et al., 2016). Price developments can thus influence the direction of technological progress (Aghion et al., 2016). After the oil price shocks of the 1970s, the rate of energy-saving technological progress rose sharply (Hassler et al., 2021; Gemeinschaftsdiagnose, 2022).

The number and variety of location factors as well as the possibilities for adjustment make it difficult to **estimate** whether and to what extent the current energy price developments will lead to a **relocation of industrial value creation.** According to evaluations by the IW Cologne, Germany is one of the world's best industrial locations: it is among the leading economies particularly in terms of the depth and size of its market and the quality of its infrastructure, but also in areas such as government, resources and knowledge (Bähr and Bardt, 2021). ↘ BOX 22 In the future, it will be important to at least partially offset the negative effects of energy prices by expanding these advantages, for example by securing the supply of skilled labour. ↘ ITEM 355

V. OVERCOMING THE ENERGY CRISIS AND IMPROVING PROSPECTS FOR INDUSTRY

332. Following the sharp rise in energy prices, there has been increasing **concern** that **Germany** could **become deindustrialised** (Gillespie et al., 2022; The Economist, 2022). Production has fallen significantly in some energy-intensive sectors. ↘ ITEM 59 The situation has become increasingly gloomy since the summer. The ifo index in which industrial sectors assess their own competitive situation has also worsened significantly. ↘ ITEM 57 The Expert Commission on Gas and Heat (ExpertInnen-Kommission Gas und Wärme) has proposed measures to limit the cost of gas. Their aim is to reduce the cost of gas for a certain consumption quota for all firms to the cost level expected in the medium to long term. ↘ ITEM 345 This would make it easier for firms that have a viable business model at these higher, long-term prices to get through the period of significantly higher gas prices experienced in the short term.

Energy-policy measures

333. The extremely high energy prices in Europe and Asia are a result of the current shortage of fossil fuels in these regions of the world, which is expected to continue at least until spring 2024. ↘ CHART 83 Various measures to **strengthen energy supply** and **reduce energy demand** can help relieve the immense price pressure. The accelerated development of LNG import infrastructure was already an important step towards improving the security of supply. ↘ BOX 14 Now the procurement of LNG must be driven forward to ensure the maximum possible capacity utilisation of the LNG terminals. This will require the corresponding delivery contracts with new suppliers. ↘ ITEMS 282 AND 301 **Joint procurement** with additional EU member states could allow greater diversification at better conditions based on larger procurement volumes. In the case of contracts without a destination clause, ↘ ITEM 288 long contract periods could be accepted, since gas that is no longer needed in the EU can be used in other regions of the world in the long term.

334. **As much power plant capacity as possible** should be mobilised **in the short term** in order to displace gas-fired power plants on the electricity market, and thus save gas and reduce electricity prices at the same time. This would move the currently expensive gas-fired power plants further up the merit order, ↘ BOX 15 so that they are less likely to set prices. Short-term measures that could help here would be: meeting the ambitious expansion targets for renewable energies, mobilising the coal-fired power plants that are currently being held in reserve and in a state of operational readiness, and extending the operating lives of nuclear power plants (NPPs). Estimates vary on the effects these measures would have on the price of electricity.

335. In a short- and medium-term analysis of the European electricity market up to 2027, Egerer et al. (2022b) come to the conclusion that these measures could **reduce the average electricity price** in Germany and also in neighbouring countries by up to 15 %. Prolonging the operating lives of NPPs alone could itself

cut prices by 8 to 12 % (Egerer et al., 2022b). Mier (2022), by contrast, puts the price reduction at only about 4 % in 2023 and just under 2 % in the two following years. According to the studies, prolonging NPP operating lives would also contribute to a significant reduction in coal-fired power generation and thus in the carbon price in the coming years (Egerer et al., 2022b; Mier, 2022). An extension beyond 15 April 2023 would therefore help ease the tension on the electricity market. Extensive safety reviews would be necessary for such an extension (BMWK and BMUV, 2022b). According to TÜV Süd (2022), however, there would be no safety concerns about the continued operation of the Isar 2 nuclear power plant, and any safety-relevant measures could be implemented during operation. Against this background, the Federal Government should carefully examine whether prolonging its operating life beyond 15 April 2023 is possible.

336. Egerer et al. (2022b) also examine the effects that different expansion pathways for renewables would have on the electricity price in 2024 and in 2027. Speeding up the expansion of renewable energies, ensuring that the Government's 'Easter Package' expansion targets (BMWK, 2022e) would be reached, would only reduce the electricity price by between 1.6 % and 2.5 % in 2024. In 2027, however, achieving the targets of the Easter Package would significantly reduce the electricity price – by up to 13 % compared to the reference scenario. This confirms that the expansion of renewable energies is an important lever **for limiting electricity price increases**, but can only make a limited contribution to easing the situation on the electricity market in the short term. It is also crucial to **forge ahead with the expansion of renewable energies throughout Europe**.

337. In order to accelerate the expansion of renewables and quickly end the temporary use of coal and nuclear power plants, **regulatory uncertainties for investors**, e.g., caused by plans to adjust the design of the energy market, should be **avoided**. ↘ BOX 15 Investment in new power generation plants could be promoted if investments can be deducted from the profit to be skimmed off under the plan to skim off windfall profits (Bundesregierung, 2022d), or if new assets are exempted from skimming off. If the expansion targets laid down in the Federal Government's Easter Package are reached, the aim of phasing out fossil fuels by 2030 – as envisaged in the coalition agreement – could also be achieved (Egerer et al., 2022a). A price reduction can be achieved in the medium term if renewables' share of electricity generation increases.

338. **Improvements in planning and approval procedures** (GCEE Annual Report 2020 Box 10; GCEE Annual Report 2021 item 203) can accelerate the expansion of renewable energies (Krüger et al., 2020; BDEW, 2021; Schäfer et al., 2022). In recent years, the Federal Government has already adopted targeted measures such as the Investment Acceleration Act (Investitionsbeschleunigungsgesetz) and the 2022 Easter Package (Osterpaket), aimed at shortening legal processes or **giving renewables priority when balancing legally protected interests**. Furthermore, **concentrating legal responsibility** for approval procedures – e.g., at a higher level such as the district or state level or in dedicated task forces – could contribute to acceleration of the renewables expansion. Furthermore, a 'legal fiction of completeness' could accelerate the start of approval procedures, and a 'legal fiction of approval' after the expiry of official deadlines

could expedite the start of projects (BDEW, 2021). In addition to speeding up procedures, it is important to **expand the amount of land that can be used** for renewable energy. The Easter Package's restriction of the federal states' escape clause in section 249 of the Federal Building Code in the event of non-achievement of the expansion targets is expedient in this regard. The Federal Government's efforts to abolish the 10-H rule in Article 82 of the Bavarian Building Code could also contribute to a faster expansion of renewable energies.

339. In addition, **measures** should be taken to reduce **demand for energy** in general **and** for **gas** in particular in order to reduce the high energy prices – and thus also the burden on industry. Firms are already limiting their gas consumption due to the high prices and are increasingly implementing energy efficiency measures. ↘ ITEM 306 However, households are not likely to respond fully to the price incentives, e.g., because, as tenants, they may be unaware of the high prices until they receive their annual bill. Firms with longer-term contracts with utilities, for example in retail or services, and the public administration, may also currently still have little incentive to reduce gas consumption. Further measures with a demand-reducing effect should therefore also be implemented soon in these sectors to prevent a gas shortage. Suitable measures include motivating actors in these sectors to use less gas and find the necessary information, measures well as enabling the actors to save gas, as well as issuing regulations on gas consumption. The latter could include lowering heating temperatures or making obligatory checks on the settings of heating systems. The introduction of gas-saving premiums could also be considered. If the savings incentives do not have a strong enough effect, some of the measures used in Japan after the Fukushima disaster could be considered. For example, mandated energy savings targets for individual actors could contribute to a solution in such a case. ↘ BOX 17

340. The future prospects of industry in Germany depend to a large extent on energy policy and not least on the availability of cheap, climate-friendly energy sources. Since in future almost all industries will have to use either renewable electricity, green hydrogen or a mixture of both, **measures that ensure low costs for these energy sources in the long term** will be of **outstanding importance for industry.** ↘ BOX 16 Increasing supply by accelerating the expansion of renewables, making the demand for electricity more flexible and expanding hydrogen and electricity infrastructures can help lower energy prices. ↘ BOX 18 Infrastructure expansion should cover not only transmission but also distribution grids ↘ GLOSSARY. Already today, the installation of photovoltaic systems is often prevented by the limited capacity of the distribution network (Müller, 2022). In addition, energy infrastructure planning must be more integrated (Board of Academic Advisors to the BMWi, 2020; EWK, 2021; dena, 2022) instead of assessing individual energy sources separately. ↘ BOX 15 The state will have a regulatory and coordinating role in infrastructure development, especially in the European context, as infrastructure planning should take place at EU level whenever possible (Altgelt and Albicker, 2022).

341. Even before the energy crisis, relative energy prices were distorted by taxes and levies, favouring fossil fuels relative to electricity (GCEE Special Report 2019 items 72 ff.) and slowing down the electrification of industry. The abolition of the

EEG surcharge is a correct step towards reducing **price distortions and sector coupling**. A further step might be to reduce the electricity tax to the European minimum tax rate (GCEE Annual Report 2020 item 391).

Direct support measures for firms

342. In view of the sharp rise in energy prices, there have been increasing calls for **government support measures for industry**. Unlike in the case of the coronavirus pandemic, however, support for firms should **not** be about **maintaining the status quo**. Rather, the instruments should **accompany the transformation** to a new equilibrium. For example, relief instruments should be based on future expected prices, such as futures prices, not on past energy prices.

343. Up to now, in addition to financing instruments (state guarantees, margining financing instruments ↘ GLOSSARY) and simplified approval procedures for fuel switching, the government has mainly used instruments that are intended to directly reduce energy costs. For example, the **abolition of the EEG surcharge**, the extension of peak balancing, ↘ GLOSSARY the energy cost containment programme and the proposed **electricity- and gas-price brakes all reduce the effective costs of many energy carriers**.

344. **Relief measures** that **cut marginal energy costs reduce incentives to save energy**; in this way, they increase shortages on the natural gas and electricity markets. Flat-rate payments, e.g., depending on (weather-adjusted) energy consumption in 2021, would therefore be more beneficial. Although the energy cost containment programme provides for regulations stating that payments are conditional on the introduction of energy management systems or the implementation of economic energy efficiency measures (BAFA, 2022d), it is unclear to what extent these measures trigger additional energy savings, especially in the case of large, energy-intensive firms. At the same time, in addition to a considerable administrative burden on state authorities, such requirements also cause additional work for firms because, in many cases, new cost calculations for energy efficiency measures are imposed (BAFA, 2022d).

345. The proposals of the Expert Commission on Gas and Heat envisage that **large firms** with a registered load profile measurement (metering) system (RLM), i.e., an annual consumption of more than 1.5 million kWh, receive a **subsidised quota** dependent on the previous year's consumption (“Gaspreisbremse”, ExpertInnen-Kommsission Gas und Wärme, 2022). The quota amounts to 70 % of their previous year's consumption at a procurement cost of 7 cents per kWh – plus approximately 5 cents per kWh for levies, taxes and fees. The firms can use their quota themselves or sell it on the market. Firms that purchase gas from several suppliers or procure it directly on the gas market cannot apply via the supplier, because only the firms themselves have the necessary data to determine the subsidy. The firms therefore will therefore have to file applications with a state authority themselves (ExpertInnen-Kommission Gas und Wärme, 2022).

346. The quotas only offer firms the full **incentive to save energy if actual consumption is above the quota** or if firms **can sell their quota on the market**. In the case of the design envisaged by the Commission, which provides for a quota of 70 % as well as the possibility of selling on the market, the savings incentive should, in principle, be sufficient to maintain industry's previous savings of 20 % ↘ CHART 81.

347. The **conditions proposed** by the Expert Commission on Gas and Heat (ExpertInnen-Kommission Gas und Wärme, 2022) **for firms to benefit** from the gas-price brake allow for a **location and transformation agreement** for firms with board-level employee participation. Firms with no such participation must keep at least 90 % of their jobs for at least one year after the gas-price brakeis no longer applied. These conditions are expedient as they prevent support going to firms that intend to relocate their production anyway under the expected higher prices in the future.

Further conditions are under discussion and **should be carefully considered**. For example, a **restriction of dividends and bonus payments** would be possible, similar to the conditions attached to the coronavirus assistance programs. The argument in favour of this would be that it would ensure that only firms that cannot overcome the gas crisis on their own take advantage of the aid. The argument against it would be that decision-makers could follow a personal calculation in such an arrangement instead of fully considering the well-being of the firm. This could result in state aid being rejected, even though it would be necessary from the point of view of the firm or the economy as a whole.

Lastly, consideration could be given to introducing a **cap up to which the rebate is paid** to ensure that decision-makers do not drive up procurement costs. A cap on subsidies is also set by the EU's Temporary Crisis Framework, the revision of which was published at the end of October 2022 to take into account the specific challenges of the energy crisis (Temporary Crisis Framework, European Commission, 2022f). It also sets out conditionalities. According to this, firms are eligible for aid, for example, if they have a negative EBITDA or their EBITDA is 40 % lower than in 2021. Furthermore, the percentage of subsidisable energy costs was expanded, as were the upper limits for subsidies. The gasprice brake would have to be brought into line with this regulation.

348. Based on analyses of the AFiD data, the gas consumption of approximately 75 % of the industrial firms in the sample is below the threshold of 1.5 million kWh, so that their consumption is not measured via RLM but via **standard load profiles** (SLP), ↘ GLOSSARY as is the case with households and firms in trade and commerce. In this case, the Expert Commission's proposal for the **gas price brake** allows for the purchase of a **quota of 80 % of the annual consumption forecast based on the September 2022 predictions** at a reduced price of 12 cents per kWh. The design does not differ from that for households, so that **gas-saving incentives** are **essentially guaranteed**. ↘ ITEM 62 However, in contrast to the regulation for RLM customers, there is no provision for the rebate paid by the suppliers to consumers to exceed the gas bill over the year. Thus, the **incentive to save for firms that greatly reduce their consumption** is **limited**. In

particular, the incentives for a fuel switch, which could potentially reduce gas consumption to 0 kWh, would be significantly reduced. This is because the investment costs of a fuel switch would be incurred, but no relief would be granted by the gas price brake if gas consumption is greatly reduced. To compensate for this, specific subsidy programmes could be launched, but these would again involve considerable administrative costs.

349. Both the effects of **lump-sum payments** and a **general reduction in energy costs** are **only targeted in some respects**. Firms that suffer only limited price changes, because they can pass on the additional costs in full, receive more or less the same support amount as those that have to absorb the cost increases through lower returns. While the energy cost containment programme partially addresses this inefficiency by giving different levels of support to firms with and without operating losses, some differentiation will have to be made in the gas- and electricity-price brakes due to the EU's revised Temporary Crisis Framework. The fact that the subsidies are not precisely targeted is understandable, since a more targeted solution would be difficult to administer, but it is unsatisfactory in view of limited funding resources.

Climate policy support measures

350. Measures that **accelerate the transformation away from fossil fuels** can also make an important contribution to overcoming the crisis. These include innovation policy instruments (GCEE Annual Report 2019 items 253 ff.) such as government support for demonstration and pilot projects (Kotchen and Costello, 2018) and subsidies and incentives in the field of energy efficiency. ↘ BOX 17

351. For example, investment subsidies could **accelerate the switch to climate-friendly energy sources** in order to move away more quickly from expensive natural gas. Carbon Contracts for Differences (CCfD), depending on their design, could provide support for both investment costs and operating costs. However, the regulatory challenges associated with CCfD are large (GCEE Annual Report 2020 item 467).

352. In order to speed up the transformation to climate neutrality, regulatory hurdles should be further reduced. To date, there is no **compelling certification for green products** such as green hydrogen or green steel. Such certifications would ensure planning security for investment decisions, so that firms that want to switch to new technologies now do not have to make unexpected adjustments later.

Support for strategically significant economic sectors

353. It is conceivable that the currently planned relief measures for some energy-intensive industries will not be sufficient for them to maintain their economic activities in Germany. Should this **affect economic sectors that are of strategic importance**, targeted industrial policy measures to maintain these economic sectors might be appropriate (GCEE Annual Report 2019 items 267 ff.). ↘ BOX 22

The big challenge, however, will be to **identify the strategically relevant industries and products without being hijacked by particular interests**. Geopolitical aspects are likely to play an important role here, similar to the European Chips Act for the establishment of a modern semiconductor industry in Europe. ↘ ITEM 504 The criteria used to identify strategic relevance should be carefully elaborated in a public consultation process. Once the criteria have been chosen, they should be disclosed and justified in detail. Such support should be subject to the condition that production is kept in Europe.

354. When considering strategically relevant industries, the objective should be the **resilience of European supply chains, not necessarily the resilience of national supply chains**. ↘ ITEMS 507 FF. Preventing the migration of certain industries or production of certain products from the domestic market could be inefficient if these industries are maintained in other EU countries. Within the EU, there are binding contracts that are legally enforceable. State aid law at the EU level also ensures that there are no distortions of competition. **Coordination at the European level** is therefore advisable.

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