



Energy Consumption

in Germany in 2023

Primary Energy Consumption in Germany Dropped Again Significantly in 2023

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Total Primary Energy Consumption

In 2023, the primary energy consumption in Germany amounted to a total of 10,735 petajoules (PJ) or 366.3 million tons of coal equivalents (Mtce); compared to the previous year, this equals a decrease of 8.1 % (please see Table 1).

In 2023, the level of energy consumption as well as its composition (energy mix) continued to be characterized by the consequences of the war in Ukraine and/or the associated noticeably higher energy prices as well as declines in growth and sectoral changes in the German economy. In addition, energy consumption continued to be influenced by political and regulatory requirements at a national or European level. Significant for the medium-term to long-term development are, for example, the gradual phase-out from nuclear energy until the end of 2022 (more specifically within the scope of the officially approved stretch-out operations until April 15, 2023), the initiated phase-out from coal-fired power generation as well as the continued

promotion and support undertaken to expand renewable energy. Relevant at a European level are, for example, the reduction of the maximum quantity of emissions during the fourth trading period between 2021 and 2030 (linear reduction factor 2.2 % per annum instead of 1.74 % per annum as had been the case during the third trading period) within the EU-ETS, the objectives pursued for climate protection in the non-ETS sector,¹⁾ the requirements for improving energy efficiency (for example, the EU Energy Efficiency Directive (EED, Directive 2012/27/EU)), binding targets for the progressive expansion of renewable energy (EU Renewable Energy Directive, Directive (EU) 2018/2001) as well as the Proposal for a Directive of the European Parliament and of the Council Amending Directive (EU) 2018/2001 (Document COM/2021/557).

In 2023 as well, Germany's most important energy carrier continued to be mineral oil with a share of

Table 1

Primary Energy Consumption in Germany in 2022 and 2023 ¹⁾

Energy Carrier	2022	2023	2022	2023	Changes in 2023 Compared to 2022			Proportions in %	
	Petajoules (PJ)		Million Tons of Coal Equivalents (Mtce)		PJ	Mtce	%	2022	2023
Mineral Oil	4,102	3,822	140.0	130.4	-280	-9.6	-6.8	35.1	35.6
Natural Gas	2,721	2,655	92.8	90.6	-66	-2.3	-2.4	23.3	24.7
Hard Coal	1,142	931	39.0	31.8	-211	-7.2	-18.5	9.8	8.7
Lignite	1,168	895	39.9	30.5	-273	-9.3	-23.4	10.0	8.3
Nuclear Energy	379	79	12.9	2.7	-300	-10.2	-79.2	3.2	0.7
Renewable Energy	2,044	2,107	69.7	71.9	63	2.1	3.1	17.5	19.6
Electricity Exchange Balance	-98	42	-3.3	1.4	140	4.8	...	-0.8	0.4
Other	218	204	7.4	7.0	-14	-0.5	-6.4	1.9	1.9
Total	11,676	10,735	398.4	366.3	-941	-32.1	-8.1	100.0	100.0

1) All data are preliminary; discrepancies in the totals are due to rounding off

Sources: Working Group on Energy Balances (AGEB); Working Group on Renewable Energies-Statistics (AGEE-Stat)

1) In this context, CO₂ pricing was introduced in Germany's heating and transportation sectors as of January 2021 within the scope of the Climate Protection Program 2030 (German Fuel Emissions Trading Act – BEHG, Act on National Certificates Trading for Fuel Emissions). Since then, both private and commercial consumers (non-ETS) have had to pay a CO₂ surcharge amounting to € 25 per ton of carbon dioxide content for such energy carriers as fuels, fuel oil, or natural gas. The CO₂ price within this national emissions trading system is to be gradually increased to € 55/t by 2025. The increase in the CO₂ price by € 5 per ton, which had originally been planned for January 1, 2023, was postponed for one year to January 1, 2024, in order not to place an additional burden on private households and the industrial economy against the backdrop of the sharp rise in energy prices (Ukraine conflict). On January 1, 2024, the CO₂ price per ton of carbon dioxide emitted will increase once again to the amount of € 45/t as had initially been intended pursuant to the German Fuel Emissions Trading Act – BEHG, Act on National Certificates Trading for Fuel Emissions. Next year, the price is to go up to 55 euros. As of 2027, the price for CO₂ emissions in the transportation and building sectors is to be linked to the market mechanisms of a European emissions trading system.

35.6 %. It was followed by natural gas with a slightly increased share of 24.7 % when compared to the previous year (2022: 23.3 %). Renewables ended up in third place with a share of 19.6 %; in 2022, their contribution had still been 17.5 %. Compared to 2022, the primary energy consumption of hard coal and lignite dropped by 18.5 % and 23.4 % respectively so that lignite covered approximately 8.3 % and hard coal 8.7 % of the demand for primary energy in 2023. Compared to the previous year, the primary energy consumption of nuclear energy declined by about 79 % in 2023. (Due to the amendment of the German Atomic Energy Act, the decommissioning of the last three nuclear power plant units Isar 2, Neckarwestheim 2, and Emsland, which had initially been scheduled for December 31, 2022, was postponed by three and a half months until April 15, 2023.) As a result of this development, nuclear energy covered still approximately 0.7 % of the demand for primary energy in 2023.

In 2023, 11.8 billion kWh (42 PJ) more electricity flowed from foreign countries into Germany than flowed from Germany into neighboring countries. This made Germany a net importer of electric power for the first time again since 2002. Consequently, the balance in the electricity exchange had a consumption-enhancing effect (by plus 0.4 percentage points) on primary energy consumption in 2023 (in 2022, the electricity exchange balance still had a consumption-reducing effect amounting to minus 0.8 percentage points).

General Conditions for the Development in Consumption in 2023

The development of primary energy consumption depends on numerous influencing factors. These factors include, in addition to changes in the general political and regulatory framework, primarily the macroeconomic and sectoral development (structural change), demographic factors, energy prices as well as temperature fluctuations.

Temperature and Weather Influence

The temperature conditions play, to a large extent, a vital role in non-industrial energy consumption because most of the energy consumed in these sectors is designated for the heating of privately and commercially used rooms. The temperature influence is usually measured with degree day figures; this index reflects – in simple terms – the cumulative temperature differences of those days on which the average temperature falls below a certain level (heating threshold temperature; here: 15 degrees Celsius).²⁾

In 2023, the number of degree days was noticeably below the level of the long-term average (arithmetic average between 1990 and 2022 taken from 16 measurement stations). The low number of days with heating threshold temperatures of less than 15° C generally points towards a higher average temperature level in the reporting year and an associated reduction of the observed demand for energy (in particular, for the heating of residential premises) as a result of milder weather.³⁾

When compared to the previous year, the number of degree days decreased as well by 101 to 3,041 because it was warmer in 2023 than it had been

in 2022. In 2023, the degree day figures were about 3 % below those of the previous year (higher temperatures) so that energy consumption in 2023, when compared to 2022, ought to have decreased due to the influence of the weather and/or the milder temperatures.

When considering the development of the degree day figures during the individual months, it becomes apparent that the year 2023, particularly during the months of January, March, September, and December, was significantly milder than the previous year. In contrast, and as measured by the degree day figures, the temperatures in February, May, October, and November 2023 were lower than those of 2022. Yet the months between October and December 2023 which are relevant for the heating period were, taken as a whole, milder than had been the case during the respective months of the previous year (degree day figures: Minus 3.4 %). In total and as measured by the degree day figures, the months between January and March 2023 were also 0.8 % warmer than those of the previous year.

When compared to the long-term average (between 1990 and 2022), the year 2023, except for the month of April (degree days: Plus 14.4 %), was consistently warmer. In particular, the month of September 2023, which was the warmest month of September since the start of the official meteorological records, exhibited unusually mild temperatures (please see Figure 1).

The impact of short-term temperature effects on the development of primary energy consumption is typically eliminated in that temperatures are assumed as indicated in the long-term average⁴⁾ and that

2) Degree day figures (in accordance with DIN VDI 3807) are specifically defined as the sum of the differences between a fixed indoor temperature (here: 20° C) and the daily average of those days on which the air temperature falls below the heating threshold temperature (here: 15° C).

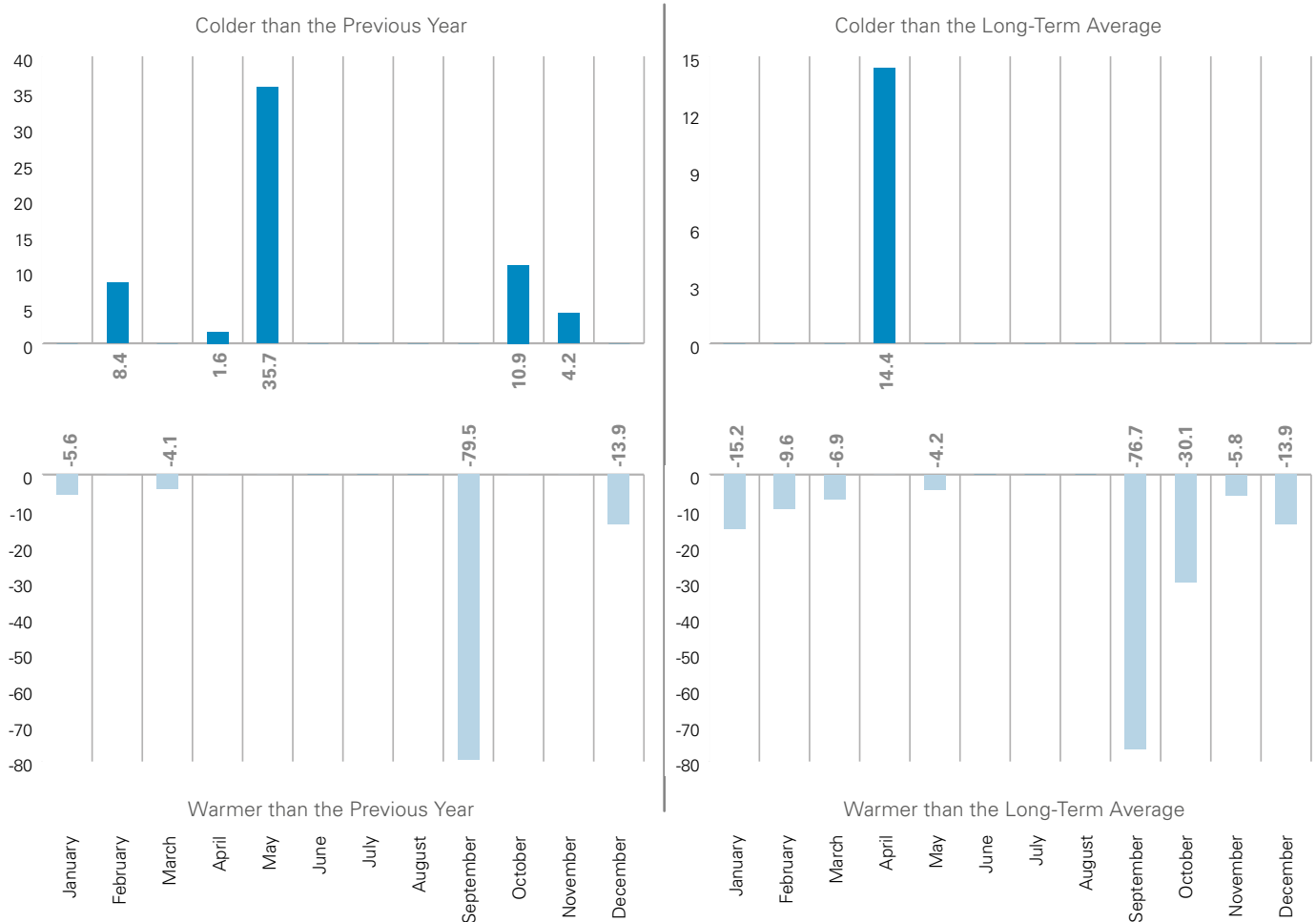
3) When compared to the long-term average (average number of degree day figures between 1990 and 2022), the year 2023 was warmer. At an annual average (as measured by the degree days), the temperatures were 13.8 % higher than the values of the long-term average. If one were to shift one's considerations solely towards this long-term perspective, then primary energy consumption in 2023 would have been noticeably above the observed level provided that the weather conditions during this year had equaled those of the long-term average.

4) For assessing the long-term developments of energy consumption (as of 1990), the temperature adjustments in this report are generally conducted by taking the long-term average into account (please see Table 15, Diagrams 15 and 16). For short-term comparisons, the weather conditions prevailing during any other comparative period (for example, the previous year) could also be considered as an alternative. It is obvious that both the level of the temperature-adjusted absolute energy consumption and the rate of change compared to the previous year depend on the reference period chosen for the respective adjustment procedure.

Figure 1

Monthly Degree Day Figures in Germany in 2023 (16 Measurement Stations)

Changes in 2023 compared to the previous year and to the long-term average (1990-2022) in %
Due to their limited informative value, the months of June and August are not included.



Source: Germany's National Meteorological Service (DWD)

inventory-adjusted data are taken into account for mineral oil consumption.⁵⁾ When taking these assumptions as a basis, then primary energy consumption would not have decreased by 8.1 %; instead, the decrease would have merely been 7.9 % in 2023. The adjustment effect has a different impact on the individual energy carriers which is dependent upon their use for space heating purposes (please see Figure 2).

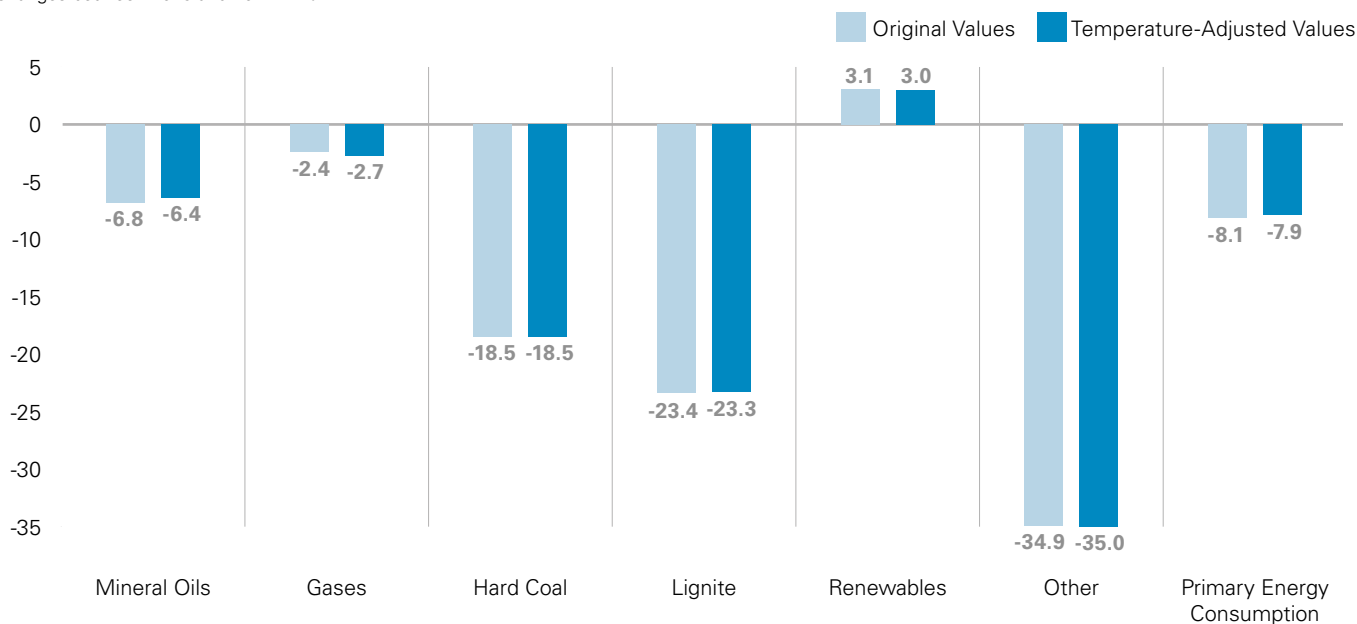
When it comes to the influence of the weather, it is generally accepted that temperature-adjusted changes in energy consumption in comparably warmer years are stronger than changes in the original values; accordingly, in colder years the increases in temperature-adjusted values are generally lower than those in the original values. This becomes also apparent from the different spreads of the energy carriers depicted in Figure 2.

⁵⁾ The information on mineral oil consumption provided in the energy balance (particularly on light fuel oil) includes, in part, only sales figures. Hence, the actual consumption of this energy carrier may deviate from the indicated sales volumes by the respective changes in stockpiling. Yet official statistics actually record these inventory changes only for the energy sector and the manufacturing industry which means that the requisite figures can only be incorporated into the consumption calculations of these two sectors. No original statistical data are available on the changes in fuel oil stocks for private households and for the trade, commerce, and service sector. In order to close the described gap, the Arbeitsgemeinschaft Energiebilanzen (AG Energiebilanzen) – Working Group on Energy Balances (Energy Balances Group) has been using for quite some time now an econometrically based method which is designed to empirically determine the inventory changes for these sectors, and which permits complete and comprehensive consumption calculations also for mineral oils. For more details on this procedure, please see Umsetzung eines Verfahrens zur regelmäßigen und aktuellen Ermittlung des Energieverbrauchs in nicht von der amtlichen Statistik erfassten Bereichen (2016), a survey conducted by the AG Energiebilanzen on behalf of the German Federal Ministry for Economic Affairs and Energy (BMWi), pp. 82ff. (Internet: https://www.bmwi.de/Redaktion/DE/Downloads/Studien/umsetzung-verfahren-ermittlung-energieverbrauch-nicht-amtliche-statistik-langfassung.pdf?__blob=publicationFile&v=7 (download date: 2023-02-21; currently only available in German)).

Figure 2

Primary Energy Consumption in Germany According to Energy Sources

Changes between 2023 and 2022 in %



Sources: Working Group on Energy Balances (AGEB); Germany's National Meteorological Service (DWD)

When it comes to mineral oil, the (stock level adjusted) trend was additionally influenced by the fact that in light of the energy prices which dropped again when compared to the crisis year 2022, primarily private (but also commercial) consumers stocked up on fuel oil and continued to refill their tanks in 2023.

Considering mineral oils as a whole, the opposing effects (stockpiling reduces the actual consumption of fuel oils whereas excluding the influence of the weather increases it) result in the fact that the primary energy consumption adjusted by inventory and temperature effects (when it comes to light fuel oil for private households and the trade, commerce, and service sector) did not decrease by about 6.8 %, but only by 6.4 %. The inventory effects actually overcompensated the impact of the weather adjustment, which increases consumption when taken in isolation, on the development of consumption in 2023 if and when the weather adjustment, as done here, is carried out on the basis of the long-term average of the degree day figures between 1990 and 2022.

When it comes to gases, however, it is solely the weather effect which plays a role within the scope of the adjustment. Against this backdrop and after having

excluded the temperature influence, gas consumption declined somewhat stronger than it had initially been presumed by the observed trend (namely, by about 2.7 % instead of the observed decline of 2.4 %). When it comes to coals and renewables, temperature and inventory effects only play a marginal role because these energy carriers are primarily used for the generation of electric power.

Macroeconomic and Sectoral Factors

An export-oriented economy which also imports a substantial share of its demand for energy carriers and raw materials as is characteristic for Germany depends to a large extent on global economic trends. According to estimates of the International Monetary Fund (IMF), the global economy ought to have increased only by 3.1 % in 2023.⁶⁾ For comparison: In 2022, the global economy had exhibited a plus of 3.5 %. For the euro-zone, the IMF projections even anticipate a decline in growth to 0.5 % (in 2022, it had still been 3.4 %).

The German economy is particularly affected by the outlined dampening of the global growth perspectives as well as by persistently high prices for energy.

6) Please see International Monetary Fund (2024), World Economic Outlook Update, January 2024.

The price-adjusted gross domestic product (GDP) in Germany shrank by about 0.3 % in 2023 so that Germany was the only one of the major economies in the eurozone to slide into a recession. In the preceding year, the price-adjusted gross domestic product in Germany had still increased by 1.8 % when compared to 2021.

Compared to the previous year, the price-adjusted consumption expenditure declined (2023: -1.1 %), whereby growth impulses neither came from private consumption expenditure (2023: -0.8 %) nor from public consumption expenditure (2023: -1.7 %). Compared to the previous year, gross fixed capital formation⁷⁾ went down by 0.4 % in 2023 (after it had still grown by 3.2 % in the previous year). The negative development of gross fixed capital formation was primarily due to continuously dwindling building investments (residential construction and non-residential construction and/or building construction and civil engineering projects) which, adjusted by price effects, shrank by 2.1 % in 2023 whereas equipment investments (machinery, equipment, and vehicles) increased by 3 % when compared to the previous year.

All told, the total domestic utilization decreased by 0.9 % in 2023. For comparison: In the previous year (2021/2022), a positive contribution to growth amounting to 3 % had still emanated from the total domestic utilization.

With a minus of 1.8 %, exports of goods and services also declined in 2023 after their growth had already slowed down substantially in the previous years (2021: +9.7 %; 2022: +3.3 %). At the same time and when compared to 2022, the value of imports went down by 3 % (previous year: +6.6 %) so that all told, a positive growth contribution (+0.6 %) came from the foreign trade balance (net visible and invisible exports). After the German export surplus had fallen to the lowest value since 2003 in 2022, the developments outlined above caused it to increase again in 2023 when compared to the previous year (2023: 159 billion euros; 2022: 143 billion euros).⁸⁾

In line with the general macroeconomic conditions, the economic development varied considerably in the individual economic branches. While some sectors, such as vehicle construction, were able to benefit from the increasing equipment investments, the economic performance in such other branches as, for example, the construction industry continued to decrease as a result of material shortages and supply bottlenecks, the lack of skilled professionals as well as high construction costs (increasing interest rates and inflation).

In the producing industry as well, the diverging trends of the individual macroeconomic aggregates contributed to the fact that the sectors developed very differently in 2023.

The production trend of those economic branches which either directly sell a significant proportion of their production abroad or act as prepaid suppliers for export-dependent sectors was decelerated by the slump in exports. Economic branches which depend on the overall situation in the construction sector recorded setbacks in growth and/or reduced their production because price-adjusted construction investments (residential and non-residential buildings) continued to decrease in 2023 when compared to the previous year 2022. The energy-intensive sectors saw themselves confronted with a reduction of their international competitiveness due to the persistently high energy price level in Germany and the resultant production cutbacks.

All told, the output in the producing industry decreased by about 2 % in 2023 (2022: -0.7 %); in the manufacturing industry, production (also measured by the production index) went down by 1.1 % in 2023 which was primarily due to high energy prices and delivery problems with important precursors, primary products, and preliminary services (after it had already decreased by 0.4 % in the year before). Energy-intensive economic branches were particularly affected by the increasing energy prices; compared to 2022, their production as a whole decreased by almost 10 % (2022/2021: -7.1 %).

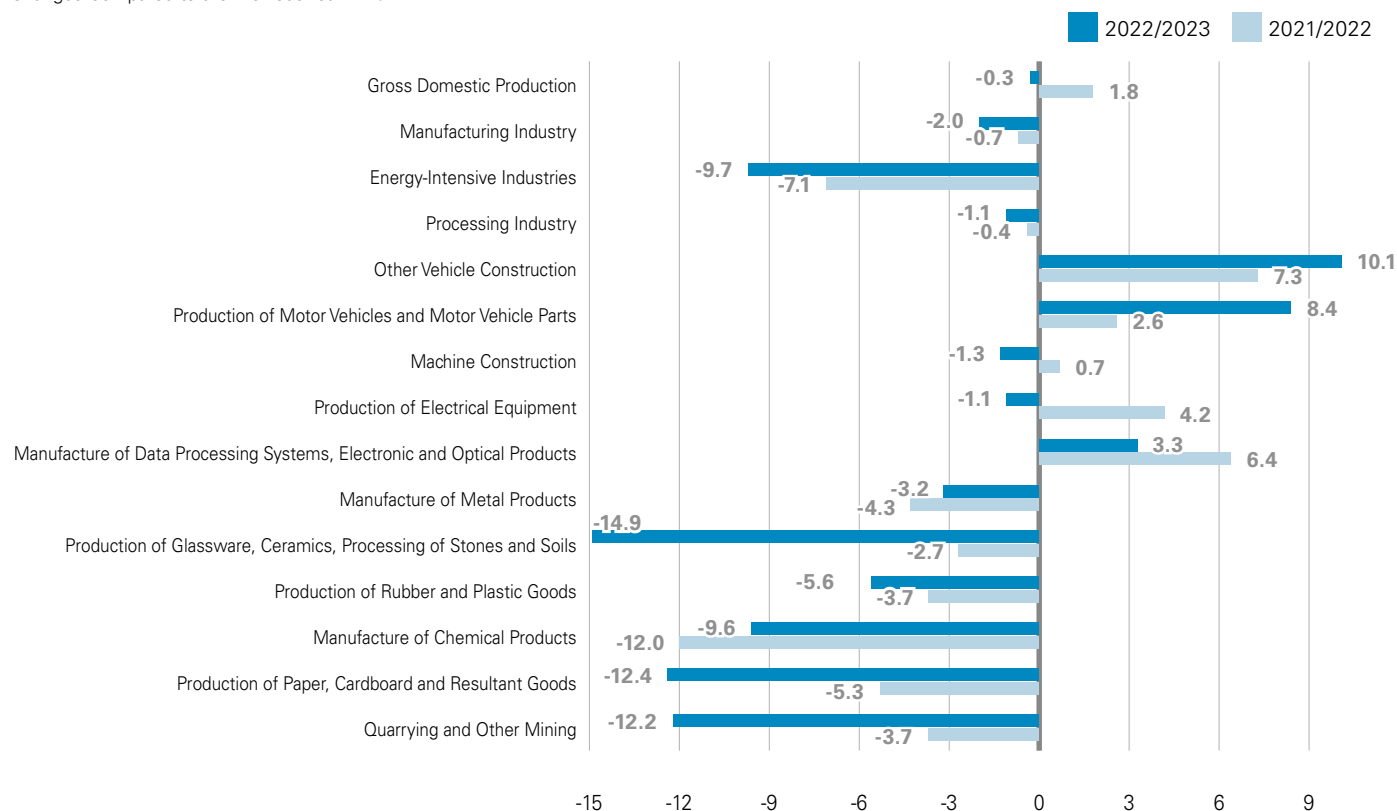
7) Investments into equipment, mechanical plants, and buildings (residential and non-residential buildings, including building construction and civil engineering) as well as changes in stocks.

8) DESTATIS, National Accounts 2023. Price-adjusted volume indications and contributions to growth; price-adjusted, chain-linked volume indications (2015 = 100).

Figure 3

Production Index in Germany's Manufacturing Industry between 2022 and 2023

Changes Compared to the Previous Year in %



Source: Federal Statistical Office (Destatis)

Against this backdrop, Figure 3 provides an overview of the annual rates of change in the production indices for 11 key economic branches of the manufacturing industry (aggregated at the two-digit level of the economic branch classification WZ) between 2022 and 2023:

- In 2023, only 3 sectors of the 11 economic branches were able to attain increases in production when compared to the previous year. These branches include, in the order of their importance, "other vehicle construction" (+10.1 %), "manufacture of motor vehicles, trailers, and semi-trailers" (+8.4 %), and finally "manufacture of computers, electronic and optical products" (+3.3 %). All told, about 4.1 million passenger cars were produced in Germany in 2023 which is 18 % more than in the previous year. On the German passenger car market, a total of about 2.8 million vehicles were newly registered in 2023 (+7 % when compared to 2022).⁹⁾

- All other sectors, in particular such energy-intensive and/or electricity-intensive economic branches as "manufacture of glass, glassware, ceramics, and the processing of stones and soils" (-14.9 %), "production of paper, cardboard, and paper products" (-12.4 %), "quarrying and other mining" (-12.2 %), "manufacture of chemical products" (-9.6 %), and others, recorded declines in production which were significantly above average when compared to the manufacturing industry after their production output had shrunk noticeably already in the previous year.
- With a minus of 1.1 %, the development in the "production of electrical equipment" sector turned out to be mediocre in 2022/2023 (as was the case in the manufacturing industry); in the previous year 2021/2022, this economic branch had still been able to expand its production by 4.2 %.

⁹⁾ The initially planned reduction of the environmental bonus for those passenger cars which run solely on battery-electric power (BEV) resulted in an anticipatory effect for new e-vehicles that were purchased at the end of the year 2023. The abrupt discontinuation of the environmental bonus on December 17, 2023 will only be reflected by those vehicles which will be newly registered as of January 2024.

As a result of the described decline in production in the manufacturing industry as a whole, a consumption-reducing impulse can generally be expected for the use of energy in the reporting year 2023. The described effect tends to be strengthened by the disproportionately high production decrease in all energy-intensive sectors of the manufacturing industry.

It should be remembered at this point that the persistently high energy prices in all economic branches create additional incentives for the utilization of efficiency potentials that have not been used so far. High energy costs in combination with the expectation that a rapid and/or complete return to the former (low) price level is virtually impossible ought to further enhance the attractiveness and/or profitability of investments into energy-saving technologies (and methods designed to substitute energy, for example, with secondary raw materials). That is why despite the partly tense economic situation, improvements in energy productivity can be expected which go above and beyond the structural change in industry.

Demographic Factors

According to initial estimates of the Federal Statistical Office, about 84.7 million people (inhabitants) lived in Germany at the end of the year 2023. Thus, the population grew by more than 0.3 million people when compared to the end of the year 2022. In 2023 as well, the net immigration (i. e. the difference between inward and outward migration) was the sole cause of the population growth. As had been the case in all years since German Reunification, the difference between births and deaths turned out to be negative also in 2023 because once again, more people died than were born.^{10) 11)}

Under these premises (updated statistical figures are not yet available), the number of households is likely to slightly increase further as well. In 2022, about

40.9 million private households existed in Germany, of which around 40.8 % were single-person households (which translates into approximately 16.7 million).

The increase in the number of households is not only due to the demographic development, but at the same time also due to the persistent trend of living in smaller households. Currently (2022), an average of approximately 2.04 persons lives in one household.

That is why taken in isolation, the demographic development as well as changes in the household sizes are likely to have had a noticeable consumption-enhancing effect on the development of energy consumption in 2023.

Energy Prices

Energy prices play an important role when it comes to consumption behavior, efficiency improvements, and substitutions (between energy and capital as well as materials and/or resources). Generally speaking, the higher the prices for individual energy carriers are, the sooner efficiency improvements and substitutions occur.

This development commenced in early 2022 with the Russian invasion of Ukraine and posed considerable challenges to the European and German energy supply. The consequences were gas shortages, temporary scarcities, and a sharp increase in energy prices. Volatile energy prices with partially drastic price peaks and the associated effects on the economic development and the global demand for energy had exerted a substantial impact on the condition of the global energy markets in 2021/2022. A counter-movement started in 2023.

Against this backdrop and at an annual average, the import prices for crude oil, natural gas, and hard coal decreased significantly again somewhere between 20 % and 48 %.

10) For more details, please see DESTATIS, Press Release No. 35 dated January 15, 2024: Bevölkerung wächst im Jahr 2023 um gut 0,3 Millionen Personen. Internet: https://www.destatis.de/DE/Presse/Pressemitteilungen/2024/01/PD24_035_124.html (download date: 2024-02-25; currently only available in German).

11) Within the scope of the following analyses and calculations, not the population at the end of the year will be considered, but instead the average population based on the 2011 Census and the results of the population projections as also applied within the scope of the National Accounts. For more details on the first annual results of the domestic product calculations for 2023, please see DESTATIS: Inlandsproduktberechnung 2023 – Erste Jahresergebnisse – Fachserie 18 Reihe 1.1. Internet: https://www.destatis.de/DE/Themen/Wirtschaft/Volkswirtschaftliche-Gesamtrechnungen-Inlandsprodukt/_inhalt.html#_jh54kz3t6 (download date: 2024-02-25; currently only available in German).

The price reductions for hard coal and natural gas were more pronounced than those for petroleum. Yet in 2023 as well, the import prices for all three energy carriers continued to be significantly above the pre-crisis level that had been observed in the years before 2021/2022 (please see Table 2).

The development of the exchange rate additionally reinforced the decline in energy prices on the global market for consumers in Germany. The exchange rate of the Euro against the US Dollar (by using the indirect quotation) increased by almost 2.7 % in 2023. This appreciation of the Euro against the US Dollar made imports of goods and services from the Dollar zone even cheaper than before.

Notwithstanding the above, the prices for domestic consumers deviate to some extent noticeably from the development of import prices because the

consumer prices, in addition to governmental taxes as well as statutory charges and levies,¹²⁾ also include such components as transport and distribution costs as well as other distribution expenses. In addition, due to the contractual ties that exist and depending on the specific energy carrier and customer group considered, the import prices and/or procurement costs usually have no direct impact on the final consumer prices. In 2023, consumer prices for such grid-bound energy carriers as natural gas and electric power (across all customer groups) increased by 14.7 % and 12.6 % respectively when compared to the previous year whereas the price for light fuel oil, in comparison to 2022, decreased by more than 22 %.

The consumer price trend for specific customer groups and/or end users will be highlighted in more detail in the respective sections of this report which refer to the individual energy carriers.

Table 2

Prices of Selected Energy Sources

Changes 2023 to 2022 in %

	2022	2023				
		1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Average
Import Prices						
Mineral Oil	57.8	-12.6	-30.9	-23.4	-10.2	-19.9
Natural Gas	178.5	-10.0	-43.0	-68.1	-54.9	-48.0
Hard Coal	161.9	-12.2	-50.5	-59.9	-37.9	-43.3
Consumer Prices						
Fuel Oil, Light	87.3	-5.6	-29.9	-29.8	-20.3	-22.2
Natural Gas	63.6	45.7	26.6	1.6	-4.0	14.7
Electricity	19.2	21.9	12.8	15.0	2.1	12.6

Source: Federal Statistical Office (Destatis)

12) For example, the increase in the national CO₂ price by € 5/t, which had initially been scheduled for January 1, 2023, in compliance with the German Fuel Emissions Trading Act – BEHG, Act on National Certificates Trading for Fuel Emissions, was postponed by one year so that the fixed price for CO₂ remained unchanged at € 30/t in 2023. An increase in the price to € 45/t will not take place before January 2024, which leads to the fact that, for example, the price for natural gas on the heating market for private consumers will go up from 0.54 ct/kWh (2022 and 2023) to 0.82 ct/kWh (2024).

Dependence on Energy Imports

When it comes to an economy's resilience to energy crises, the availability, production, and utilization of domestic energy resources play a role that should not be underestimated. Stable domestic production volumes generally reduce the dependence on imports and lower the risk of disturbances or disruptions in the overall supply as well as the commodity price risk for businesses and consumers.

On an international scale, Germany is considered to be a country with rather poor resources, renouncing the use as well as also increasingly abandoning the production of indigenous coal reserves, but at the same time, it is systematically expanding the use of renewable energy sources which are attributed to domestic energy production. Against this backdrop, a glance at Germany's foreign trade balance for energy carriers is of particular interest. Germany is a considerable net importer of virtually all fossil fuels (i. e. hard coals, mineral oil, and natural gas). Nor did this situation fundamentally change in 2023; Germany's dependence on imports remained at a level that was about as high as it had been in the previous year even though the procurement and/or supply structures of energy imports (natural gas, hard coal, petroleum) changed dramatically because Germany turned away from Russia as the hitherto most important energy supplier. In 2023, domestic primary energy consumption was covered by imports which amounted to about 98 % for mineral oils and more than 96 % for natural gas.

100 % of the hard coals came from foreign sources. In contrast, 100 % of the lignite continued to be made available from indigenous sources, and renewables also came almost entirely from domestic production. According to initial preliminary calculations, the dependence of Germany's entire energy supply from energy imports dropped to 68 % in 2023 which is a minor decrease when compared to the previous year.

What changed fundamentally were the import prices for energy carriers. All told, the significant reduction of import prices when compared to 2022, together with the dwindling domestic energy consumption and the associated decline in energy imports, caused the import calculation for coal, oil, and gas to decrease from about 135.4 billion euros in 2022 by 55 billion euros to 80.4 billion euros in 2023, which equals a total reduction of more than 40 %. The value of (net) oil imports decreased by almost 23 %, the value of natural gas imports even by 58 %. The value-based import balance for coals dropped by more than 46 %. In 2023, more electricity flowed from foreign countries into Germany than conversely from Germany into neighboring countries; this made Germany a net importer of electric power for the first time again since 2002. This resulted in a (value-based) import surplus amounting to 0.7 billion euros for electric power in 2023 compared to the previous year when Germany had exported electric power to neighboring countries which on balance amounted to 5.3 billion euros (please see Table 3).

Table 3

Balance of Foreign Trade with Energy Carriers in Germany between 2019 and 2023

	2019	2020	2021	2022	2023	Changes in 2023 Compared to 2022	
						Billion Euros	%
Coal, Coke, and Briquettes	4.1	2.3	4.7	12.7	6.8	-5.9	-46.7
Petroleum, Petroleum Products, and Related Goods	42.8	26.9	36.6	62.2	48.2	-14.0	-22.5
Gas ¹⁾	15.9	12.3	28.4	60.5	25.4	-35.1	-58.0
Total Fossil Fuels	62.9	41.4	69.6	135.4	80.4	-55.0	-40.6
Electric Power	-1.6	-0.9	-2.3	-5.3	0.7	6.0	-113.6
Total	61.3	40.6	67.4	130.1	81.1	-49.0	-37.7

1) Including transit volumes

Source: Federal Statistical Office (Destatis)

Primary Energy Production in Germany

Except for renewables, domestic energy production decreased for all other energy carriers in 2023 which resulted in an overall decline of approximately 6.7 % to 3,345 PJ or 117.3 Mtce (please see Table 4).

The domestic production of fossil fuels attained a level of 1,326 PJ in 2023; compared to the year 2022 (1,636 PJ), this equals a decline of 311 PJ which translates into 19 %. The decline in the domestic energy production was primarily due to the dwindling contribution of lignite whose production dropped by 277 PJ in 2023 when compared to 2022 (which equals a minus of 23.2 %).

Compared to 2022, the production of natural gas and petroleum gas in 2023 declined by nearly 11 % and, thus, by about 16 PJ;¹³⁾ the production of petroleum is likely to have decreased by 5 % (4 PJ).

A positive contribution towards domestic energy production in 2023 came from renewable energy sources; they were able to expand their production,

for example, due to the construction of new plants and the increased supply of wind and water by 65 PJ, which translates into 3.2 %.

The overall result shows that renewables represented the most important indigenous energy source with a proportion of more than 61 % in 2023. About 27 % of the domestic energy production was provided by lignite in 2023; thus, lignite reduced its contribution margin by 5.7 percentage points when compared to the previous year. However, both energy carriers (renewables and lignite) continued to rank far ahead of the domestic production of natural gas and petroleum.

When taking primary energy consumption in 2023 into account, the overall proportion of domestic production increased slightly; namely, from 31.5 % in 2022 to now about 32 % (please see Table 4). The increase in this share can be attributed to the fact that primary energy consumption decreased more significantly than domestic energy production.

Table 4

Primary Energy Production in Germany in 2022 and 2023

	Production				Changes in 2023 Compared to 2022		Proportions	
	2022	2023	2022	2023	PJ	%	2022	2023
	Petajoules (PJ)		Million Tons of Coal Equivalents (Mtce)				%	
Mineral Oil	72	69	2.5	2.3	-4	-5.0	2.0	2.0
Natural Gas, Petroleum Gas	153	137	5.2	4.7	-16	-10.6	4.2	4.0
Hard Coal	0	0	0.0	0.0	0	0.0	0.0	0.0
Lignite	1,193	916	40.7	31.3	-277	-23.2	32.4	26.7
Renewable Energy	2,044	2,109	69.8	72.0	65	3.2	55.5	61.4
Other Energy Carriers	218	204	7.4	7.0	-14	-6.5	5.9	5.9
Total	3,681	3,435	125.6	117.3	-246	-6.7	100.0	100.0
For information purposes: Proportion of Primary Energy Consumption							31.5	32.0

Some figures are estimates; discrepancies in the totals are due to rounding off

Sources: Working Group on Energy Balances (AGEB); German Association of Energy and Water Industries (BDEW); The German Coal Industry's Statistical Office; Federal Office for Economic Affairs and Export Control; en2x - Fuels & Energy Business Association; Working Group on Renewable Energy Statistics (AGEE-Stat)

13) Over the past few years, the domestic production of petroleum and natural gas dropped because of the increasing depletion of old fields and deposits. To that extent, this trend continued during the reporting year 2023. However, it also needs to be pointed out in this context that the production of natural gas and petroleum not only depends on geophysical-technical factors, but also on economic constraints. Increasing oil and gas prices usually generate a particular impulse to reinforce the exploration efforts. Also worth mentioning here is that in times of high energy prices, the recommissioning of old fields and the use of new production technologies can perhaps be economically viable as well.

Mineral Oil

According to preliminary calculations made by the AG Energiebilanzen, the primary energy consumption of mineral oil in Germany amounted to 3,822 PJ (130.4 Mtce) in 2023, which was 6.8 % below the previous year's level.

Domestic sales of mineral oil products recorded a decline of approximately 6.2 % in 2023. Taken together, consumption of the most important mineral oil products developed very differently from one another (please see Table 5): Compared to the previous year,

Table 5

Consumption and Volume of Mineral Oil in Germany in 2022 and 2023

	2022	2023 ¹⁾	Change
	in Million Tons	in Million Tons	in %
Total Consumption	96.4	90.2	-6.4
Self-Consumption and Losses ²⁾	6.3	5.7	-8.9
Domestic Consumption	90.0	84.5	-6.2
Proportion of:			
Gasoline	16.9	17.4	2.6
Diesel Fuel	34.6	33.2	-4.0
Aviation Fuels	9.1	9.4	3.8
Fuel Oil, Light	12.2	11.3	-7.3
Fuel Oil, Heavy ³⁾	0.9	0.6	-31.1
Naphtha	12.8	10.4	-18.6
Liquid Gas	3.4	3.0	-12.1
Lubricants	0.8	0.7	-7.2
Other Products	10.0	8.8	-12.0
Recycling (to be deducted)	-6.9	-6.6	-4.4
Biofuels ⁴⁾ (to be deducted)	-3.7	-3.8	2.0
Total Volume	90.0	84.5	-6.2
Domestic Production	1.9	1.8	-4.5
Refinery Production	102.5	92.7	-9.5
Generated from:			
Input of Crude Oil	89.3	79.4	-11.1
Input of Products	13.2	13.3	0.9
Foreign Trade Products (Balance)	8.1	10.7	
Imports	35.6	34.9	-1.8
Exports	27.5	24.2	-12.0
Compensation [Balance (Bunker, Differences)]	-14.1	-13.1	
Refining Capacity	105.7	105.7	0.0
Utilization of Refining Capacity in %	84.5	75.2	
Primary Energy Consumption of Mineral Oil (Mtce)	4,102	3,822	-6.8

1) Preliminary data; some figures are estimates

2) Including changes in stocks

3) Including other heavy residues

4) Only added biofuels

Discrepancies in the totals are due to rounding off

Sources: Working Group on Energy Balances (AGEB); Federal Office for Economic and Export Control (BAFA); en2x - Fuels & Energy Business Association

the consumption of diesel fuels decreased by 4 % to 33.2 million tons. Nonetheless, sales of diesel fuels continued to be almost twice as high as those of gasoline (17.4 million tons) whose demand increased by 2.6 % in 2023 when compared to the previous year. The consumption of aviation fuels increased once again during the reporting year 2023; namely, by 3.8 %. Thus, sales in this segment in 2023 (about 9.4 million tons) ranged approximately 7.8 % (0.8 million tons) below the “normal volume” that had been recorded before the outbreak of the Covid crisis. All told, the demand for fuels (2023: About 60 million tons), which accounted for an approximate share of 66 % in Germany’s total oil consumption, was around 1 % (which equals 0.6 million tons) lower in 2023 than it had been in 2022.

With a decrease of more than 7 %, which equals 0.9 million tons, sales of light fuel oil experienced a clear downward trend. This trend was most likely due to the milder weather (for more details, please see Section *Temperature and Weather Influence* hereinabove), continuing savings in fuel oil due to the substitution of oil-fired heating systems, continuing efficiency improvements as well as attitude and behavior related savings on part of the consumers.

Refinery production decreased by 9.5 % to a level of 92.7 million tons in 2023. Towards this end, refinery production from crude oil, which accounted for a share of 85.6 %, went down by 11 % whereas the processing of products increased by 0.9 %. In light of the reduced production, the refining capacity of 105.7 million tons, which compared to the previous year remained unchanged once again, was actually utilized at 75.2 % in 2023; in 2022, the degree of utilization had amounted to about 84.5 %.

Foreign trade in mineral oil products changed significantly in 2023. On balance, imports predominated in 2023; with 34.9 million tons, they topped the exports of 24.9 million tons. Quantitative exports of mineral oil products dropped by more than 12 % whereas imports decreased by over 1.8 % when compared to 2022.

Due to its limited domestic petroleum resources, Germany is primarily dependent on crude oil imports;

with 72.6 million tons, they fell 16.9 % below the previous year’s level, which translates into 14.8 million tons, in 2023. Compared to the previous years, the procurement regions for deliveries of crude oil to Germany shifted significantly in 2023. The main cause of these structural shifts were the resolutions adopted by the EU on the imposition of an embargo on oil from Russia. The first step of the EU sanctions, which became effective on December 5, 2022, stipulated a stop of crude oil imports via maritime transport (oil tankers).¹⁴⁾ The second step of the embargo put a ban on imports of crude oil via the Druzhba pipeline as of January 1, 2023, and the third step finally prohibited imports of diesel and other mineral products (as of February 5, 2023).

Against this backdrop, imports of crude oil from the states of the Russian Federation decreased noticeably in the shrinking German import market. In 2023, crude oil imports from Russia went down by 22.7 million tons and, thus, by almost 100 % (which still equals a supply share of 0.2 % in the crude oil import market). For comparison: In 2021, Germany had still imported 27.7 million tons, which translates into a share of 34.4 %, of its total import volume from Russian deposits. The decline in Russian oil supplies was compensated by increased procurement volumes from other supplier countries; above all, the USA (+9.3 %), Norway (+9.1 %), and other countries (+31.9 %).

In 2023, the most important supplier countries for crude oil were (with regard to their market shares) the USA and Norway which each had a supply share of 18.3 % of the total imports. Kazakhstan and the United Kingdom followed in third and fourth place with supply shares of 11.7 % and 10.9 % respectively whereby the United Kingdom actually reduced its delivery volume by 8.6 % in 2023 when compared to the previous year (please see Table 6).

Split into individual oil producing regions, the proportion of crude oil imports from the countries of the former Soviet Union (CIS states) decreased; it went down from 38.4 % (2022) to 13.6 % in 2023. In contrast, the OPEC states (2023: 28 %) recorded noticeable increases in their shares in the shrinking market. When compared to 2022, deliveries of crude

¹⁴⁾ At the same time, a price cap for crude oil amounting to 60 US dollars per barrel was agreed upon; this price cap is designed to force Russia into selling crude oil to clients in non-EU countries at prices that do not exceed this cap.

Table 6

Germany's Crude Oil Imports in 2022 and 2023 According to Countries of Origin

Important Supplier Countries/Production Regions	2022	2023	Changes 2022/2023	2022	2023
	in Million Tons			Proportions in %	
Russia	22.8	0.1	-99.5	26.1	0.2
United Kingdom	8.7	7.9	-8.6	9.9	10.9
Norway	12.2	13.3	9.1	13.9	18.3
Kazakhstan	8.5	8.5	0.2	9.7	11.7
USA	12.1	13.3	9.3	13.9	18.3
Nigeria	2.9	2.8	-2.8	3.3	3.9
Other Countries	20.2	26.7	31.9	23.1	36.7
Total	87.4	72.6	-16.9	100.0	100.0
OPEC	15.5	20.4	30.9	17.8	28.0
North Sea ¹⁾ (excl. FRG)	21.1	21.4	1.3	24.1	29.5
Former CIS	33.6	9.8	-70.7	38.4	13.6
Other	17.2	21.0	22.3	19.7	29.0
Total	87.4	72.6	-16.9	100.0	100.0

1) Including other EU countries

Discrepancies in the totals are due to rounding off. Data for 2023 preliminary, partially estimated.

Sources: Federal Office of Economics and Export Control (BAFA); Federal Statistical Office (Destatis)

oil from OPEC states increased by 4.8 million tons, which equals a plus of almost 31 %. The countries bordering the North Sea were able to increase their supply share only slightly by 1.3 % and, thus, attained a market share of 29.5 % in 2023 (2022: 24.1 %).

In 2023 as well, international oil prices and the Euro/US Dollar exchange rate, which determine the price for German crude oil imports, exhibited a very volatile development; in other words, they experienced considerable short-term fluctuations (please see Figure 4).

While the prices for crude oil grade Brent UK, which is important for Europe, with an annual average of about 100 US dollars per barrel (US \$/bbl; 1 barrel = 159 liters) in 2022 had already been approximately 30 US dollars above the previous year's values, they decreased once again to a level of 82 US dollars in 2023. Despite the above-mentioned decline, the price for Brent continued to exceed the price level that had been attained in 2021 by approximately 12 US dollars, which translates into 16.6 % above that level.

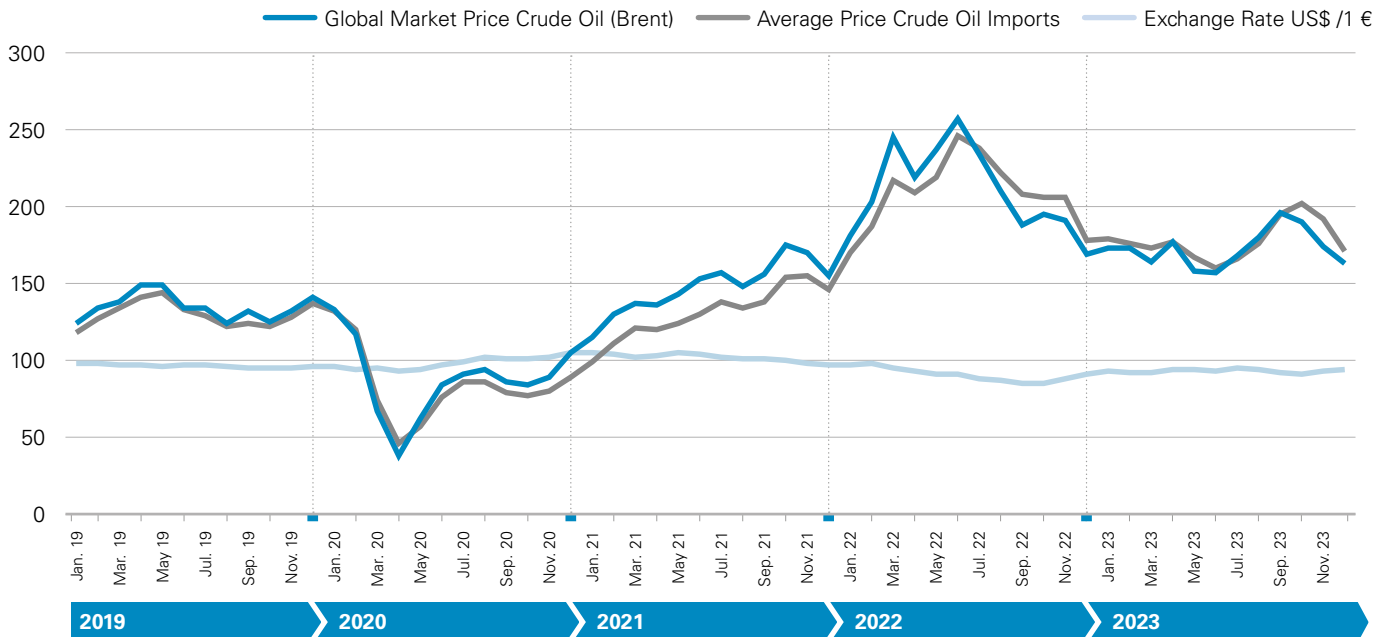
Over the course of the year 2023, the decline in prices outlined above showed a much more pronounced development in individual months. Based on its value in January (with about US-\$ 83/bbl), the crude oil price initially dropped to an annual low of less than US-\$ 75/bbl until May/June 2023. Subsequently, the crude oil price increased again and reached its annual peak of almost US-\$ 94/bbl by September 2023. Thereafter, a continuous decline in the price to nearly US-\$ 78/bbl was observed once again until December 2023. Compared to the pandemic-related low in May 2020 (about US-\$ 18/bbl), the oil price based on dollars was four to five times higher during all months of the reporting year.

German crude oil import prices (average price of crude oil imports, in €/t) developed to a large extent parallel to the global market prices. Differences are essentially influenced by fluctuations in the exchange rate of the Euro (to the US Dollar). Since January 2022, the exchange rate increased from US-\$ 1.08/€ (indirect quotation) to about US-\$ 1.11/€ in July 2023. Subsequently, a depreciation to approximately US-\$ 1.06/€

Figure 4

Global Market Prices for Crude Oil (Brent)¹⁾, Border-Crossing Prices for German Crude Oil Imports²⁾, and Exchange Rates between 2019 and 2023

January 2015 = 100



1) Original values in US dollars per barrel

2) Original values in euros per ton

Sources: Federal Ministry for Economic Affairs and Energy (BMWi); Deutsche Bundesbank (German Central Bank); en2x - Fuels & Energy Business Association

could be observed until September 2023 before the exchange rate increased again to US-\$ 1.09/€ at the end of the year (December 2023).

A direct monthly comparison with the previous year shows opposing trends: From January to March 2023, the exchange rate (indirect quotation) ranged somewhere between slightly more than 2.8 % and nearly 5.5 % below the level of the respective months of the previous year (depreciation). Between April and December 2023, the exchange rate ranged somewhere between 1.3 % and 8.6 % above the level of the respective months of the previous year.

At an annual average, the exchange rate in 2023 increased by almost 2.7 % to US-\$ 1.08/€ when compared to the year 2022 (appreciation of the Euro against the US Dollar).

Consequently, the appreciation of the Euro described above tended to additionally support the decline in crude oil prices on the global market for German consumers over the course of the year; it was only during the months between January and March 2023 that

the depreciation resulted in a slight weakening and/or compensation of the price drop for consumers in Germany. All told, German crude oil import prices (on an annual basis and calculated in Euro/bbl) decreased to a noticeably greater extent (-15.3 %) than the global market prices (in US-\$/bbl) for crude oil (-13.1 %) between 2022 and 2023.

Converted into euros and tons, German crude oil import prices went down from an annual average of € 690/t in 2022 to about € 583/t in 2023.

Prices for oil products in Germany followed primarily the changes in crude oil costs and in international product quotations; albeit at different rates (please see Figure 5). In 2022, the average annual prices for premium gasoline, diesel fuel, and light fuel oil had risen to record highs in conjunction with the repercussions of the war in Ukraine. In 2023, consumer prices for fuels and fuel oil dropped again when compared to the previous year. For example, the average annual prices for premium gasoline at gas stations decreased by 4 % to € 1.85/liter and for diesel fuel by more than 11 % to € 1.74/liter. Irrespective of the lower fuel prices,

the year 2023 remained the second most expensive fuel price year behind 2022 for car drivers (as well as commercial freight transport). At an annual average, consumer prices for light fuel oil dropped by about 22 % in 2023. Thus, a liter of fuel oil cost in total and on average € 1.04/liter in the year 2023.

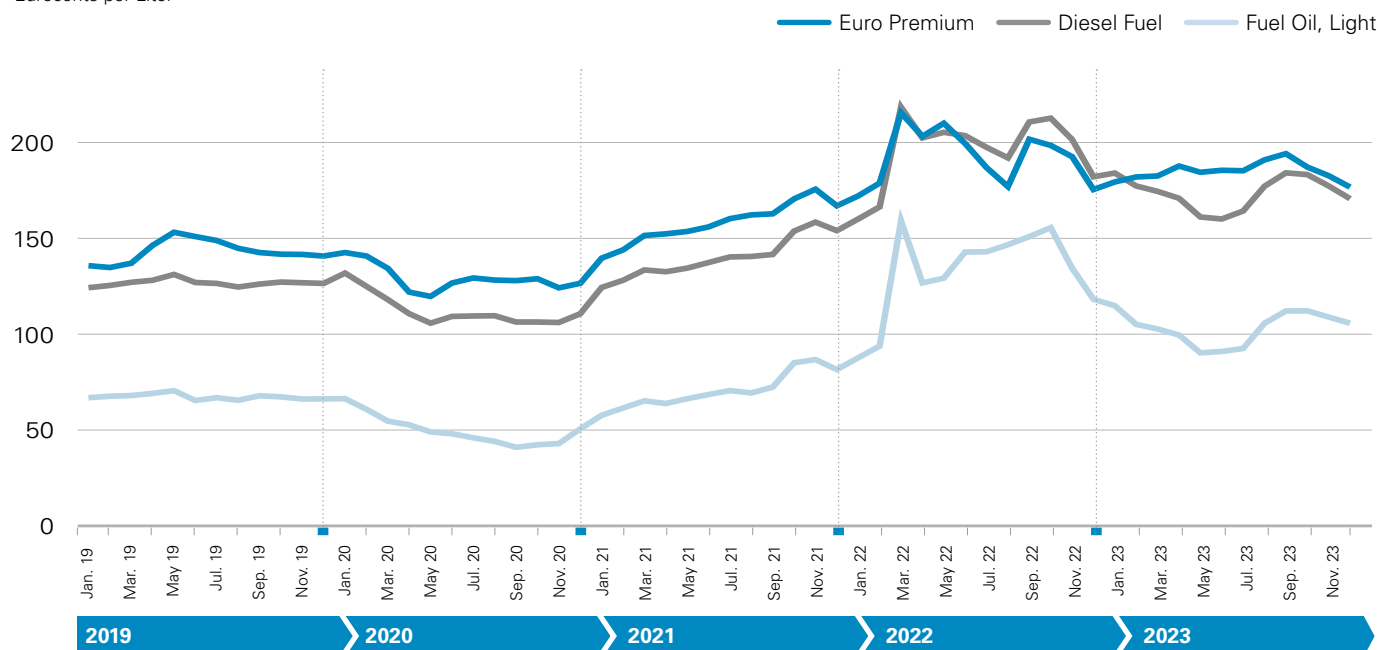
Considering the entire year under review, the prices for the mineral oil products mentioned above experienced a volatile trend; albeit the overall fluctuations in prices were less pronounced over the course of the reporting year 2023 than during the crisis year 2022.¹⁵⁾ In 2023, the price for premium gasoline at the fuel pumps fluctuated between a minimum of € 1.77/liter (December 2023) and a maximum of € 1.94/liter (September 2023) and, thus, about ±4.7 % around the average value. When it comes to the prices for

diesel fuel, the overall spread around the average value proved to be more pronounced with -7.3 % and +6.6 %, whereby the low was reached at a price level of about € 1.60/liter in June 2023. Over the course of the year 2023, the consumer prices for light fuel oil followed more or less the curve of the price trend that was observed for diesel fuel; albeit at a lower level. With about 90 ct/liter, one liter of fuel oil (light) was cheapest in June 2023, and with € 1.15/liter most expensive in January (2023); this means that the prices fluctuated between -11.8 % and +12.2 % (related to the average value). For customers buying fuel oil, this development produced, in the worst case, price differences amounting to nearly 24 ct/liter, depending on whether the order was placed during the heating period (January) or in the spring (May).

Figure 5

Prices for Fuels and Light Fuel Oil in Germany between 2019 and 2023

Eurocents per Liter



Sources: en2x - Fuels & Energy Business Association; Federal Statistical Office (Destatis)

15) When interpreting the development of fuel prices in 2022, it needs to be considered that a temporary reduction of the energy tax on gasoline and diesel fuel ("fuel price brake," "fuel discount") was in effect between June 1, 2022, and August 31, 2022. After the expiration of the fuel discount, fuel prices initially went up during the year 2022 before they once again decreased significantly by the end of the year.

Natural Gas

According to preliminary data, natural gas consumption in Germany decreased by 2.4 % to about 737 billion kWh (H_i), which translates into 2,655 PJ (H_i), in 2023.¹⁶⁾ Thus, natural gas consumption dropped more or less down to a consumption level which had last been recorded during the first half of the 1990s (primary energy consumption of natural gas in 1994: 2,567 PJ (H_i)). When compared to 2022, the proportion of natural gas of the total primary energy consumption increased by 1.4 percentage points to 24.7 % in 2023 because the entire primary energy consumption dropped more substantially during the period under review. In 2023 as well, the development of natural gas consumption described herein continued to be essentially characterized by the consequences of the Russian war of aggression against Ukraine, a price level that was still comparatively high, continuous savings measures on part of the consumers and, finally, the economic slump.

Domestic production of natural gas continued to decline in 2023; with an estimated volume of

approximately 38 billion kWh, it will, thus, fall about 10.6 % below the previous year's value (2022: 42.5 billion kWh). In 2023, domestic production of natural gas covered about 5.2 % of Germany's natural gas consumption. About 96 % of the natural gas used or, on balance, stored in Germany were imported.

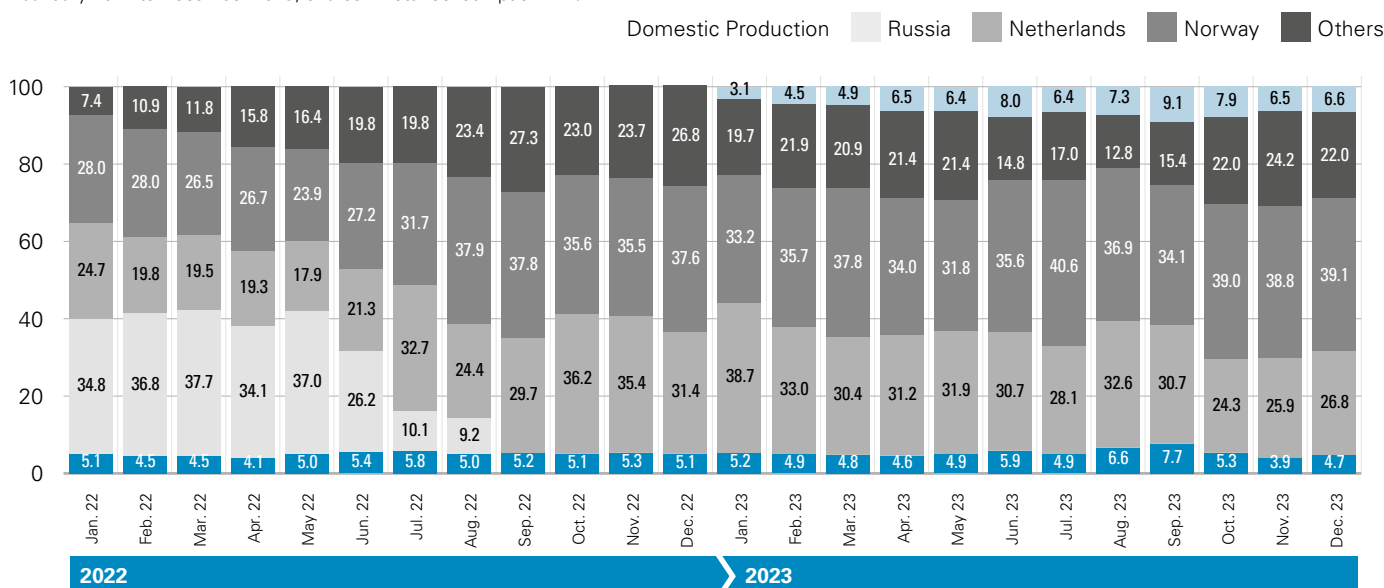
Since the reporting year 2018, the data reflecting the development of natural gas imports and exports have also included all transit volumes which pass through the Federal Republic of Germany's territory to its neighboring countries. That is why only the foreign trade balance (net imports) will be examined closer here. In 2023, the import volume of natural gas remaining in Germany (imports minus exports) amounted to about 689 billion kWh (H_i). Thus, the net import volume decreased by more than 14 % when compared to the previous year.

The consequences of the war of aggression against Ukraine are reflected by distinctly changed import structures. Whereas a total of about 55 % of the

Figure 6

Origin of the Gas Consumed in Germany

January 2022 to December 2023; Shares in Total Consumption in %



Sources: ENTSOG; FNB; BDEW; own calculations

16) The AG Energiebilanzen calculates natural gas consumption both in the energy balance for Germany and in all other publications based thereon according to the heating value (previously referred to as lower calorific value, H_i , i = inferior, Latin for "below"). The calorific value (previously referred to as upper calorific value, H_s , s = superior, Latin for "higher") of natural gas is approximately 10 % above the heating value.

natural gas consumed in Germany had still come from Russia in 2021, imports declined noticeably in 2022; since September 2022, Germany has no longer imported any natural gas directly from Russia. The discontinuation of these supplies was offset by additional imports from Norway and the Netherlands as well as via pipelines from other neighboring countries (please see Figure 6).

In addition, the gas infrastructure was expanded by terminals built as entry points for liquefied natural gas (LNG). This permitted direct gas supplies to be procured from countries which are not connected to the German long-distance pipeline grid, so it was now possible to diversify gas supplies even further. In December 2023, three terminals were in regular operation in Wilhelmshaven, Brunsbüttel, and Lubmin. Due to the urgency of the matter, all three terminals were created with the help of floating storage and regasification units (FSRU).¹⁷⁾ Such FSRU are converted LNG tankships which are capable of converting LNG and feeding it into the German long-distance grid. Towards this end, the FSRU in Lubmin exhibits a unique feature: Since it cannot be approached directly by larger LNG tankships due to the local water levels, the LNG is initially transferred to an LNG tankship anchoring off Rügen and then transported from there with smaller LNG tankships to the FSRU in Lubmin.

The terminal with the highest utilization capacity was the one in Wilhelmshaven through which 65 % of the total amount of 65 billion kWh (H_i) that had been received in 2023 so far were fed into the long-distance grid. This equals four landings of LNG tankships per month, whereas each of the terminals Lubmin and Brunsbüttel recorded one LNG landing per month.

With a proportion of 84 % of the total supplies, the USA dominated the six LNG supplier countries in 2023. The other regions of origin (Norway, Angola, Egypt, the United Arab Emirates as well as Trinidad and Tobago) exhibited supply shares between 1 % and 5 % in 2023.

At the beginning of 2023, the underground storage facilities connected to Germany's natural gas grid started with a filling level of 90.5 %. With the statutory requirement of filling levels for gas storage facilities, operators of such storage facilities in Germany are obligated to always safeguard and guarantee average minimum filling levels at specific points in time. With a filling level of 78.3 % on February 1, the targeted minimum filling level of 40 % was easily exceeded; the same applied for the target levels as per October 1 and November 1. During the month of November, even the 100 % level was maintained over a longer period of time. According to Gas Infrastructure Europe, the stock level rose to a rate of 91.0 % by December 31, 2023.¹⁸⁾ On balance, about 10 billion kWh (H_i) of natural gas were withdrawn from storage facilities in 2023. For comparison: On balance, approximately 92 billion kWh (H_i) of natural gas had still been stored in 2022.

According to (preliminary) calculations and when compared to the previous year, domestic sales of natural gas decreased by 7 % to 722 billion kWh (H_i) in 2023. All told, the following trends become apparent for 2023 (please see Table 7):

- The demand for natural gas attributable to the plants of mining facilities and the manufacturing industry dropped by an estimated total of 10 % to 246.6 billion kWh (H_i) in 2023. The outlined decline in industrial natural gas consumption was due, on the one hand, to price-induced substitutions and savings measures and, on the other hand, to production cutbacks as a consequence of the continuously high energy prices which particularly affected the energy-intensive economic branches. When interpreting the differentiation of industry's use of natural gas which was selected here, it should be noted that this representation also includes consumption in natural gas fired power plants that generate electricity and heat and are operated by the industrial enterprises themselves as well as the non-energetic consumption of natural gas.

¹⁷⁾ LNG storage and regasification vessels are referred to as "floating storage and regasification units," abbreviated FSRU.

¹⁸⁾ Depending on the individual data source (Gas Storage Europe, ENSOG, or DESTATIS), the stock levels and/or the storage balances calculated therefrom deviate from one another. These differences have multiple reasons; they range from different data statuses and level indicators all the way to spatial delineations. For the early estimate of Germany's energy balance for 2023 and the natural gas balance derived therefrom (please see Table 7), reference was made to the respective data published by the Federal Statistical Office.

Table 7

Volume and Use of Natural Gas in Germany in 2022 and 2023

	Unit	2022	2023 ¹⁾	Change in %
Domestic Production	Billion kWh	42.5	38.0	-10.6
Imports ²⁾	Billion kWh	1,315.7	898.0	-31.8
Total Volume of Natural Gas	Billion kWh	1,358.2	936.0	-31.1
Exports ²⁾	Billion kWh	510.4	208.6	-59.1
Storage Balance ³⁾	Billion kWh	-92.0	10.0	-
Primary Energy Consumption	Billion kWh	755.8	737.4	-2.4
	Petajoules (H_i)	2,721.0	2,655.0	-2.4
	Mtce (H_i)	92.8	90.6	-2.4
Structure of Natural Gas Generation by Origin				
Domestic Production ⁴⁾	%	5.6	5.2	
Import Quota	%	96.9	95.9	
Structure of Natural Gas Consumption According to Consumer Groups				
Industry (Including Industrial Power Plants)	Billion kWh	274.1	246.6	-10.0
Power Supply (Including CHP Plants)	Billion kWh	96.7	96.5	-0.3
Provision of District Heating and Cooling (Including CHP Plants)	Billion kWh	49.4	48.1	-2.6
Private Households	Billion kWh	248.5	229.0	-7.8
Trade, Commerce, Services	Billion kWh	105.2	99.4	-5.5
Transportation	Billion kWh	2.2	2.2	1.4
Total Sales of Natural Gas	Billion kWh	776.1	721.8	-7.0
Self-Consumption	Billion kWh	11.3	8.5	-24.8
Statistical Differences	Billion kWh	31.7	-7.1	
Primary Energy Consumption	Billion kWh	755.8	737.4	-2.4

1) Preliminary data; some figures are estimates

2) Import and export volumes including all transit volumes

3) Minus = storage; plus = withdrawal

4) Share of domestic natural gas supply

Discrepancies in the totals are due to rounding off

Sources: Federal Statistical Office (Destatis); Federal Association for Natural Gas, Crude Oil, and Geogeneity (BVEG); Working Group on Energy Balances (AGEB)

- Natural gas consumption of companies in the trade, commerce, and service sector decreased noticeably as well. In contrast to industry, more than four fifths (2022: Approximately 89 %) of the natural gas in this consumption segment are used for space heating purposes. Hence, the milder weather conditions prevailing in 2023 caused the demand for

natural gas of the businesses and enterprises in the trade, commerce, and service sector to decrease. Investment as well as attitude, behavior, and price related savings measures reinforced this effect. The overall result shows that the weather, attitude and behavior as well as price induced savings actually overcompensated the increased consumption by the

economic trend in this segment (the price-adjusted gross value creation went up by 0.6 % in 2023 when compared to the previous year). All told, a consumption minus of almost 5.5 % can be anticipated in the trade, commerce, and service sector for the year 2023.

- When it comes to private households (including the housing companies supplying them with space heating and hot water), a significant decline in consumption is to be anticipated as well due to the milder outside temperatures in combination with high energy prices in 2023. Current data indicate a 7.8 % reduction of the natural gas consumption to 229 billion kWh (H_i) for 2023.
- All told, about 77.7 billion kWh of electricity, which is about 1.7 % less than during the previous year, were generated in the gas-fired power plants of electricity suppliers and industrial enterprises and in combined heat and power plants of other electricity producers in 2023. The use of natural gas as a fuel in power plants and heating stations supplying electricity dwindled in 2023 despite the slightly improved competitiveness when compared to the previous year. When it comes to electricity supplied to the general public (including combined heat and power plants), a decline in natural gas consumption is to be anticipated somewhere around 0.3 %.
- Higher temperatures caused the demand for district heat and/or heat extraction to decrease as well. The use of natural gas for the coupled and uncoupled provision of district heat went down by 2.6 % to 48.1 billion kWh (H_i) in 2023.
- Sales of natural gas (either in compressed form, CNG, or in liquefied form, LNG) to the transportation sector are likely to have increased by 1.4 % in 2023 so that a consumption level of 2.2 billion kWh (H_i) was attained here.

According to preliminary data, about 10.5 billion kWh (H_i) of biogas processed to natural gas quality (biomethane) were fed into the German natural gas grid in 2023 – this equals the previous year's level. In 2022 (figures for 2023 are not yet available), approximately 9.8 billion kWh of biomethane had been used in combined power generation and around 1.2 billion

kWh as a fuel. Another about 0.9 billion kWh were sold on the heating market (space heating, hot water). In accordance with the balancing scheme of the AG Energiebilanzen, these quantities are recorded both on the volume side and the consumption side under renewable energy and not under natural gas.

Since the liberalization of the energy markets, spot and futures markets have evolved for natural gas. At these virtual trading points, essential supply and demand based price signals are created for the European and, thus, also the German market today. The development of oil prices according to the principle of netback pricing based on oil indexation (*Anlegbarkeitsprinzip*) no longer plays any role in the development of the procurement costs for gas today.

Compared to the peak levels that had been attained during the crisis year 2022, the import price for natural gas dwindled once again in 2023. Between 2022 and 2023, the border-crossing price (on an annual basis) decreased from € 21/GJ (which equals 7.56 ct/kWh) to about € 12/GJ (4.29 ct/kWh); thus, it declined by 43.2 % when compared to the previous year. Regardless of this drop in prices, the average annual import prices for natural gas still remained at a very high level in 2023; in fact, they were about 69 % above the value which had been observed prior to the energy crisis (2021: € 7.1/GJ). Thus, the annual average for 2023 continued to noticeably exceed the old peak level which had been attained prior to the crisis in 2012 (€ 8.08/GJ or 2.90 ct/kWh).

A glance at the monthly development reveals an even more pronounced picture: After the import price for natural gas had reached its all-time high of € 41.26/GJ (14.85 ct/kWh) in August 2022 and peaked at € 26.1/GJ (9.38 ct/kWh) in December 2022, the border-crossing price started at € 17.62/GJ (6.3 ct/kWh) in January 2023. A further decline in the import price for natural gas to € 8.05/GJ (nearly 3 ct/kWh) was observed until May 2023 (which generally corresponds to the price level attained in September 2021). Since March 2023, the border-crossing price for natural gas has once again been quoted persistently below the level of the import price for crude oil. A lateral movement of the import price for natural gas ranging between € 8/GJ and € 13/GJ became apparent between March and December 2023.

In addition, Figure 7 indicates that the import price for natural gas to some extent had decoupled itself significantly from the development of the border-crossing price for crude oil imports over the course of the crisis year 2022, a phenomenon which had been observed to a less pronounced degree in the periods before the start of the war in Ukraine. Since March, April 2023, a normalization has been observed in the difference of the prices and the progress of the trend for crude oil and natural gas; albeit at an increased price level.

Parallel to the import prices for natural gas, the price level for natural gas at the energy exchange (spot market) decreased significantly from € 125.72/MWh to € 40.86/MWh (-67.5 %).¹⁹⁾ For comparison: In 2021, the spot market price for natural gas had still been quoted at € 47.09/MWh.

The development of import and wholesale prices, i. e. costs for the procurement of natural gas, has different effects on domestic sales prices. Varying procurement periods for diverse customer groups typically result in diverging price trends on the end consumer market. In

addition, the relative price changes for bulk consumers are higher because of the lower overall price level.

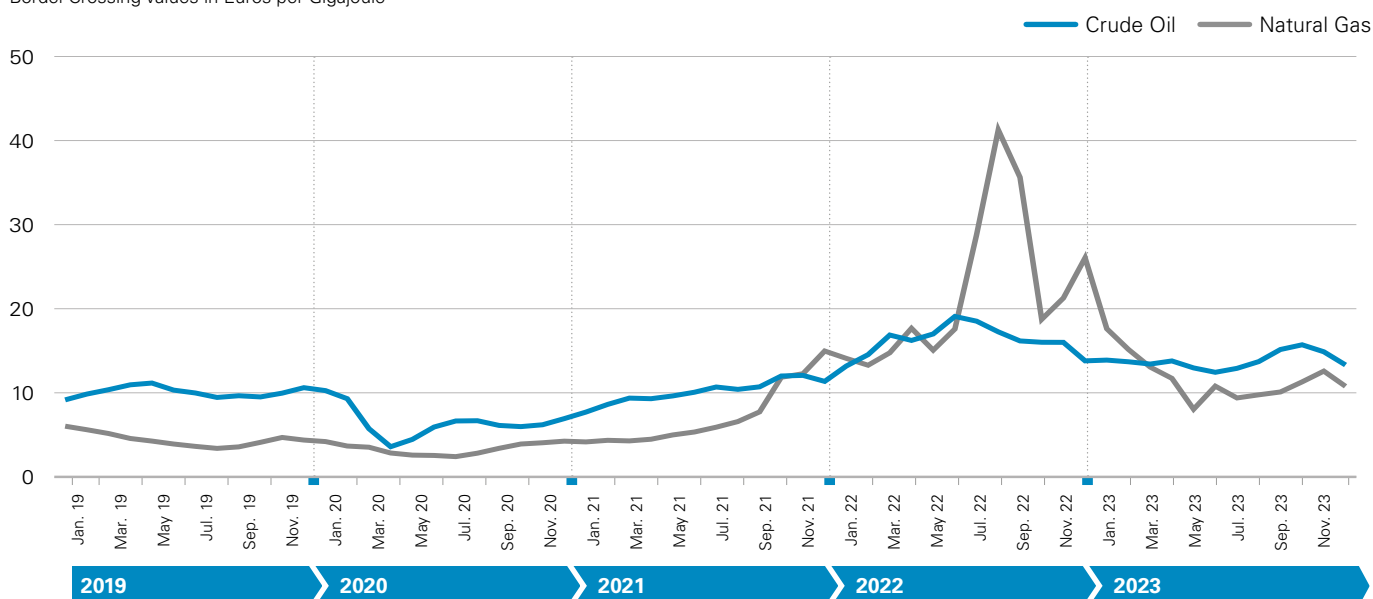
Against the backdrop of the declining import and wholesale prices for natural gas over the course of the year 2023 when compared to the previous year, the end customer prices and/or sales prices to consumers also decreased noticeably over the course of the year; albeit to a different extent. Particularly when compared to the peak levels that had been attained during the second half of the crisis year 2022, sales prices dropped significantly across all customer groups. For example, it was above all the price for power plant gas which went down by 56.6 % until December 2023 (with fluctuations) when compared to the peak value recorded in September 2022. The drop in prices for industrial clients was even more considerable: By the end of 2023, natural gas prices for industrial clients, also compared to September 2022, even decreased by 61.8 %.

When it comes to smaller customers of natural gas ("trade and commerce") as well as household

Figure 7

Monthly Border-Crossing Values for Crude Oil and Natural Gas between 2019 and 2023

Border-Crossing Values in Euros per Gigajoule



Source: Federal Office of Economics and Export Control (BAFA); Federal Statistical Office (Destatis)

¹⁹⁾ Average value taken from the daily reference prices of the market areas Gaspool, NCG, and TTF; for more details, please see the BDEW Gaspreisanalyse [Gas Price Analysis] (last update: February 2024) (currently only available in German).

customers, price peaks in the customer prices recorded in the aftermath of the Russian war of aggression against Ukraine had not occurred until November and/or December 2022. Compared to these values, customer prices in trade and commerce decreased by 18.3 % until December 2023 whereas the natural gas price for household customers dropped by 19.6 % until December 2023 (when compared to December 2022).

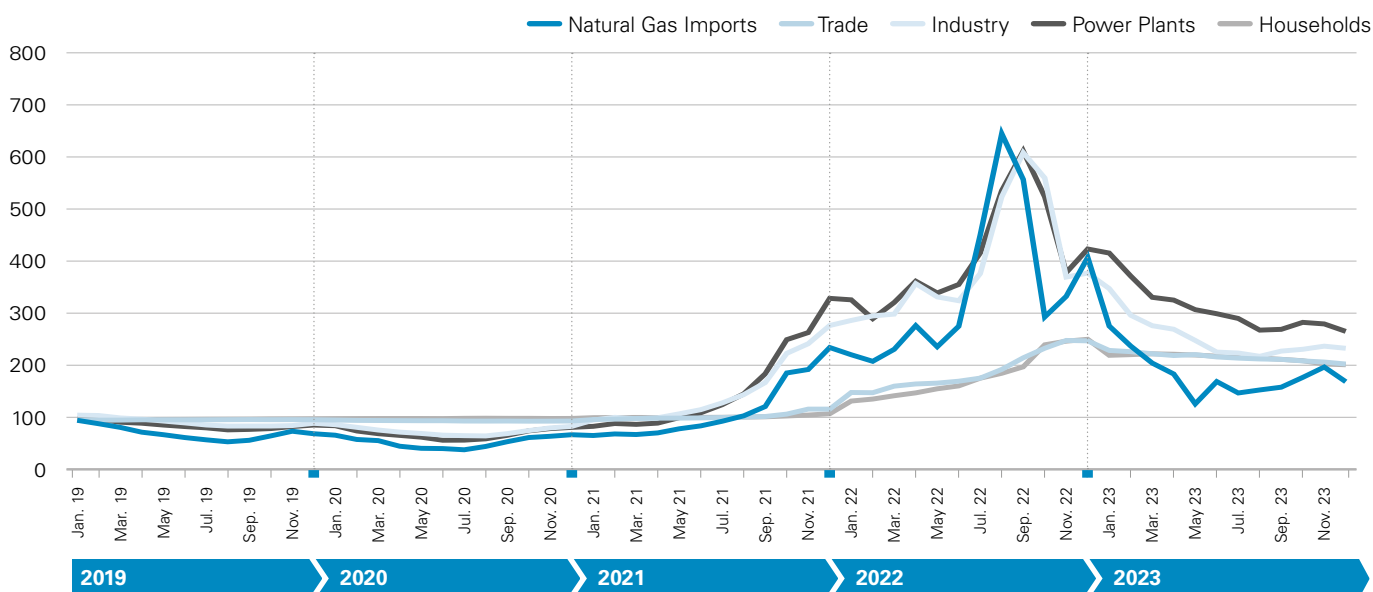
Also based on the annual average, sales prices for natural gas to power plants as well as to industrial clients went down between 2022 and 2023. For industrial clients, this resulted in a price reduction of 36 %; for power plants, the decrease amounted to about 24 %.²⁰⁾

Due to differentiated procurement strategies, gas prices for the sectors "trade, commerce, services" and "households" continued to increase on an annual basis in 2023 when compared to the previous year, which was in contrast to the forecast development for large customers (industry, power plants) who have been under review so far. When compared to the previous year, gas prices for private households went up by almost 19 % while an average increase in gas prices of more than 14 % was recorded for the "trade and commerce" sector (please see Figure 8).

Figure 8

Prices for Natural Gas Imports and Natural Gas Sales in Germany between 2019 and 2023

January 2015 = 100 (Basis of Producer Price Indices 2015 = 100)



Sources: Federal Office of Economics and Export Control (BAFA); Federal Statistical Office (Destatis)

20) When interpreting the price trend for industrial clients, it should be noted that the purchase prices for large industrial clients (annual supply of more than 500 GWh) decreased by almost 42 % compared to the previous year because natural gas had to be procured at shorter notice; for small industrial gas consumers (supply of 11.63 GWh/a), though, the natural gas price went down by only 6.4 % over the same period of time (2022/2023).

Hard Coal

According to preliminary estimates and compared to the previous year, Germany's primary energy consumption based on hard coal decreased by 18.5 % to 931 PJ (31.8 Mtce) in 2023 (please see Table 8). After a period of growth during 2021 and 2022, which interrupted the continuous downward trend that had previously persisted for many years and which was due, above all, to special effects and/or the direct consequences of the war in Ukraine, the long-term trends are, thus, more likely to become apparent once again. Notwithstanding the above, the primary energy consumption of hard coal in 2023 continued to be 3.9 % above the lowest consumption value which had been observed in 2020 (896 PJ which translates into 30.6 Mtce).

Right after nuclear energy and lignite, hard coal was one of the energy carriers that were most affected by the overall declining primary energy consumption. While the decrease in consumption in the steel industry was still comparatively moderate with -1.8 %, the use of hard coal in the power industry for the production of electricity and heat dropped by about one third. Thus, the growth recorded in the previous year was fully compensated for once again in 2023.

In concrete terms, the use of hard coal in power plants supplying the general public and in industrial power plants generating electricity and heat decreased by almost 34 % to 394 PJ (which translates into 13.4 Mtce) (please see Table 8). According to data released by the German Association of the Energy and Water Industries (BDEW) in its quick statistics and when compared to the respective months of the previous year (based on normal working days), with the exception of February (+21.9 %), the use of hard coal for power generation experienced a sharp decline almost over the entire course of the year 2023, in part with two-digit negative growth rates. When considering the entire course of the year 2023, then this results in an average growth rate of -35.5 %. Thus, the previous year's development, which had mostly been characterized by two-digit positive growth rates, turned almost entirely into the opposite direction.

The use of hard coal in the steel industry declined once again in 2023; namely, by 1.8 % to 466 PJ (which translates into 15.9 Mtce). Thus, this sector remained the largest economic branch and/or customer in the German hard coal market. The decline in consumption in the steel industry was primarily

Table 8

Volume and Use of Hard Coal in Germany in 2022 and 2023

	2022		2023 ¹⁾		Change in %
	PJ	Mtce	PJ	Mtce	
Primary Energy Consumption	1,142	39.0	931	31.8	-18.5
Power Plants and Thermal Power Stations	596	20.3	394	13.4	-33.8
Steel Industry ²⁾	475	16.2	466	15.9	-1.8
Other Sectors ³⁾	49	1.7	47	1.6	-3.5
Statistical Differences	-23	-0.8	-23	-0.8	-
Hard Coal Production	0	0.0	0	0.0	0.0

1) Preliminary data

2) Coke converted into coal, including coking plant

3) Other industrial sectors including non-energy consumption and other heating markets (private households; trade, commerce, and service sector; district heating plants); statistical differences

Discrepancies in the totals are due to rounding off

Sources: Working Group on Energy Balances (AGEB); bsn - Industry Association for Hard Coal and Post-Mining

Table 9

German Hard Coal Imports¹⁾ According to Supplier Countries in 2022 and 2023 (January to December)

	2022	2023 ²⁾	Change	2022	2023
	in Million Tons		in %	Proportions in %	
Poland	1.6	1.7	2.0	3.6	5.1
Czech Republic	0.2	0.2	-14.1	0.5	0.6
Russia	13.0	0.6	-95.6	28.8	1.8
South Africa	4.2	3.7	-11.9	9.4	11.4
USA	9.2	9.3	1.0	20.5	28.5
Canada	0.9	0.6	-33.8	2.1	1.9
Columbia	7.3	5.0	-31.6	16.3	15.4
Australia	6.4	8.5	33.5	14.1	25.9
Other EU Countries	2.1	3.1	48.6	4.7	9.5
Total Imports	45.0	32.7	-27.3	100.0	100.0

1) Including coke imports; coke converted into coal

2) Preliminary information

Source: Federal Statistical Office (Destatis)

attributable to the reduced production of oxygen steel when compared to the previous year; according to the German Steel Federation (WV Stahl), it dropped by almost 1 % to 25.6 million tons. Germany's crude iron production also went down at the same percentage rate to 23.6 million tons. With 35.4 million tons, the total production of crude steel in Germany fell to a historic low in 2023. The development outlined hereinabove can be attributed, for example, to the weak national and international demand for steel as a consequence of the overall economic situation as well as to the deteriorating global competitiveness of German crude steel which is primarily due to high electricity prices in Germany.²¹⁾

In terms of volume, the use of hard coal only played a minor role in the other sectors (foundries, district heating plants, small businesses, and private households); it decreased by 3.5 % to about 47 PJ (which equals 1.6 Mtce).

After the termination of domestic hard coal mining at the end of 2018, the volume side of Germany's hard coal market has been sourced merely from imports and existing stocks. According to preliminary data derived from the foreign trade statistics of the Federal Statistical Office and when compared to the previous year, Germany's hard coal imports dropped by 27.3 % to 32.7 million tons in 2023 (please see Table 9). By applying the generalized conversion method based on a value of 7,000 kcal/kg (i. e. without considering the actual heating values), this resulted in imports amounting to about 28 Mtce. Of this figure, 55.2 % accounted for power plant coals, 35.2 % for coking coals, 2.0 % for anthracite coals and briquettes as well as 7.6 % for hard coal coke.

The hard coal embargo issued by the EU against Russian exports had scheduled a transitional period of 120 days as of April 2022. Accordingly, imports of Russian hard coal to the EU had initially been permitted if and to the extent that the underlying supply contracts

21) For more details, please see German Steel Federation (WV Stahl), Press Release dated January 23, 2024: Stahlproduktion sinkt 2023 auf historisch niedriges Niveau. Internet: <https://www.stahl-online.de/medieninformationen/jahresbilanz-2023-stahlproduktion-sinkt-2023-auf-historisch-niedriges-niveau/> (download date: 2024-01-23; currently only available in German).

for coal were concluded before April 9, 2022. As of August 11, 2022, the EU embargo against Russian hard coal had entered into full force and effect. Additional hard coal imports from Russia to the EU were from now on strictly forbidden. But even thereafter, i. e. during the period between September and December 2023, the Federal Statistical Office still recorded imports in its monthly reports that were declared with "country of origin: Russia." Last year, these volumes still amounted to half a million tons, with a strong downward trend. In December, for example, as much as 20,000 tons were recorded. This remaining Russian tonnage was imported to Germany from neighboring EU countries (above all, the Netherlands and Belgium) and came, in particular, from storage sites of the Northwest European coal terminals (in Amsterdam, Rotterdam, and Antwerp = ARA ports). This Russian coal had already been stored there within the EU before August 11, 2022, which is why it did not fall under the embargo.

After hard coal imports from Russia had been reduced to a large extent, the total volume of hard coal imported to Germany was sourced, above all, from the United States (29 %), Australia (26 %), and Columbia (15 %). In a sectoral breakdown according to the individual coal types, major countries of origin for power plant coals were the United States (30 %), Columbia (27 %), and South Africa (almost 20 %). When it comes to coking coal imports, however, Australia (60 %) and the United States (33 %) played the most important roles. Imports from Russia, thus, disappeared almost entirely from virtually all sectors. It was only the market for anthracite coal, which was almost empty on the supply side, on which imports from Russia maintained their position with a share of about 35 %. This translates into a tonnage amounting to about 200,000 tons.

According to first preliminary estimates of the German Coal Importers Association (VDKi), a new record volume in global hard coal production hovering above 8.2 billion tons becomes apparent for 2023. When compared to the previous year, this would translate into an increase of nearly 4 %. The driving force behind this development was, above all, the People's Republic of China. Its Central Government enforced a comprehensive multi-annual program designed to increase production in the Chinese coal industry (to run until 2027) after temporary supply constraints had

occurred in the country in 2021. India also focused again on its own hard coal reserves and improved the productivity in most of its production sites. According to the Indian Ministry of Coal, this was achieved, in particular, through substantial investments into modern production technology.

Due to the Ukraine crisis, it has become even more difficult than had been the case in the past to obtain any Russian export data. The currently available database now covers only a period until January 2022. For the subsequent period of time, one has to rely on monthly estimates based on individual reports as well as data published by various other information services. Notwithstanding the above, the following statements can be made: Due to Western sanctions, Russia has adapted its entire coal export portfolio and orientates itself increasingly towards the Far East, particularly towards China. The majority of these deliveries are carried out via rail as domestic trade and are, thus, no longer part of the maritime hard coal trade. This does not apply to "multimodal transports" which are transported further via ship from Russian ports in the Far East. According to estimates, Russia delivered about 104 million tons of hard coal to China in 2023 – as much as never before (+42.9 % when compared to the previous year). As measured by China's total hard coal imports which amounted to 416 million tons (+41.9 % when compared to the previous year's value of 293.2 million tons; which was also an all-time record), this would translate into a Russian share of 25 %. With 24.8 %, this share had also been reached already in the previous year; albeit at a substantially lower absolute level (72.8 million tons of Chinese imports from Russia).

Prices for power plant coals on international markets returned to a normal level last year; currently, they are increasingly stabilizing themselves at the pre-crisis level (related to the Covid pandemic). During the 31st calendar week (until July 29, 2022), the weekly quotations for steam coals free Northwest Europe (cif ARA) had reached their new all-time high in the amount of US \$ 407/t but thereafter, they experienced a significant decline. Last year, the downward trend continued almost persistently; early this year, this resulted in a price that slightly exceeded about US \$ 110/t cif ARA.

Figure 9 conveys an indication of the long-term price trend for power plant coals also in comparison to the

changes experienced by crude oil. The import price for steam coals²²⁾ went down from almost US-\$ 338/tce (annual average 2022) to approximately US-\$ 150/tce in 2023. But it was still 7.5 % above the pre-crisis level (2021: US \$ 139/tce).

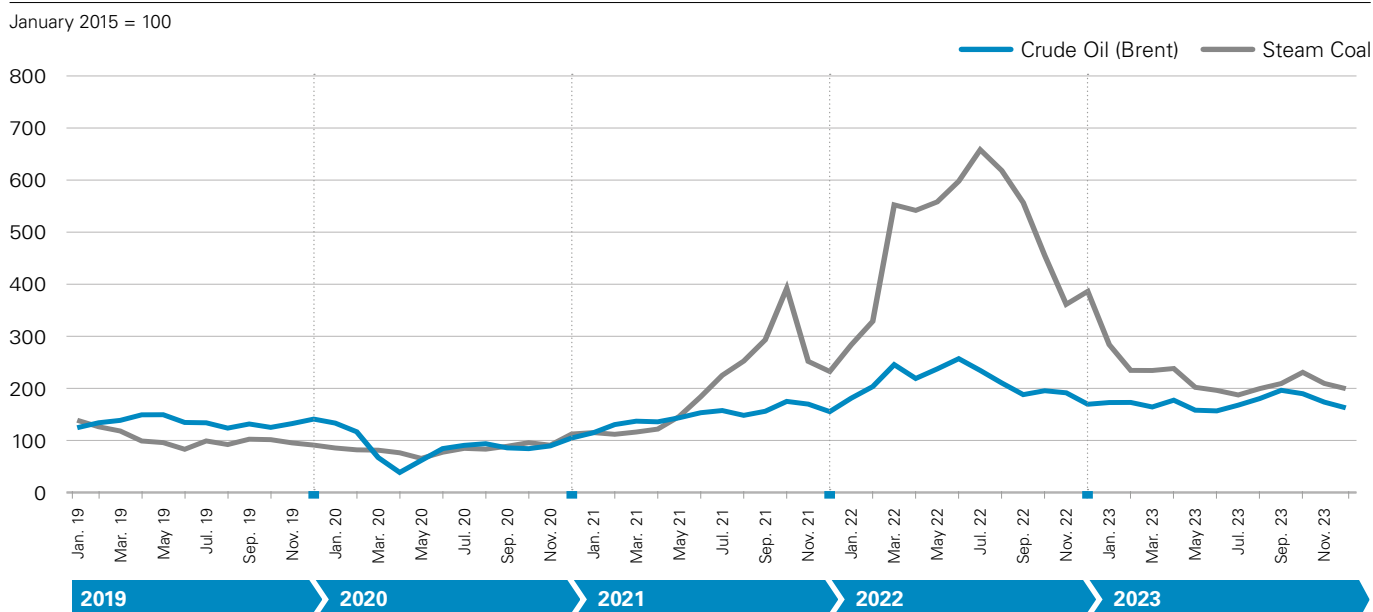
The price for steam coals amounted to US-\$ 195/tce in January 2023 and dropped to almost US-\$ 128/tce in July 2023. During the second half of the year, the price for steam coals increased slightly again and after an interim high (November 2023: US-\$ 159/tce), it reached a level of US-\$ 137/tce in December 2023.

Figure 10 shows in addition the import prices for hard coal coke and coal from third countries (power plants and steel producers). The overall picture reveals that the import prices for hard coal coke as well as steam coals and power plant coals which, after the invasion of Ukraine by Russian troops on February 24, 2022, had initially skyrocketed and reached their individual peak levels in the case of hard coal during the third quarter of 2022 (about € 400/tce) and/or in the case of hard coal

coke in May 2022 (almost € 600/tce), declined again by the end of the year. This trend essentially continued over the course of the year 2023. While the import price for hard coal (steam coal) dropped from about € 245/tce during the first quarter to € 181/tce during the fourth quarter of 2023, which equaled a reduction of more than 26 %, the import price for hard coal coke went down by more than 10 % between January and December 2023 and reached an absolute level of € 385/tce by the end of the year. As a result, the import price for hard coal coke in December 2023 fell almost 36 % below the price peak which had been observed in May of the previous year; the import price for hard coal during the fourth quarter of 2023 even hovered by more than half (-55 %) below the price level that had been reached during the third quarter of 2022. From an overall perspective, the price movements and price surges, particularly those of the crisis year 2022, were noticeably more significant for hard coal than was the case with the import prices for hard coal coke.

Figure 9

Global Market Prices for Crude Oil (Brent) and Steam Coal between 2019 and 2023



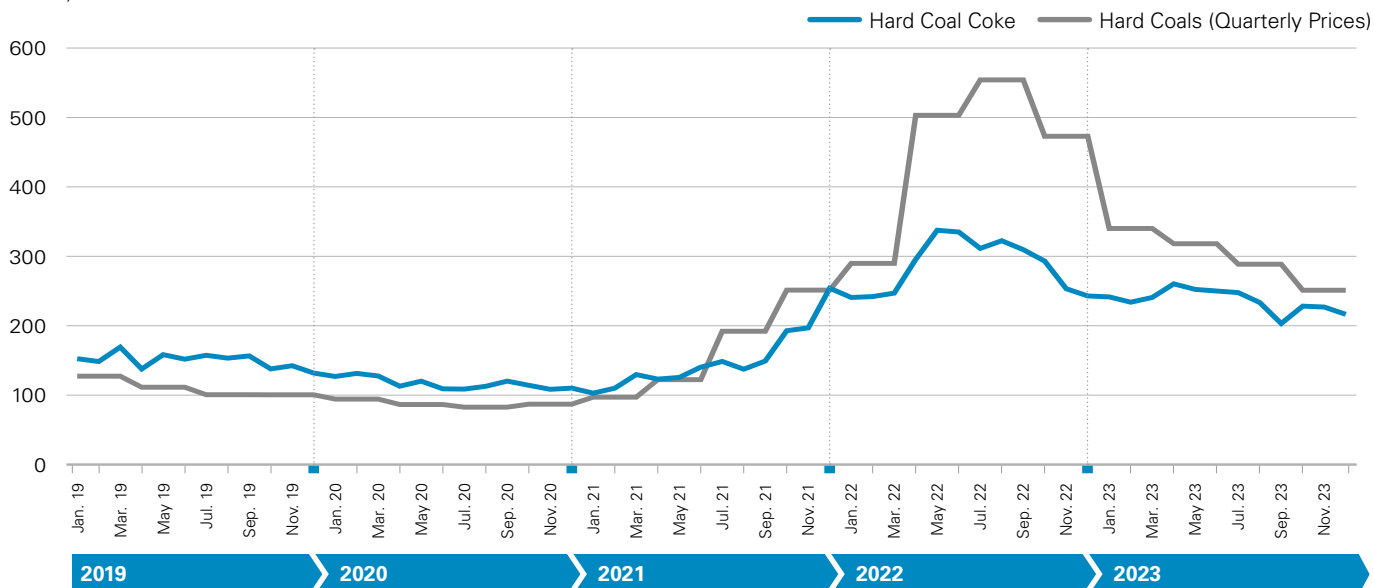
Sources: German Coal Importers Association (VDKI); en2x - Fuels & Energy Business Association

22) Spot price for power plant coals NWE; average over the weekly quotations according to the MCIS Steam Coal marker; expressed in US \$/t tce; cif ARA.

Figure 10

Development of Selected Hard Coal Import Prices between 2019 and 2023

January 2015 = 100



Sources: German Coal Importers Association (VDKi); Federal Office of Economics and Export Control (BAFA); Federal Statistical Office (Destatis)

Lignite

With about 102.3 million tons in 2023, lignite production as a whole was 21.8 % below the previous year's yield. In 2023, the calorific value of the extracted coal was all told on average somewhat lower than the previous year. The energy content of the mined lignite was, thus, with 31.3 Mtce (916 PJ) 23.2 % below the previous year's value. Lignite's share in domestic energy generation amounted, therefore, to about 27 %. It, thus, continued to be an important domestic energy carrier.

Production developed differently in the individual mining districts: In Central Germany nearly 28 % less were extracted and in the Rhineland area about 26 % less. In Lusatia, production sank by 14 %. This change generally corresponds to the development of deliveries to power plants supplying the general public (a total of 89.9 million tons; -23.1 %) which received around 90 % of the production.

Power generation based on lignite in Germany decreased from 116 billion kWh during the same period last year to approximately 87 billion kWh. Lignite's share in the gross power generation amounted to about 17 % in 2023. Lignite, thus, continued to be an important and a reliable source of energy for power generation in Germany also in 2023.²³⁾

In order to assure a secure supply of energy, the lignite-fired power plant units Niederaußem E, Niederaußem F, and Neurath C of the RWE Power AG corporation as well as Jänschwalde F and Jänschwalde E of the Lausitz Energie Kraftwerke AG corporation are permitted to participate in the electric power market

in accordance with the updated German Ordinance on the Retrieval of Supply Reserves (VersResAbV) until March 31, 2024. This measure was implemented by the Federal Government in October 2023. Through the participation of these power plant units as supply reserves, it was possible to increase the availability of production capacities by 1,900 MW and it was also possible to reduce the use of natural gas.

The manufacture of refined products based on lignite decreased by 18 % to more than 4 million tons. Consequently, pulverized coals exhibited a minus of 13 % and fluidized bed coals a minus of 31 % whereas coke recorded a plus of 8 %. At the end of 2022, the briquette factory in Frechen in the Rhineland area had been shut down in accordance with the German Coal-Fired Power Generation Termination Act (KVBG) which resulted in a 36 % reduction of briquette production.

With 30.5 Mtce (895 PJ), the primary energy consumption of lignite fell more than 23 % below the previous year's level. Lignite, thus, covered about 8 % of the entire domestic energy demand (please see Table 10).²⁴⁾

In 2023, the final energy sectors reduced the use of lignite and lignite products by a total of approximately 1.9 Mtce when compared to the previous year which translates into a decline of about 24 %. In industry, the use of lignite decreased by nearly 24 % while sales to private households and the trade, commerce, and service sector declined by 18 % (please see Table 11).

²³⁾ Additional data on lignite can be found at: <https://kohlenstatistik.de/> (currently only available in German).

²⁴⁾ Deviations from Table 1 due to minor variations in data statuses and rounding-off differences.

Table 10

Volume and Use of Lignite in Germany in 2022 and 2023

		2022	2023 ¹⁾	Change
	Unit			in %
1. Domestic Raw Lignite				
Total Lignite Production	Million Tons	130.8	102.3	-21.8
	Mtce	40.7	31.3	-23.2
	PJ	1,192	916	-23.2
2. Foreign Trade				
Total Imports	1,000 tce	28.9	31.8	10.2
Total Exports	1,000 tce	898.5	745.0	-17.1
Foreign Trade Balance	1,000 tce	-869.6	-713.1	-
3. Primary Energy Consumption				
	Mtce	39.9	30.5	-23.4
	PJ	1,169	895	-23.4
4. Sales				
Total Sales	Million Tons	117.7	90.6	-23.0
to Power Plants Supplying the General Public	Million Tons	116.9	89.9	-23.1
to Other Customers	Million Tons	0.8	0.7	-6.8
Use for Refinement	Million Tons	11.5	9.8	-14.5
Use in Lignite-Fired Power Plants	Million Tons	1.7	1.7	0.5
Change in Stocks	Million Tons	0.0	0.1	-
5. Electricity Production from Lignite				
Power Plants Supplying the General Public	Billion kWh	114.1	85.3	-25.2
Industrial Power Plants	Billion kWh	2.1	1.9	-9.5
Total Electricity Production from Lignite	Billion kWh	116.2	87.2	-24.9

1) Preliminary data; some figures are estimates

Discrepancies in the totals are due to rounding off

Source: The German Coal Industry's Statistical Office

Table 11

Lignite Balance for Germany in 2022 and 2023

in 1,000 tce

	2022	2023 ¹⁾	Change
			in %
Domestic Production	40,701	31,255	-23.2
+ Imports	31	32	4.4
= Volume	40,731	31,287	-23.2
+/- Change in Stocks (Reduction: +, Replenishment: -)	8	-4	-
- Exports	898	745	-17.0
= Primary Energy Consumption	39,841	30,538	-23.4
- Use in Power Plants	36,812	28,031	-23.9
- Other Conversion Input	3,948	3,331	-15.6
+ Conversion Output	3,919	3,228	-17.7
- Consumption during Production and Conversion as well as Non-Energetic Consumption	480	475	-1.0
= Final Energy Consumption	2,521	1,929	-23.5
Industry	2,163	1,633	-24.5
Households, Trade, Commerce, Services, Concessionary Coal	358	295	-17.6

1) Preliminary data; some figures are estimates

Source: The German Coal Industry's Statistical Office

The Electric Power Industry

In 2023, the electric power industry was characterized by the overall weakening economy and mild weather, but primarily also by the increases in prices for primary energy and the overall availability of fuels. The consumption of electric power (gross domestic electricity consumption) decreased by an estimated 4.2 % to 525.5 billion kWh. Power generation (gross electricity production) recorded an even greater decrease with 11.1 %. The balance of Germany's electricity trading shifted to a plus with an import surplus of 11.8 billion kWh for the first time in many years after an export surplus of 27.3 billion kWh had still been observed in 2022.

The electric power generation mix in 2023 was, above all, influenced by the general economic development, price effects, the weather, and the decommissioning of the last three remaining nuclear power plants on April 15, 2023. The weather conditions contributed towards an increase in the generation of electric power from wind, sun, and water.

The wholesale prices for natural gas, which had dropped again significantly at the beginning of 2023, and the CO₂ prices, which continued to be relatively high at the same time, had a considerable impact on the power generation infrastructure. But also industry's decreasing demand due to the economic downturn and the structural transformation led to a reduction of the electric power generation from lignite and hard coal. According to initial figures, natural gas fired power plants produced with about 78 billion kWh only 1.7 % less electric power in 2023 than in 2022.

According to preliminary figures, 272.4 billion kWh of electricity were generated from renewables during the last year. The proportion of renewables in the gross electricity consumption – the decisive ratio for renewables in achieving their targets – amounted to 51.8 %. In 2023, wind power was the most important energy carrier in the German electric power mix with a total electricity production of 142.1 billion kWh whereby renewables as a whole were able to generate altogether 272.4 billion kWh of electricity. This was followed by lignite with 87.2 billion kWh and natural gas with 77.7 billion kWh (please see Table 12).

Lignite-fired power plants generated a total of 87.2 billion kWh of electricity in 2023. This translates into a 25 % decrease in production when compared to the previous year. A net power plant capacity of 19,318 MW was installed at the end of the year. This figure includes, though, about 1,900 MW of power plant capacity from the standby mode for backup purposes which returned to the electricity market for a limited period of time.

With an estimated 40.6 billion kWh, hard coal fired power plants also delivered significantly less electricity than in the previous year. Their electricity production dropped by about 36.2 % after it had increased by nearly 17 % in the previous year. By the end of the year, the installed capacity of hard coal fired power plants amounted to 18,294 MW. This includes, though, 5,580 MW from market returnees whose planned decommissioning was postponed in accordance with the Substitute Power Plants Maintenance Act (EKBG) or which returned to the electricity market from the grid reserve for a limited period of time. An additional 1,352 MW continue to be in the grid reserve, i. e. more than a third of the installed capacity will be decommissioned within the foreseeable future or will return once again to the grid reserve.

In the year under review, 2023, a total of 77.7 billion kWh of electricity were generated from natural gas in the power plants of electricity suppliers and in the power plants of industrial enterprises as well as in the combined heat and power plants of other electricity producers. Thus, electricity production from natural gas went down slightly by a total of 1.7 %. The gas prices which once again dropped noticeably in spot markets with concurrently, relatively high CO₂ prices have significantly improved the competitiveness of gas-fired power plants when compared to the electricity production from hard coal and lignite.

The indicators which are typically used to measure the contribution margin of power plants in a specific market environment (fuel prices, CO₂ price, EEX spot market price, degree of efficiency) are the so-called "clean spark spread" (gas-fired power plants), the "clean dark spread" (hard coal fired power plants) as well as the "clean brown spread" (lignite-fired power

Table 12

Gross Electricity Production in Germany between 1990 bis 2023 According to Energy Carriers

	1990	2019	2020	2021	2022	2023 ¹⁾	2022/ 2023	1990/ 2023
	in Billion kWh					Average Annual Change in %		
Lignite	170.9	114.0	91.7	110.1	116.2	87.2	-25.0	-2.0
Hard Coal	140.8	57.5	42.8	54.6	63.7	40.6	-36.2	-3.7
Nuclear Energy	152.5	75.1	64.4	69.1	34.7	7.2	-79.2	-8.8
Natural Gas	35.9	89.9	94.7	90.3	79.1	77.7	-1.7	2.4
Mineral Oil	10.8	4.8	4.7	4.6	5.7	4.9	-14.4	-2.4
Renewables	19.7	241.6	251.5	233.9	254.6	272.4	7.0	8.3
Other	19.3	25.5	24.8	24.5	23.8	23.6	-0.9	0.6
Gross Electricity Production	549.9	608.2	574.7	587.1	577.9	513.7	-11.1	-0.2
Electricity Flows from Foreign Countries	31.9	40.1	48.0	51.7	49.3	70.3	42.5	2.4
Electricity Flows into Foreign Countries	31.1	72.8	66.9	70.3	76.6	58.5	-23.6	1.9
Foreign Electricity Exchange Balance	0.8	-32.7	-18.9	-18.6	-27.3	11.8	-	-
Gross Electricity Consumption	550.7	575.6	555.8	568.5	550.6	525.5	-4.6	-0.1
<i>Change versus Previous Year in %</i>	X	-2.9	-3.4	2.3	-3.2	-4.6		
	Structure of Gross Electricity Production in %							
Lignite	31.1	18.7	16.0	18.8	20.1	17.0		
Hard Coal	25.6	9.4	7.5	9.3	11.0	7.9		
Nuclear Energy	27.7	12.3	11.2	11.8	6.0	1.4		
Natural Gas	6.5	14.8	16.5	15.4	13.7	15.1		
Mineral Oil	2.0	0.8	0.8	0.8	1.0	1.0		
Renewables	3.6	39.7	43.8	39.8	44.1	53.0		
Other	3.5	4.2	4.3	4.2	4.1	4.6		
Gross Electricity Production	100.0	100.0	100.0	100.0	100.0	100.0		

1) Some figures are preliminary and estimates

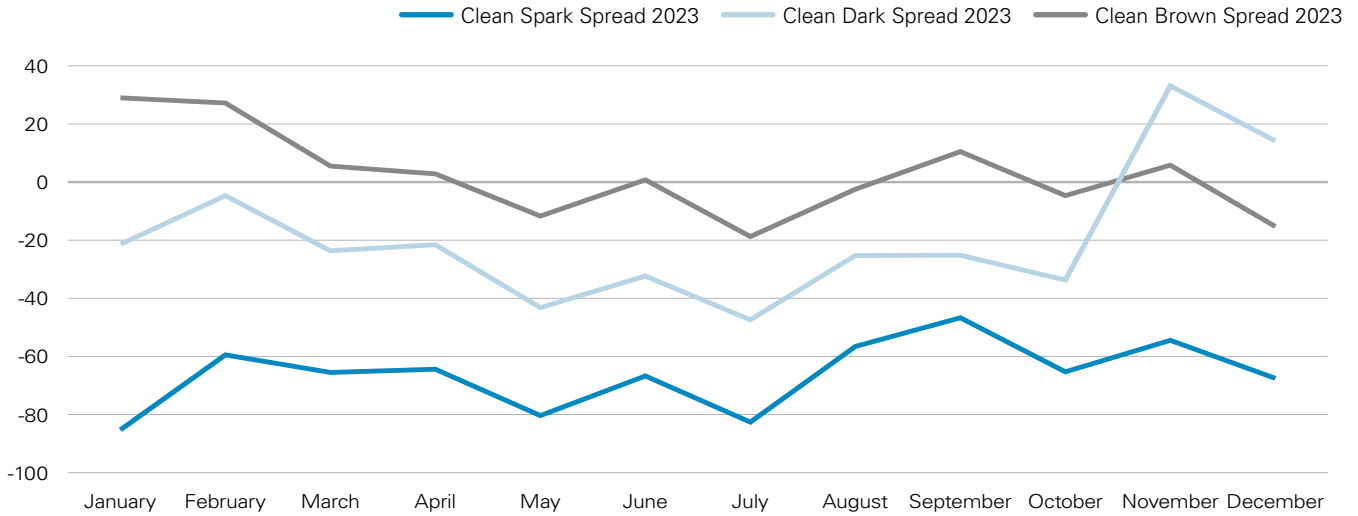
Discrepancies in the totals are due to rounding off

Sources: German Association of Energy and Water Industries (BDEW); The German Coal Industry's Statistical Office; Working Group on Energy Balances (AGEB); Federal Statistical Office (Destatis); Working Group on Renewable Energies-Statistics (AGEE-Stat) (for renewables)

Figure 11

Profit Situation of Different Power Plant Types

2023, in EUR/MWh (Existing Power Plants)



Sources: Our own calculations in line with the Federal Statistical Office (Destatis), EEX, and The German Coal Industry's Statistical Office

plants).²⁵⁾ Figure 11 shows the changes in the profit situation of natural gas fired power plants in relation to coal-fired power plants over the course of the year 2023.

Compared to the previous year, the installed capacity of gas-fired power plants increased due to new installations by 775 MW to 33,039 MW in 2023; however, 1,388 MW of which are currently in the grid reserve. Another 1,263 MW are in the capacity reserve, 988 MW are classified as the so-called special grid-technical equipment (bnBM), and 1,578 MW are temporarily decommissioned, i. e. more than 15 % of the installed capacity are currently not active on the electricity market.

In 2023, the last three nuclear power plants in Germany produced just 7.2 billion kWh of electricity until their final shutdown and, thus, nearly 80 % less than in the previous year. In order to safeguard and assure a sufficient supply of electricity, the remaining nuclear power plant units Neckarwestheim 2, Isar 2, and Emsland were in the so-called stretch-out operation beyond their originally scheduled decommissioning date on December 31, 2022. They were then permanently shut down on April 15, 2023.

Wind energy continued to be the most important renewable energy source in Germany. With 118.2 billion kWh, onshore wind turbines produced 18.6 % more electricity in 2023 than 2022. Offshore wind turbines with a total output of 23.9 billion kWh supplied less electricity than had been the case in the previous year (-4.9 %). One reason for this were grid-based curtailments. According to preliminary figures, the installed capacity of wind energy on shore increased by about 3,300 MW to currently approximately 61,300 MW in 2023. At sea, a new offshore wind farm was completed in 2023. The installed capacity increased by about 250 MW to 8,149 MW. Considerably more expansion is to be once again expected for offshore wind power during the next two years 2024 and 2025.

With 61.9 billion kWh, photovoltaic systems supplied more electricity than in the previous year (+1.5 %). This amount of electricity includes not only the electric power fed into the grid supplying the general public, but also the plants' own in-house consumption on site. According to preliminary calculations, an additional photovoltaic capacity of about 13,600 MW_p was newly installed in 2023; thus, the total capacity installed at the end of the year amounted to approximately 81,100 MW_p. Hence, the installation of new

25) The calculation of "clean spreads" represents an approximation of the costs incurred from the conversion of fuels into electric power while also taking the CO₂ costs into account. Consequently, this indicator helps assess whether the production in the individual type of power plant under review will be profitable with regard to the specific market situation or whether the production should be limited and/or suspended. The "clean spreads" shown herein were ascertained with the help of average degrees of efficiency in the existing power plant pool, which means that they do not refer to the competitive situation of any single plants or new plants.

photovoltaic capacities in 2023 significantly surpassed the previous record year 2012 when a photovoltaic capacity of nearly 8,161 MW_p had been newly installed.

According to preliminary data, 43.6 billion kWh of electricity were produced from solid, liquid, and gaseous biomass (including landfill gas, sewage gas as well as sewage sludge) in 2023 and, thus, 5.3 % less than during the previous year. With the proportionate volume produced in waste-fired power plants (from biogenic waste), a total of 49.3 billion kWh of electricity were produced from biogenic energy sources in Germany in 2023.

Electricity production from hydropower increased by 11.4 % to 19.6 billion kWh in 2023. The reason for this increase was the higher precipitation when compared to 2022. Electricity production from hydroelectric power, thus, stabilized a bit again.

In 2023, power storage facilities connected to the German electricity grid (with a net nominal capacity

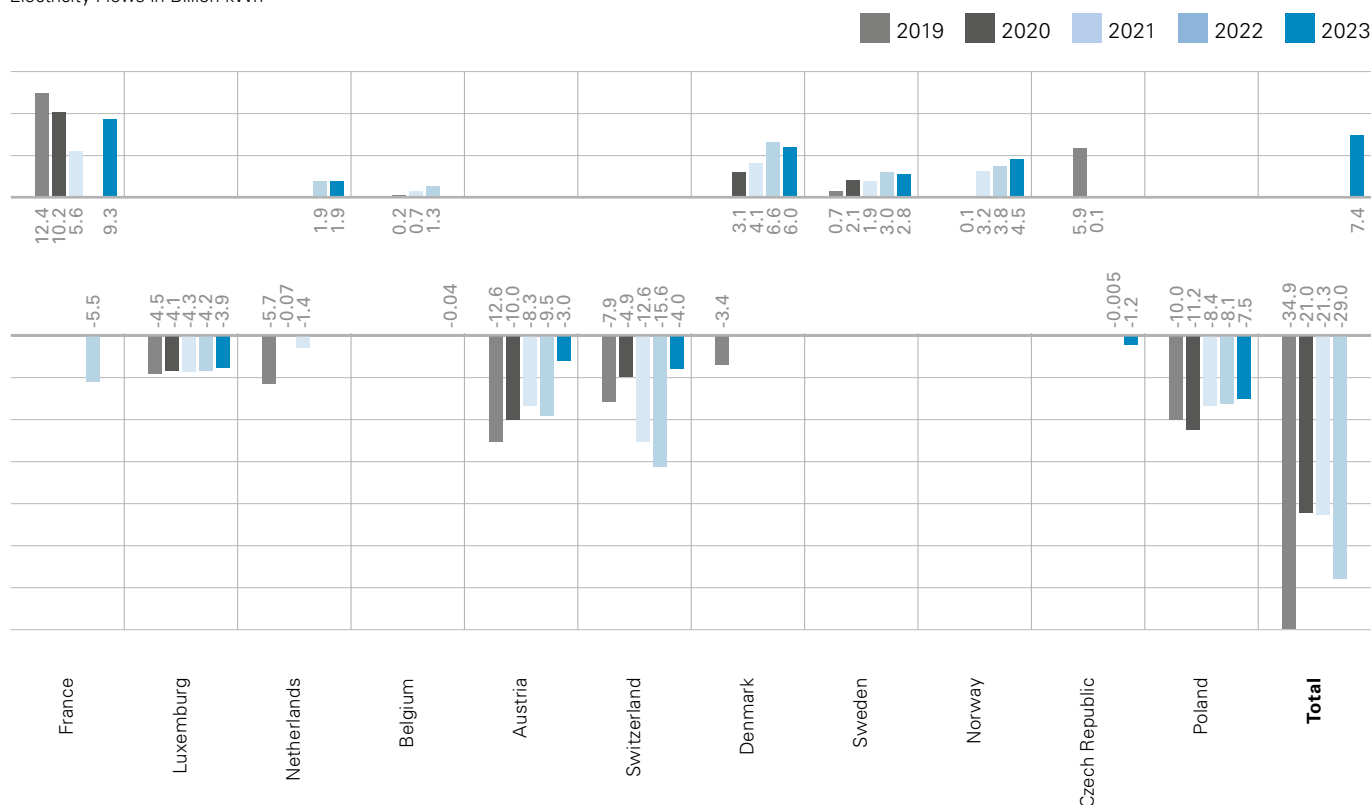
of at least 1 MW and/or a storage capacity of at least 1 MWh) collected a total of 8.0 billion kWh of electric power and fed 6.0 billion kWh back into the grid again. Pumped storage plants assumed the largest proportion in this development: While the pumping capacity was 7.4 billion kWh, 5.5 billion kWh were withdrawn from the plants. According to initial data, the usable storage capacity of these large-scale storage facilities amounted to 142 GWh at the end of 2023.

In 2023, 7.4 billion kWh more electric power flowed from abroad to Germany than the other way around from Germany to neighboring countries. (The official figures which are also used in the German energy balance, please see Table 12 of this report, cannot be used hereinafter due to data confidentiality of the federal states. The deviations are based on another data source (namely, the German Association of Energy and Water Industries (BDEW)). Germany is, thus, once again a net importer of electricity for the first time since 2002. When compared to the previous year, electricity exports dropped by 21.7 % to 61.7 billion kWh while electricity imports increased by

Figure 12

Germany's Electricity Exchange Balance with Neighboring Countries between 2019 and 2023

Electricity Flows in Billion kWh



Source: German Association of Energy and Water Industries (BDEW)

38.5 % to 69.0 billion kWh. At the end of 2023, Germany was – as is typical for the winter months – once again in a net export position with regard to the neighboring countries (please see Figure 12).

The changes in the electricity exchange are a sign of a functioning European domestic electricity market. At times during the past months, cheaper production options were available in neighboring countries to meet the electricity demand than would have been the case in Germany. Above all, the generation of electricity from hard coal and lignite fired power plants in Germany declined significantly due to relatively high CO₂ prices as well as the reduction of production capacities. At the same time, the expansion of renewables is also moving ahead in other European countries and resulted there in a higher electricity production from renewables during sunny months as well as during phases of high winds. Finally, the decommissioning of the last three nuclear power

plants in Germany and, compared to the previous year, the higher availability of nuclear power in France all resulted in the import surplus.

Higher electricity imports do not necessarily indicate any dependence on other European countries when it comes to the supply of electricity nor do they indicate any shortfall in Germany because sufficient domestic production capacities to cover the energy demand in Germany would have been available at any time. The utilization of cheaper production options in other European countries – in particular from renewable energies as well as from nuclear power plants – actually substituted fossil-based electricity generation in Germany. Consequently, the importation of electricity actually led to a reduction of emissions in the German CO₂ balance.

According to initial data, the end consumption of electricity amounted to 466 billion kWh in 2023.

Table 13

Electricity Balance of Germany's Power Supply between 2019 and 2023

	2019	2020	2021	2022	2023 ¹⁾	Changes 2022/2023
	Billion kWh				Change in %	Change in %
Gross Electricity Production	608.2	574.7	587.1	577.9	513.7	-11.1
Self-Consumption in Power Plants	-31.0	-27.7	-29.8	-28.3	-24.9	-12.2
Net Electricity Production	577.2	547.0	557.3	549.5	488.8	-11.0
Electricity Flows from Foreign Countries	40.1	48.0	51.7	49.3	70.3	42.5
Electricity Flows into Foreign Countries	72.8	66.9	70.3	76.6	58.5	-23.6
Net Domestic Electricity Volume	544.5	528.1	538.7	522.3	500.6	-4.1
Pump Current Consumption	8.1	8.8	7.2	8.1	7.4	-8.9
Grid Losses and Unrecorded Factors	27.5	26.9	26.6	26.3	27.0	2.6
Net Electricity Consumption	509.0	492.4	504.9	487.8	466.2	-4.4
Proportion of:						
Mining and Manufacturing Industries	218.4	206.7	214.4	201.4	187.0	-7.1
Households	127.0	128.0	139.3	135.2	130.4	-3.6
Commerce and Trade, Public Institutions	140.9	135.6	128.0	126.8	124.4	-1.9
Transportation	11.6	11.5	12.9	14.1	15.3	8.7
Energy Consumption in the Conversion Sector (without Power Plants' Own In-House Consumption)	11.0	10.6	10.4	10.4	9.0	-12.7
Gross Domestic Electricity Consumption	575.6	555.8	568.5	550.6	525.5	-4.6

1) Some figures are preliminary and estimates

Sources: Working Group on Energy Balances (AGEB); Federal Statistical Office (Destatis); German Association of Energy and Water Industries (BDEW)

The decrease by 21.6 billion kWh included all consumption sectors; increased consumption, however, is to be only expected in the transportation sector. The decrease is, in addition to the overall economic effects, above all due to the reactions to the high electricity and energy prices which resulted in thriftier consumer behavior and, in part, also in production cutbacks (please see Table 13).

In 2023, the largest electricity consumer was still industry with a share of 41 % despite its continued reduction in consumption, followed by private households with a share of 28.5 %. The share of the trade, commerce, and service sector amounted to more than 27 %, and the share of the transportation sector amounted to more than 3 %.

The electricity consumption of industry (mining and manufacturing industries) is expected to amount to a total of 287 billion kWh and, thus, declined by 7.1 % during the year under review. The electricity consumption of private households is expected to have dropped by 3.6 % and by 1.9 % in the trade, commerce, and service sector. According to first data, the transportation sector is expected to exhibit a plus of 8.7 % for the traction current of rail vehicles and for electric mobility.

Electricity prices for customers from industry (supply in the medium voltage range, annual consumption of 160,000 kWh to 20 million kWh, without electricity tax, new contracts) dropped by nearly 45 % when compared to the previous year. During the first quarter of 2024, this price trend continued according to initial data (during the first quarter of 2024, the electricity price for industry declined by more than 37 % when compared to the first quarter of 2023). The main reason for this development was to be found in lower procurement costs, power grid charges, and distribution costs which were reduced by about 44 % in 2023 when compared to the previous year. At the same time, governmental burdens of industry due to taxes, duties,

and levies were reduced in 2023 when compared to 2022; in particular, due to the discontinuation of the EEG levies²⁶⁾ since the second half of 2022 and due to the reduction of the CHP levy. This development was offset by an increase of the offshore grid levy by about 0.17 ct/kWh. All told, the governmental burdens for industrial customers due to taxes, duties, and levies were reduced by a total of nearly 38 % in 2023.²⁷⁾

Electricity prices for customers from private households increased by almost 21 % to a level of 45.73 ct/kWh in 2023 when compared to the previous year.²⁸⁾ The reason for this surge was the sharp increase of electricity prices in the wholesale trade in 2022. After the peaks during the third quarter of 2022, wholesale prices dropped again noticeably at the beginning of the year, but were still about three times above the level which had been observed prior to the energy crisis. Similar to how the drastic price increases of 2022 had affected the end customer prices with a temporal delay and in a reduced fashion, the observed current price reductions in wholesale electricity will also reach the end customers only gradually. Since the first quarter of 2023, however, the average electricity price for private households had been dropping and amounted to 44.17 ct/kWh in the fourth quarter of the year. Taxes, duties, and levies, thus, only amounted to a share of 27 % in the electricity price whereas the share of procurement and distribution costs continued to be 52 %. Grid charges amounted to 21 %. In 2024, taxes, duties, and levies will decrease only minimally. The so-called electricity price brake, which capped the commodity price for 80 % of the forecast annual consumption at 40 ct/kWh, produced an additional relief for the electricity bill of private household customers (please see Figure 13).

If one were to take a look at the monthly development of the electricity exchange prices since 2009, then this curve had initially exhibited fluctuations in the procurement costs which had always ranged between

26) On May 28, 2022, the Act to Reduce the Cost Burden of the EEG Levy and to Pass on This Reduction to End Consumers became effective. Its objective is to provide relief from the EEG levy for electricity customers as of July 1, 2022. Electricity suppliers are required to pass on this reduction (the EEG levy had amounted to 3.72 ct/kWh so far) in full to end consumers. The EEG levy was permanently abolished as of January 2023. The subsidies for expanding renewable energies will be financed, thus, no longer via the electricity price but instead by the special Energy and Climate Fund (EKF) of the German Federal Government.

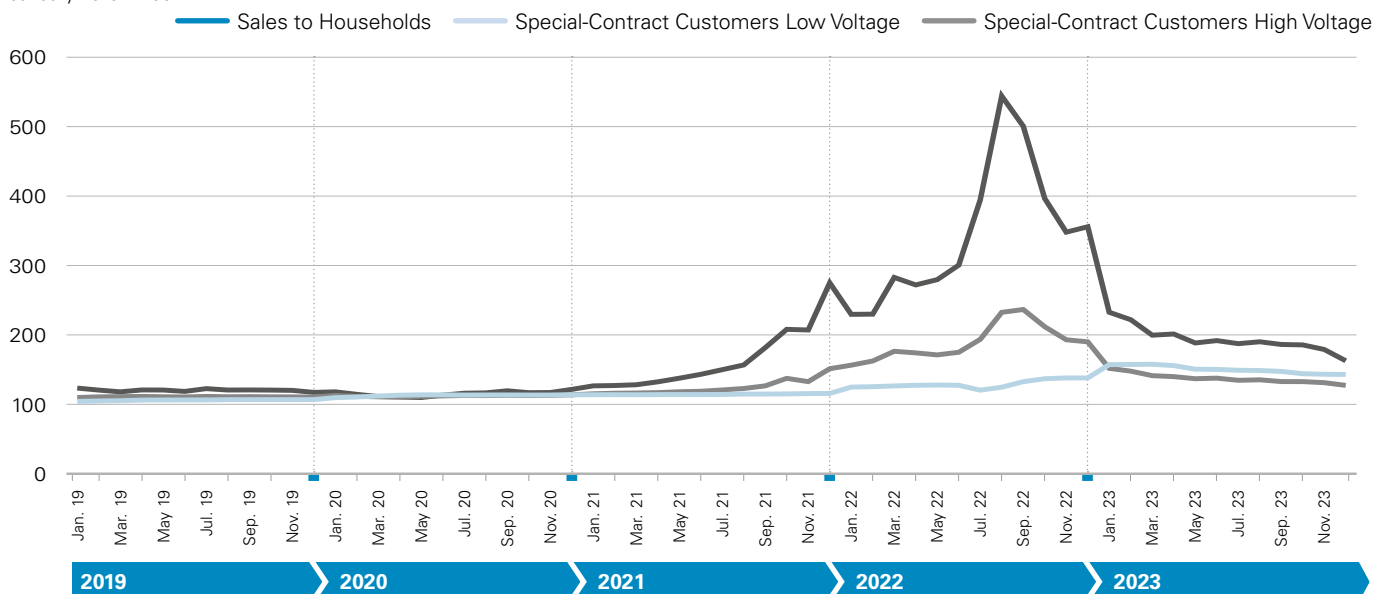
27) For more details and data, please see BDEW-Strompreisanalyse, Haushalte und Industrie, February 2024. Retrieved on March 18, 2024 from: <https://www.bdev.de/service/daten-und-grafiken/bdev-strompreisanalyse/> (currently only available in German).

28) Average electricity price for a private household in ct/kWh, annual consumption of 3,500 kWh, base price pro rata share included, tariff-based products, basic supply tariffs, and new customer tariffs included, not volume-weighted. For more details, please see BDEW-Strompreisanalyse, Haushalte und Industrie, February 2024. Retrieved on March 18, 2024 from: <https://www.bdev.de/service/daten-und-grafiken/bdev-strompreisanalyse/> (currently only available in German).

Figure 13

Electricity Producer Price Index for Special-Contract Customers and Sales to Households in Germany between 2019 and 2023

January 2015 = 100

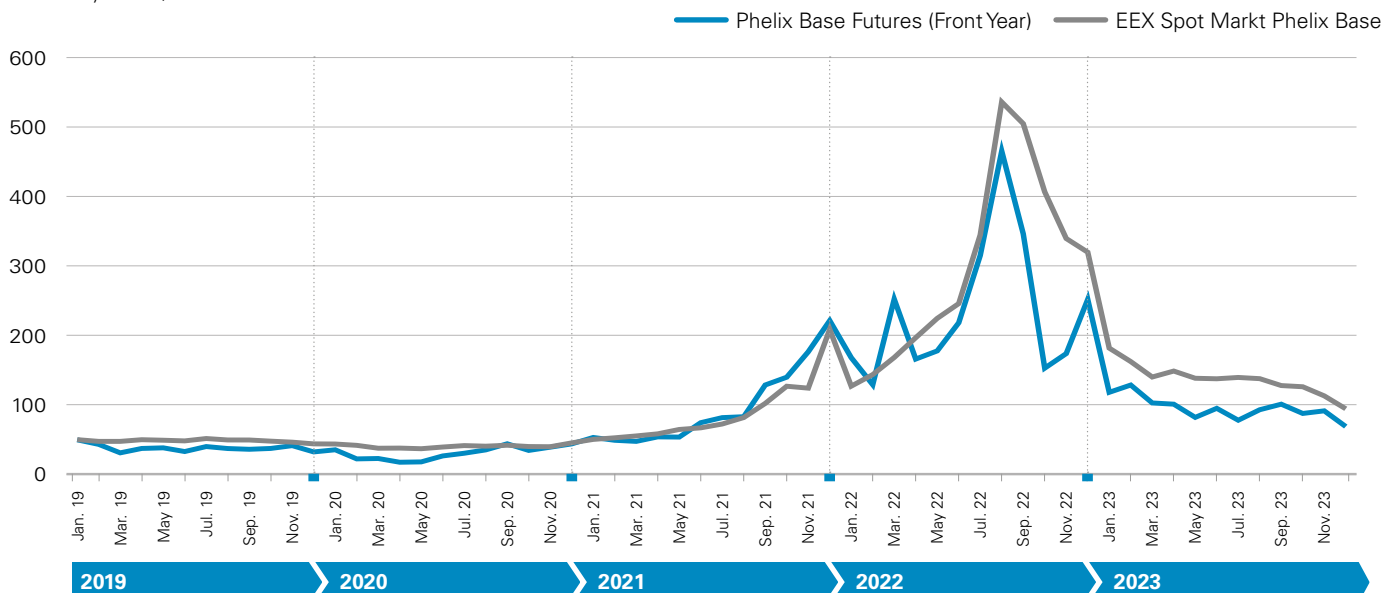


Source: Federal Statistical Office (Destatis)

Figure 14

Development of Electricity Prices on the EEX Spot Market and Futures Market (Front Year) between 2019 and 2023

Electricity in EUR/MWh

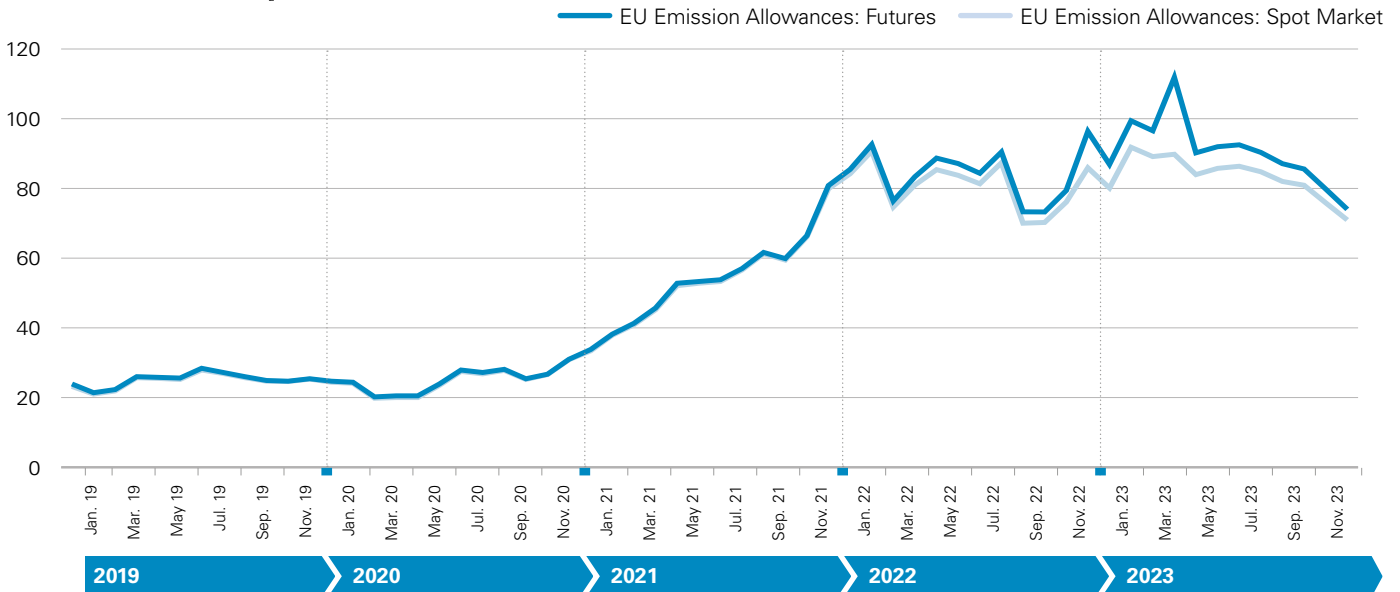


Source: Federal Ministry for Economic Affairs and Energy (BMWi)

Figure 15

European Emission Allowances on the EEX Spot Market between 2019 and 2023

Certificate Prices in Euro/t CO₂



Source: European Energy Exchange AG (EEX)

€ 22/MWh and € 57/MWh from January 2009 to December 2019. As of 2020, this picture changed dramatically: After the wholesale prices had dropped significantly over the course of the year 2020 and reached a low level with about € 17/MWh in April 2020, the electricity exchange price once again experienced a considerable increase already by the end of 2020 when it peaked at a level of € 44/MWh (December 2020). This price increase continued with a few interruptions until 2022. In 2022, the electricity exchange price underwent strong fluctuations and reached a new all-time high with € 465.18/MWh in August 2022. During the fourth quarter of the year, the situation on the market calmed down, the wholesale price dropped significantly again, and ended at a level of € 251.62/MWh in December 2022. The price level underwent comparably few fluctuations in 2023. In January, the electricity exchange price began at € 117.83/MWh and ended with € 68.52/MWh in December (please see Figure 14).

The CO₂ emissions for the electric power industry – in other words, the CO₂ emissions of all electric power plants (including the plants of industry and electricity generation from CHP plants within the delimitation of the German energy balance) in Germany – dropped significantly by about 29 % to 154 million tons of CO₂

in 2023 (in 2022: 200 million tons of CO₂) according to preliminary calculations. This was accompanied by an additional reduction of specific emissions in electric power generation.

Despite the discontinuation of electric power generation from nuclear power as of April 2023, emissions from the electric power industry dropped sharply over the course of the year above all as a result of the reduction of coal-fired power generation by more than a quarter. Another key component was the fact that Germany imported significantly more electricity in 2023 while the flow of electricity from Germany into neighboring countries declined. In addition, both the continued expansion of renewables as well as the decline in domestic electricity consumption resulting primarily from the economic downswing reinforced this development.

Prices for CO₂ emissions certificates developed primarily sideways and ranged between approximately € 80.00 and € 90.00 per ton of CO₂ during the course of the year 2023; however, the prices dropped below 70 euros by the end of the year. The annual average price amounted to about € 84.00 per ton of CO₂ (please see Figure 15).

Renewable Energy²⁹⁾

In 2023, the primary energy consumption of renewable energy sources amounted to a total of 2,107 PJ (please see Table 14). When compared to the previous year (2,043 PJ), this equaled an increase of 3.1 %. The decisive factor that influenced this development were more favorable weather conditions for electricity production from wind energy and hydropower than in the previous year. Solar-powered electricity production only increased slightly due to reduced solar radiation when compared to the extremely sunny previous year despite the high level of newly installed electricity production capacities. The utilization of environmental heat and geothermal energy went up by 16 % due to the increased number of heat pumps.

The entire electricity production from renewable energy sources amounted to a total of about 272.4 billion kWh in 2023. Compared to the previous year, this translates into an increase of 7 % (2022: 254.6 billion kWh).

In 2023 as well, wind energy was again the most important energy carrier in the German electricity mix ahead of lignite. Onshore and offshore wind turbines delivered about 23 % of the gross electricity consumption – thus, for the first time ever more than all lignite and hard coal fired power plants together. With 142.1 billion kWh, they actually contributed more than half of the renewable electric power. In addition to above average wind conditions, especially in Central Germany, but also in the North German Lowlands, the continued addition of new production capacities must also be mentioned in this context as a cause for this increase: While 258 MW of new generation capacities went into operation off shore, the net addition on shore reached 3,028 MW (this translates into an increase of about 44 % when compared to 2022). Thus, a total wind power capacity of about 61.1 GW was installed on shore and approximately 8.5 GW off shore at the end of 2023.

In 2023, electricity production from photovoltaics covered for the first time 12 % of the domestic gross

electricity consumption. With 61.2 billion kWh, it contributed 22.5 % of the electricity produced from renewable energy sources. Compared to the previous year, solar-based electricity production increased by only 0.9 billion kWh in 2023 because the global solar radiation equaled only the average level of the last 10 years, but was at the same time significantly below the extraordinarily sunny year 2022. This weather condition was ultimately offset by a very high level of new photovoltaic systems with a peak electricity output of 14,595 MW (+95 % when compared to the previous year 2022). With regard to the end of 2023 when the installed total capacity amounted to 82.2 GW, the number of existing photovoltaic systems increased by nearly 22 % just in the year 2023 alone. Against this backdrop, it can be assumed that the connection to the power grid was partly delayed so that some of the new systems will only contribute fully to the electricity production in the upcoming years.

Electricity production from biomass including biogenic waste was with 49.3 billion kWh in 2023 about 5 % below the previous year's level (51.7 billion kWh) while electricity production from hydropower increased by 2.0 billion kWh to a total of 19.6 billion kWh due to the weather conditions with higher precipitation. When it comes to balancing the primary energy contribution of electricity production from renewable energy sources, it needs to be pointed out that a special energy-statistical feature, the so-called efficiency principle, is applied here: In the absence of a physically ascertainable calorific value, a fictitious efficiency of 100 % is assumed for the conversion of energy in the balance sheets for the energy carriers hydropower, wind power, and photovoltaics while the use of biogenic fuels in power plants and other production facilities is entered with their actual energy content in the balance sheets. The efficiency principle, thus, results in the fact that, for example, the primary energy contribution of electricity production from photovoltaics (conversion input of 220 PJ) shown in Table 14 is entered in the balance sheet as being 43 % lower than the fuel input for electricity production

29) This text is based on the work conducted by the Working Group on Renewable Energies-Statistics (AGEE-Stat; last update: 2024-02-15). For further information on the development of renewables in 2023, please turn to the background paper published by the Federal Environment Agency (UBA) under the title: Erneuerbare Energien in Deutschland - Daten zur Entwicklung im Jahr 2023: <https://0/www.umweltbundesamt.de/publikationen/erneuerbare-energien-in-deutschland-2023> (currently only available in German).

Table 14

Renewable Energy in Germany in 2022 and 2023 According to Its Use and Energy Sources

	Hydropower		Wind Energy (Onshore and Offshore)			Solar Energy			Geothermal Energy			Biomass			Waste			Total		
	2022	Changes	2023	Changes	2023	2022	Changes	2023	2022	Changes	2023	2022	Changes	2023	2022	Changes	2023	2022	Changes	2023
	Petajoules	%	Petajoules	%	Petajoules	Petajoules	%	Petajoules	Petajoules	%	Petajoules	Petajoules	%	Petajoules	Petajoules	%	Petajoules	Petajoules	%	Petajoules
Domestic Production	63	11	449	14	252	253	0	89	103	16	1,062	1,043	-2	128	128	0	2,044	2,109	3.2	2,109
Foreign Trade Balance											-1	-2	165				-1	-2	165.3	-2
Primary Energy Consumption	63	11	449	14	252	253	0	89	103	16	1,062	1,041	-2	128	128	0	2,043	2,107	3.1	2,107
Use in Power Plants (Electricity)	63	71	449	14	217	220	2	7	7	0	343	325	-5	58	58	0	1,139	1,193	4.8	1,193
Use in Power and Heating Plants (Heat)					0	0	0	6	6	0	49	48	-1	47	47	-1	102	101	-0.7	101
Consumption during Conversion, Losses											22	21	-4	1	1	0	22	21	-4.2	21
Final Energy Consumption					35	33	-6	75	90	19	648	647	0	22	22	0	780	791	1.4	791
Industry					0	0	0	0	0	0	98	98	0	22	22	0	121	121	0.0	121
Transportation											125	127	2				125	127	1.5	127
Households, Trade, Commerce, Services					35	33	-6	75	89	19	425	422	-1				535	544	1.7	544

All values are preliminary (last update: February 2024)

Source: Working Group on Renewable Energies-Statistics (AGEE-Stat)

from biomass including biogenic waste (conversion input of 383 PJ) even though electricity production from photovoltaics exceeded electricity production from biomass including biogenic waste by 24 %.

The entire primary energy consumption of biomass and biogenic waste amounted to 1,169 PJ in 2023 and was, thus, approximately 2 % below the previous year's value (1,190 PJ). About 43 % of which were used in the conversion sector, i. e. essentially for the use as a fuel for the generation of electricity and district heat including the amount needed to cover the in-house consumption of production plants. The majority (57 %) of the energetic use of biomass accounted for final energy consumption as had been the case in the previous years. Nearly two thirds of the bioenergy sources were consumed by private households as well as in the trade, commerce, and service sector (422 PJ) while the share of the transportation sector (127 PJ) amounted to approximately a fifth due to the admixture of liquid and gaseous biofuels and the share of the industrial sector (120 PJ) was about 17 %. Due to the still very high prices for

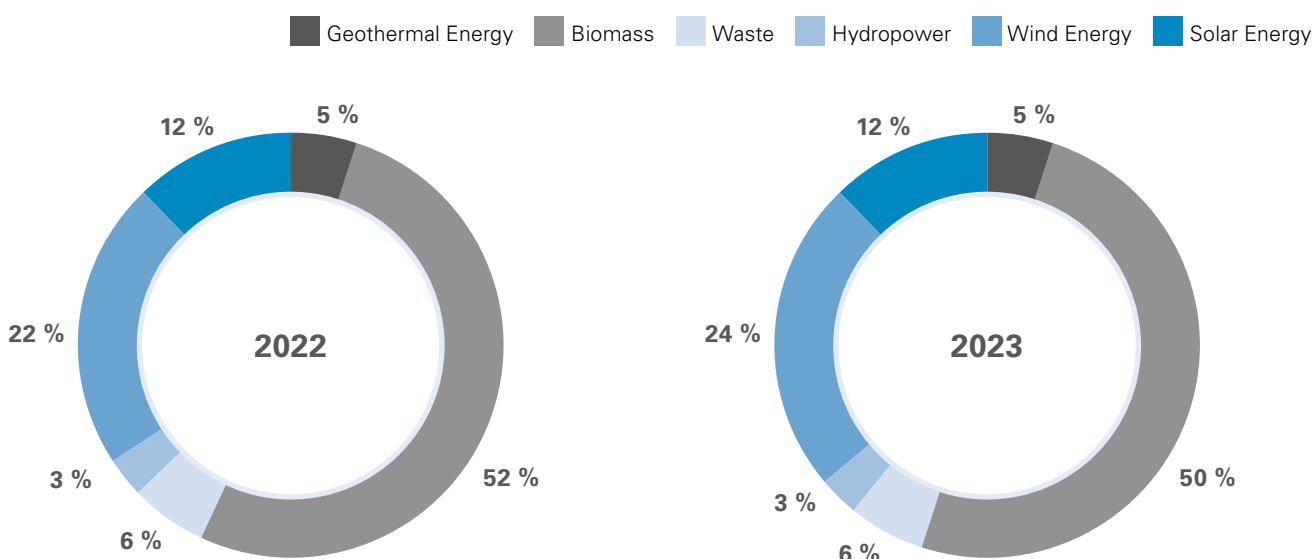
fossil energy carriers when compared to the situation prior to the war in Ukraine, it can be assumed that wood fuels are still being used to a considerable extent in private households as a substitute for fossil heating energy sources. The substitution effects can only be estimated with considerable uncertainties at this time because the requisite empirical data will only be available over the course of the year.

The utilization of environmental heat, including near-surface geothermal energy, deep geothermal energy, and solar thermal energy, accounted for a share of 6.5 % in the total primary energy consumption of renewables in 2023. In particular, electric heat pumps exhibited a strong growth according to the German Federal Heat Pump Association (BWP): With approximately 356,000 heat pumps sold in 2023, sales increased again for the second year in a row by more than 50 %. Sales of hot water heat pumps even topped the previous year's value by 81 % with 82,500 sold units. Consequently, approximately 2.1 million heat pumps were installed in Germany at the end of 2023. As a result, the renewable environmental

Figure 16

Structure of Renewable Energy Sources in Germany between 2022 and 2023

Shares in Total Renewable Energy in %



Source: Working Group on Renewable Energies-Statistics (AGEE-Stat)

heat and near-surface geothermal energy generated through these heat pumps, thus, increased by 18 % to 86 PJ. In addition, about 17 PJ of deep geothermal primary energy were used to produce electricity and heat.

Solar thermal heat generation decreased proportionally by 6 % to 33 PJ due to the lesser amount of solar radiation in the year 2023. After the increase in demand resulting from the crisis of 2022, the addition of solar thermal units to support the hot water and heating systems also dropped significantly in 2023 according to the German Solar Industry Association. With around 376,000 square meters of newly installed collector surface, only a little bit more than half of the collectors was installed when compared to the previous year. When also considering the decommissioning of units, then the total collector surface installed in Germany stayed constant at 22.4 million square meters.

An analysis of the individual technologies designed to utilize renewables clearly illustrates that the energy carrier specific primary energy consumption shows different tendencies (please see Figure 16). When compared to 2022, wind power was able to gain additional shares (+2.3 percent) due to the above average wind conditions (and the addition of new wind turbines). The same applies to geothermal power and hydropower which were also able to marginally increase their market shares in the entire primary energy consumption of renewables (+0.5 % and +0.3 % respectively). In contrast, biomass (-2.6 %) as well as solar energy (-0.3 %), and biogenic waste (-0.2 %) lost shares in the expanding market of renewables.

Biomass (including renewable waste) continued to be by far the most significant energy carrier amongst renewable energies with a share of about 55.5 % in 2023, followed by wind energy with 24.3 % and solar energy with 12 %.

Energy Efficiency in Germany

Already within the scope of Germany's national Sustainable Development Strategy, the Federal Government had established the objective of doubling the macroeconomic energy productivity by 2020 when compared to the respective figures ascertained for 1990. The Energy Efficiency Strategy 2050 also continues to see improvements in increasing the energy efficiency as a key strategy for the success of the targeted energy turnaround.

It should be kept in mind, though, that empirically determining energy efficiency is by no means clear and simple, and not every technically feasible increase in energy productivity is, at the same time, also economically viable. Because efficiency improvements actually require not only time, but usually also the application of innovative technologies and, thus, the increased use of physical capital.

A typical indicator for the measurement of energy efficiency is considered to be the energy intensity; namely, the consumption of primary or final energy in relation to such guiding economic parameters as, for example, the gross domestic product or the population. Every reduction of the energy intensity defined that way is synonymous with an increase in energy productivity and/or energy efficiency.

In 2023, the macroeconomic energy productivity in Germany improved by about 8.4 % when compared to the previous year (based on the original values ascertained for primary energy consumption). By using a unit of primary energy (GJ), it was possible to generate a gross domestic product of more than € 304 in 2023. In 2022 (final data), this value had still amounted to € 281. The growth of the macroeconomic energy productivity has many overlapping causes. On the one hand, the weakening economy with a simultaneous, rapidly accelerating intersectoral structural change, on the other hand, led to the entire economy having become more energy-extensive. In particular, the persistently high energy prices and the associated energy costs as a consequence of the Ukraine conflict led to an unwanted spread in the growth rates (in 2023, energy-intensive branches had to accept noticeably greater production losses than

energy-extensive economic sectors (for details, please see Page 6 ff of this report)).

A further (consumption-dampening) impact on the macroeconomic energy consumption and/or energy productivity was also due to the comparably mild weather conditions of 2023. When taking the adjusted temperature, compared to the long-term average (1990 to 2022), and the adjusted stock level effects into account, then the macroeconomic energy productivity improved by only 8.2 % when compared to the previous year. The improved (adjusted) macroeconomic energy productivity during the current reporting year 2023 was, thus, still significantly above the level of the long-term trend (1990 to 2023: About 2.5 % per annum).

All told, the decoupling process between the overall economic development and energy consumption (related to the adjusted values) continued even further in 2023; albeit, at an accelerated rate due to the special developments since 2022 (please see Table 15 and Figure 17).

However, such a review of the macroeconomic energy productivity, which is based on primary energy consumption, also reflects statistical effects. These effects are associated with the assessment of hydropower, wind energy, photovoltaics as well as nuclear energy from a primary energy perspective (which are all used for electricity production) and for which no uniform conversion standard exists such as the calorific value (for fossil fuels). Within the scope of preparing its energy balances, the AG Energiebilanzen evaluates and assesses these energy carriers according to the so-called efficiency method (which is also applied internationally for calculating the primary energy consumption and for preparing energy balances). In the past, the substitution method used to be the common evaluation standard in Germany. Depending on the respective substitution processes in the mix of energy carriers, any decision made in favor of the one or the other method actually influences not only the level, but also the development of primary energy consumption and the associated macroeconomic energy productivity.

Table 15

Macroeconomic Energy Productivity in Germany between 1990 and 2023

	Unit	1990 ¹⁾	2019	2020	2021	2022	2023 ²⁾	Average Annual Change in %	
								2022 to 2023	1990 to 2023
Gross Domestic Product (Price-Adjusted; Reference Year 2015)	Concatenated Volume Figures in Billion Euros	1,959.1	3,242.2	3,118.2	3,216.8	3,274.9	3,264.9	-0.3	1.6
Population ³⁾	1,000	79.8	83.1	83.2	83.2	83.8	84.5	0.8	0.2
Primary Energy Consumption (Unadjusted)	Petajoules	14,905	12,808	11,887	12,443	11,675	10,735	-8.1	-1.0
Primary Energy Consumption (Adjusted) ⁵⁾	Petajoules	15,038	12,992	12,124	12,483	11,900	10,964	-7.9	-1.0
Total Electricity Consumption ⁴⁾	Billion kWh	550.7	575.6	555.8	568.5	550.6	525.5	-4.6	-0.1
Energy Productivity (Unadjusted)	Euros/GJ	131.4	253.1	262.3	258.5	280.5	304.1	8.4	2.6
Energy Productivity (Adjusted) ⁵⁾	Euros/GJ	130.3	249.6	257.2	257.7	275.2	297.8	8.2	2.5
Electricity Productivity	Euros/kWh	3.6	5.6	5.6	5.7	5.9	6.2	4.5	1.7

1) Some figures are estimates

2) Preliminary information

3) Average population based on the 2011 census (result as per the closing date May 9, 2011: 80,219,695 inhabitants)

4) Including pump current generation

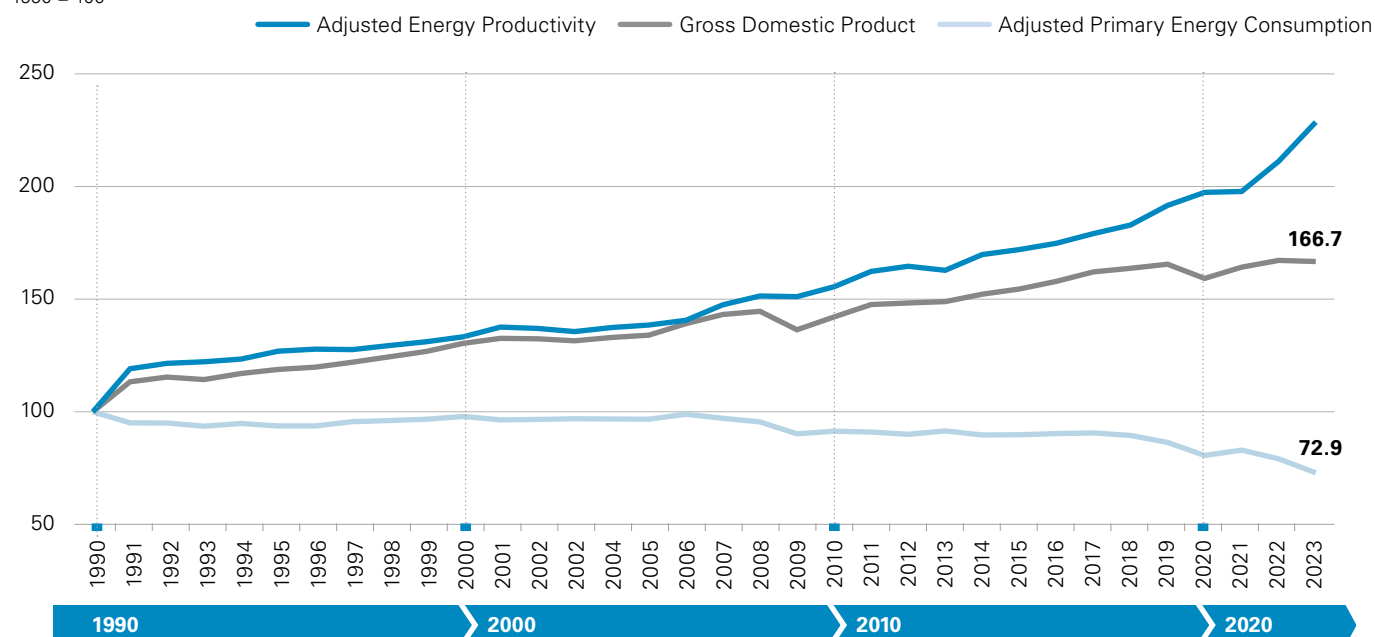
5) Values adjusted for temperature, mineral oil adjusted for inventory

Sources: Federal Statistical Office (Destatis); Germany's National Meteorological Service (DWD); German Association of Energy and Water Industries (BDEW)

Figure 17

Gross Domestic Product, Primary Energy Consumption, and Energy Productivity in Germany between 1990 and 2023

1990 = 100



All values for 2023 are provisional

Sources: Federal Statistical Office (Destatis); Federal Ministry for Economic Affairs and Energy (BMWi); Federal Ministry of Finance (BMF); Working Group on Energy Balances (AGEB)

Details of the effects both assessment methods have on primary energy consumption can be found, for example, in the AGEB publication *Energy Consumption in Germany in 2019*, p. 38, which can be downloaded from the AG Energiebilanzen's website at: [ageb_jahresbericht2019_20200505_engl_web.pdf](https://www.ag-energiebilanzen.de/ageb_jahresbericht2019_20200505_engl_web.pdf) (ag-energiebilanzen.de).

Furthermore, the highly aggregated focus on macro-economic energy efficiency actually prevents a clear view of many other factors which characterize energy consumption. With the help of the component decomposition method, it is possible to illustrate the key factors which influence the changes in the (adjusted) primary energy consumption (please see Figure 18). Towards this end, the long-term changes (1990-2023) clearly demonstrate the considerable influence of the decreased energy intensity (in other words, the improvement of the energy efficiency) on the reduction of the (temperature-adjusted) primary energy consumption (-11,230 PJ). This way, it was possible to significantly overcompensate the consumption-enhancing

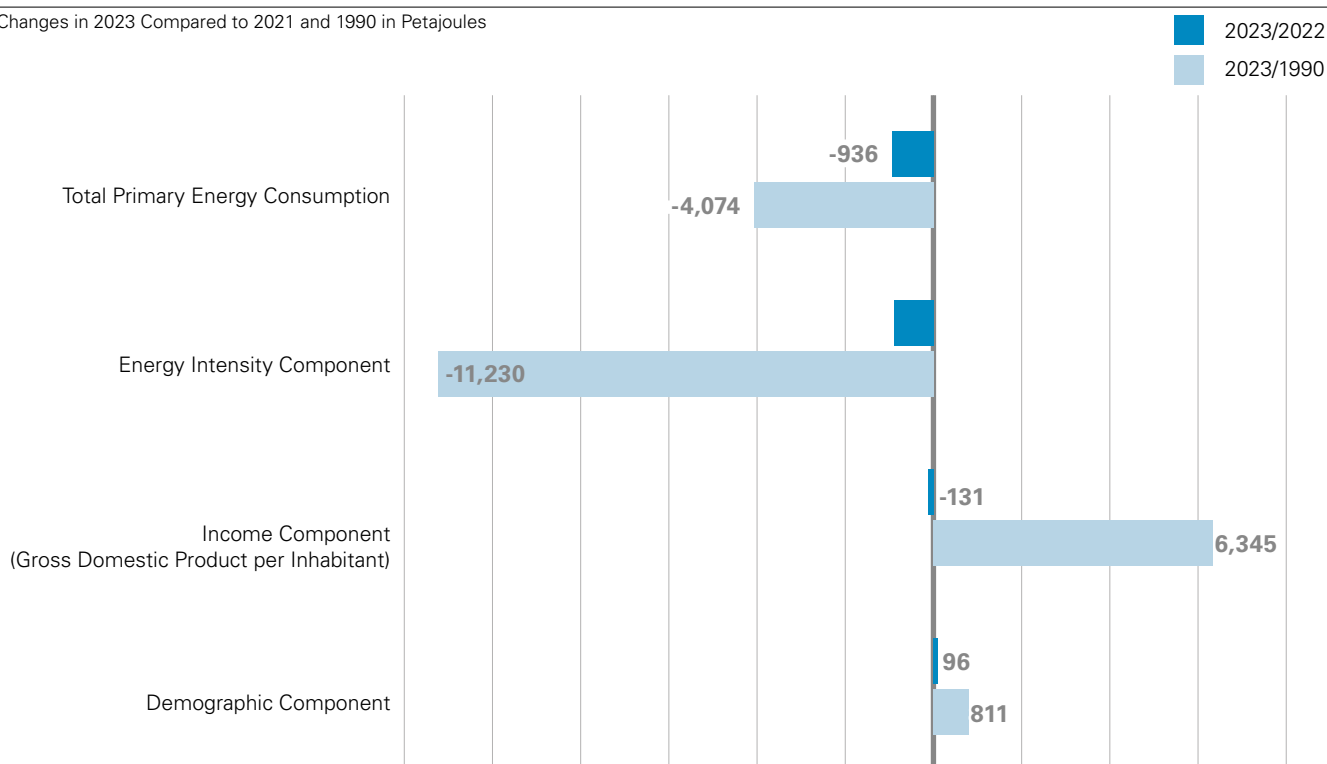
effects of macroeconomic growth (+6,345 PJ) and the increase in population (+811 PJ). All told, the adjusted primary energy consumption decreased by 4,074 PJ between 1990 and 2023.

The correlations outlined above apply in a similar way to the short-term consideration of the changes between 2022 and 2023: The gains in efficiency associated with the utilization of energy led to a slight decline in primary energy consumption (-901 PJ) when compared to the long-term perspective. The dwindling economic performance reduced the adjusted primary energy consumption in 2023 (as opposed to the long-term development since 1990 during which this impact factor still set an expansionary impulse) by an additional 131 PJ when compared to the previous year. When seen from the short-term perspective, a consumption-enhancing effect comes solely from the population component (+96 PJ) which, when also seen from the long-term perspective and viewed absolutely, had the least impact on primary energy consumption. In 2023, this resulted in a decline of

Figure 18

Contributions of Diverse Influencing Factors to the Changes in the Adjusted Primary Energy Consumption in Germany

Changes in 2023 Compared to 2021 and 1990 in Petajoules



Sources: Federal Statistical Office (Destatis); Germany's National Meteorological Service (DWD); Working Group on Energy Balances (AGEB)

the (adjusted) primary energy consumption by 936 PJ (when compared to 2022).

However, when it comes to the assessment of the results of such a component decomposition, it should be noted that the changes in primary energy consumption are, of course, not only influenced by the factors which are taken into account here (economic growth, population trend, and macroeconomic energy efficiency). In fact, the development of energy consumption can neither be sufficiently explained from a monocausal perspective nor in an extremely simplified form; it is rather the result of a very complex interaction between numerous (partially interdependent) determinants which, in addition to the influencing factors considered within this component decomposition, also have an impact on the consumption trend.

These factors and/or determinants include, above all, the impact of the structural change. Typically, a distinction is made between two types of structural change: The intersectoral structural change, which refers to the shift of economic activities between different industrial branches, as well as the intrasectoral, i. e. branch-internal structural change (in other words, the demand and/or sales induced shift of product portfolios within a single industrial branch). The structural change may result in energy savings (declining relevance of energy-intensive branches and/or products) or increases in the consumption of energy (growing relevance of energy-intensive processes). In Germany, the sectoral structural change tended to cause energy consumption to decrease in the past. Notwithstanding the above, such structural effects are not included in this component decomposition which is assumed here in a simplified manner.

When assessing the macroeconomic energy productivity, it must also be kept in mind that above average gains in efficiency in the use of fuels and heat are often contrasted by comparably moderate savings in the specific consumption of electricity. This is due to the fact that an improvement of the energy productivity in numerous economic branches can often only be attained through the increased use of state-of-the-art plant engineering, and that many of the applied process technologies which are designed to save fuels actually increase the specific electricity consumption. Yet there were also the increased

requirements with regard to matters revolving around environmental protection as well as the persistent trend towards automation and the electronic control of processes which, for example, resulted in the fact that the electricity savings potentials, which are to be rated lower anyway, were partially compensated for by the increased use of this energy carrier in new fields of application.

Against this backdrop, the macroeconomic electricity productivity (expressed as the ratio of the price-adjusted gross domestic product to gross electricity consumption) improved by 4.5 % in 2023 (when compared to 2022) due to the sharp decline in electricity consumption (by 4.6 % to 525.5 billion kWh) while the price-adjusted gross domestic product declined by 0.3 % during the same period of time. As a result, a gross domestic product of approximately € 6.2 was generated from one kilowatt hour in 2023; in 2022, the same figure had still been € 5.9.

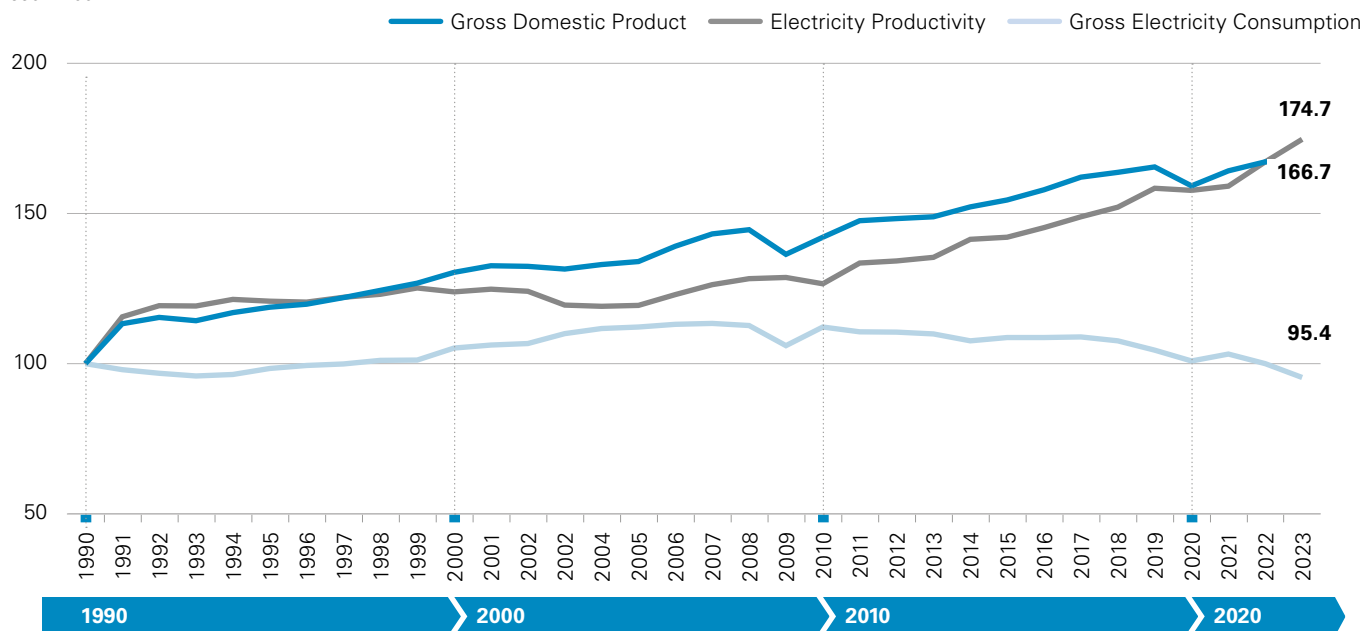
When taking the long-term period between 1990 and 2023 into account, the electricity productivity increased by an annual average of 1.7 %. For comparison: The total energy productivity (adjusted) increased by 2.5 % per annum over the same period of time (for more details on this topic, please see Table 15 as well as Figures 19 and 20).

The impact of select components (economic growth, population trend, and electricity productivity) on the changes in electricity consumption in Germany between 1990 and 2023 and/or 2022/2023 is illustrated in Figure 21. The diagram shows that the decrease in gross electricity consumption by 25.1 billion kWh in 2023 when compared to 2022 was primarily caused by higher electricity productivity (electricity intensity component) which, as outlined above, was in part also due to the sharp decline in production in the electricity-intensive economic sectors. Just due to the efficiency improvement alone, this results in mathematical terms in a decline in the consumption of electric power amounting to 23.5 billion kWh. The efficiency component of electricity consumption during the reporting year was also influenced by the mild weather conditions (unlike the component decomposition of the total primary energy consumption, the representation of electricity consumption is based on observed, but not temperature-adjusted

Figure 19

Gross Domestic Product¹⁾, Gross Electricity Consumption, and Macroeconomic Electricity Productivity²⁾ in Germany between 1990 and 2023

1990 = 100



All values for 2023 are provisional

1) Price-adjusted

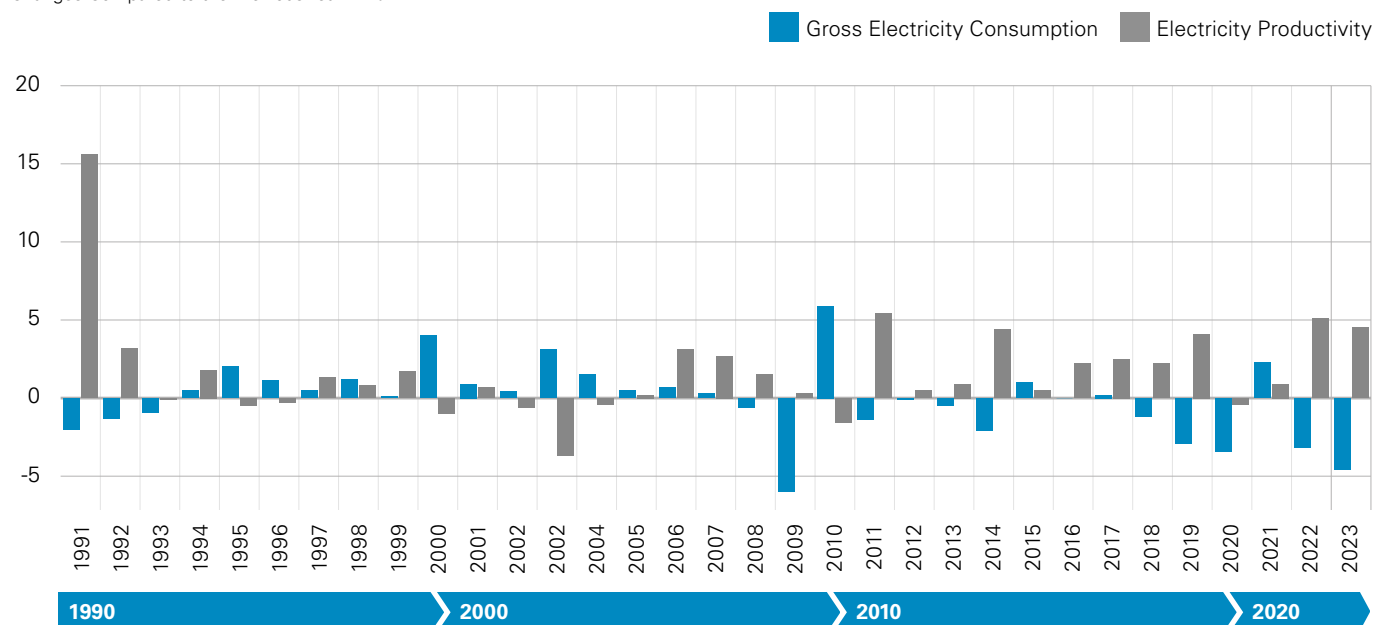
2) Gross domestic product per unit of gross electricity consumption

Sources: Federal Statistical Office (Destatis); Federal Ministry for Economic Affairs and Energy (BMWi); Federal Ministry of Finance (BMF); German Association of Energy and Water Industries (BDEW)

Figure 20

Changes in Gross Electricity Consumption and Electricity Productivity between 1991 and 2023

Changes Compared to the Previous Year in %



Sources: Federal Statistical Office (Destatis); German Association of Energy and Water Industries (BDEW); Working Group on Energy Balances (AGEB)

values) and by consistently high electricity prices on the wholesale market when compared to the levels prior to the crisis, which were passed on to the final consumers (with delays, depending on the individual consumer category) where they created short-term attitudinal and behavioral as well as medium-term incentives for savings.

The shrinking economic performance resulted in reduced consumption in 2023. Just the slump in the macroeconomic production and economic performance alone reduced electricity consumption by 6.1 billion kWh. In contrast, the demographic component (population growth) led to an increase in the macroeconomic demand for electricity by 4.5 billion kWh in 2023 due to the continuing population growth during that year.

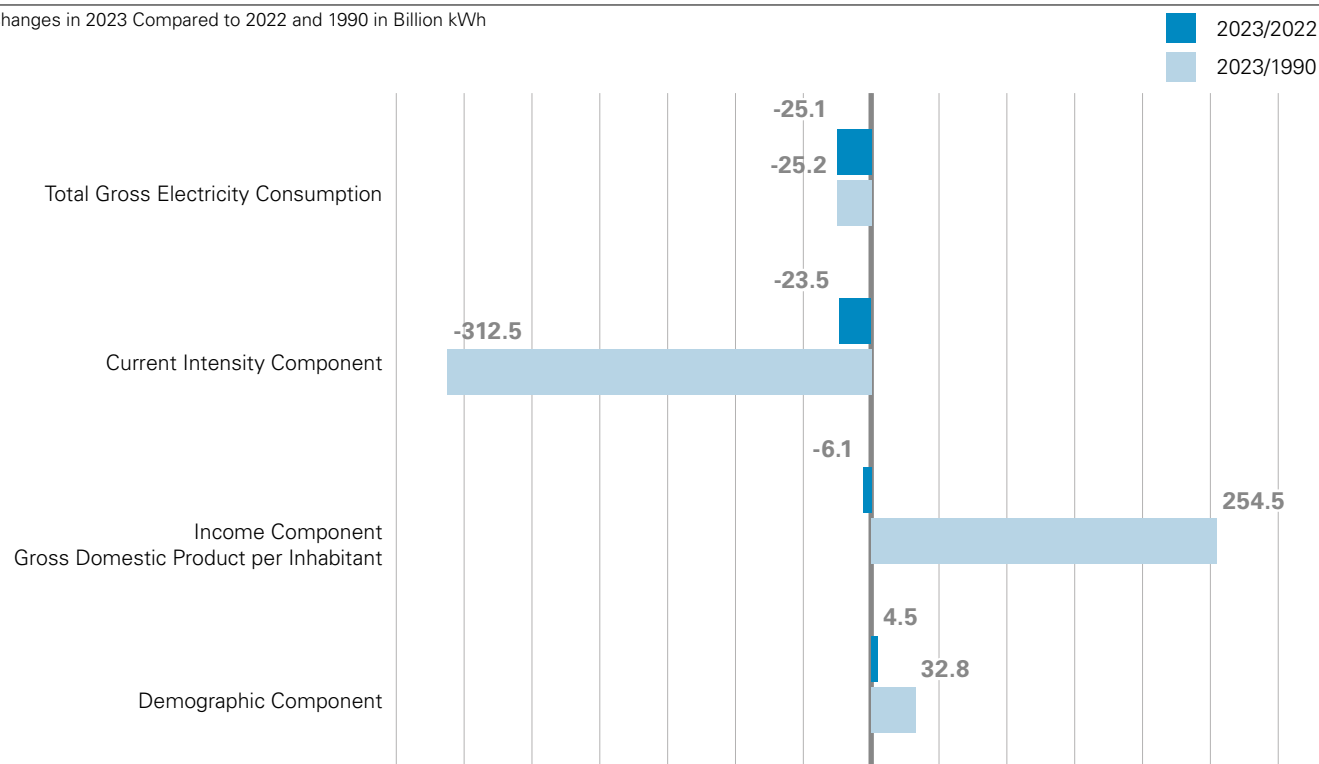
Also when considering the entire period between 1990 and 2023, i. e. over the long-term perspective, the continuous increase in electricity productivity led in “purely mathematical terms” to an absolute decrease in electricity consumption; namely, by about 313 billion kWh. However, when it comes to the use of electric energy, the achieved gains in efficiency were to a large extent offset again by increased consumption due to the noticeably expanding economy (+255 billion kWh) when compared to 1990 as well as the demographic component and/or the growing population (+33 billion kWh).

Electricity consumption as a whole dropped by about 25 billion kWh (which equals a decrease of about 4.6 %) when compared to 1990; in 2023, it was, thus, actually about 30 billion kWh (-5.5 %) below the Covid-driven low point of 2020 (555.8 billion kWh) and, all told, at the lowest level since 1990.

Figure 21

Contributions of Diverse Influencing Factors to the Changes in Gross Electricity Consumption in Germany

Changes in 2023 Compared to 2022 and 1990 in Billion kWh



Sources: Federal Statistical Office (Destatis); Federal Ministry for Economic Affairs and Energy (BMWi); Federal Ministry of Finance (BMF); Working Group on Energy Balances (AGEB); German Association of Energy and Water Industries (BDEW)

CO₂ Emissions

According to the available preliminary data and despite the discontinuation of electricity production from nuclear energy that has been in effect since April 2023, the CO₂ emissions of all power generation plants (power generation plants supplying the general public as well as power generation plants of mining facilities and the manufacturing industry, including the electricity produced in cogeneration plants according to the differentiation made in the energy balance for Germany) decreased to 154 million tons in 2023. Compared to the previous year, this equals a reduction of CO₂ emissions of around 23 % or 45 million tons of CO₂. The reason for this development was that the electricity production mix in Germany became more CO₂-extensive when compared to 2022, which means that specifically the proportion of renewables was increased even further and the contribution of coal to electricity production actually decreased. Another aspect is that Germany imported more electricity from abroad than it exported into neighboring countries in 2023.

When it comes to power generation in the plants of mining facilities and the manufacturing industry, the production of electricity (and heat) exhibited a decline between 2022 and 2023 which was primarily due to the overall economic situation. In 2023, declines in production due to high energy prices and the weak economy were primarily found in such energy-intensive branches as, for example, the chemical or the paper industry and, thus, in those economic sectors in which the combined in-house generation of electricity and heat assumes a prominent role. According to first estimates, CO₂ emissions in this segment ought to have dropped in 2023 (compared to the previous year) by approximately 1.1 million tons (minus 5.1 %).

The production of district heat (in heating plants and cogeneration plants) and the associated CO₂ emissions also decreased in 2023 (primarily due to milder exterior temperatures); namely, by about 2.1 million tons of CO₂ or more than 10 %.

From the preliminary data and estimates compiled in this report on the energy consumption trend in 2023, the following general assumptions can also be made for the development of energy-related carbon dioxide

emissions in other sectors, primarily those related to final energy consumption:

- According to first estimates, the consumption (and/or sale) of fuel and energy in the transportation sector ought to have decreased in 2023. This development is reflected in the CO₂ emissions which dropped by 2.2 million tons or 1.3 % in 2023 when compared to the previous year. The outlined decline in traffic-related carbon dioxide emissions is the result of various, partially contrasting developments: A reduction of CO₂ emissions amounting to about 2.3 % or 3.2 million tons appears to have occurred in road traffic due to the continuously high fuel prices as well as the weakened economy (commercial passenger car and truck traffic). According to our calculations, reduced CO₂ emissions are to also be expected in rail traffic in 2023. In contrast, CO₂ emissions from air traffic rose by approximately 3.6 % or about 1 million tons when compared to the previous year. Thus, CO₂ emissions due to air traffic reached a level of more than 29 million tons in 2023 (for comparison: In 2019, the emissions in this sector had amounted to nearly 32 million tons; during the Covid-19 crisis year 2020, less than 15 million tons). Inland water transportation is also likely to have emitted more CO₂ in 2023 than in 2022 (+6.8 %). In absolute terms, however, the CO₂ emissions of this traffic carrier hovered at a rather low level (2023: 0.75 million tons; 2022: 0.7 million tons) so that changes in this subsector did not have any particular impact on the CO₂ balance of the transportation sector as a whole.
- In the manufacturing industry (without electricity production in industrial power plants and without the energy used in refineries, blast furnaces, and coking plants), the AG Energiebilanzen expects, on the basis of currently available estimates, that the (directly) energy-related CO₂ emissions are likely to have decreased by approximately 6 million tons (-7.2 %) in 2023 when compared to the previous year due to the decline in industrial production, price-induced cutbacks and substitutions as well as the short-term impact of the energy price shock on the economic structure (a decline in growth in the energy-intensive branches). In the order of their

relevance, the greatest absolute CO₂ reductions ought to be attributable to metal production (-3.4 million tons or -8.7 %), the manufacture of basic chemicals (-1.4 million tons or -10.1 %), the paper industry (-0.8 million tons or -16.1 %) as well as mining and quarrying (-0.4 million tons or -5.1 %). Due to the positive economic trend, CO₂ emissions in the manufacture of motor vehicles sector increased by more than 0.5 million tons (+22 %) in 2023 when compared to the previous year.

- Due to the milder weather conditions when compared to the previous year and the persistently high energy prices, which continued to produce impulses for savings, private households seem to have consumed less energy for heating private homes in 2023 which is probably also associated with a development in emissions heading in the same direction. Against this backdrop and according to first estimates, CO₂ emissions of private households could have declined by about 6.6 million tons or 8.5 % in 2023 when compared to the previous year.
- Finally, a reduction of CO₂ emissions amounting to about 1.8 million tons (or -5.4 %) is also expected for the trade, commerce, and service sector in 2023 when compared to the previous year.

Subsequent to the reporting on greenhouse gas emissions, the Federal Environment Agency (UBA) estimated the CO₂ emissions for 2022, by differentiating between the individual sectors, at about 671 million tons, of which approximately 628 million tons are directly attributable to the use of fuels and, thus, combustion processes which is how they are also recorded in the energy balance for Germany.³⁰⁾ Thus, according to calculations made by the Federal Environment Agency (UBA), energy-related CO₂ emissions decreased by 0.5 % (-3.4 million tons) in 2022 when compared to the previous year 2021 (primarily as a consequence of the economic recovery after having overcome the effects of the Covid-19 pandemic).

If one were to summarize the developments outlined in this section for an initial overall assessment, then according to rough calculations made by the AG Energiebilanzen another decrease in energy-related CO₂ emissions can be anticipated once again for the year 2023.³¹⁾ By taking the early estimate of the energy balance for Germany for the reporting year 2023 as a basis, it is likely to be expected that the (observed) energy-related CO₂ emissions actually decreased by 11.8 % (related to the figure estimated by the Federal Environment Agency (UBA) for the previous year 2022, this would equal an absolute reduction of CO₂ emissions amounting to about 74 million tons).

³⁰⁾ For more details, please see the Federal Environmental Agency (UBA); National Trend Tables for the German Atmospheric Emission Reporting for 2022; work in progress: 2023-12-13 (Internet: https://www.umweltbundesamt.de/sites/default/files/medien/361/dokumente/2024_01_15_em_entwicklung_in_d_trendtabelle_thg_v1.0.xlsx (download date: 2024-03-01).

³¹⁾ When considered in detail, the calculations on the development of energy-related CO₂ emissions conducted by the AG Energiebilanzen and the Federal Environment Agency (UBA) may differ from one another. Deviations may result, for example, from the divergent differentiation of sectors, the use of different emission factors, and different data statuses ascertained on the respective calculation dates.

Summary of the Trends

According to preliminary calculations made by the AG Energiebilanzen, energy consumption in Germany decreased by 8.1 % to 10,735 petajoules (PJ), which translates into 366.3 million tons of hard coal equivalents (Mtce), in 2023. It, thus, dropped to the lowest level since 1990.

Responsible for this drop in energy consumption were primarily the still fairly high energy prices, the weakening economy and/or even shrinking economic performance as well as the mild weather. In addition, those determinants of energy consumption which are more likely to have a long-term effect continued to be effective in 2023 as well. It was, above all, improvements of the energy efficiency, energy-saving substitution processes as well as the sectoral structural change which generated consumption-reducing impulses for the development of primary energy consumption. Energy-intensive industrial branches in particular recorded disproportionate declines in production during the recession which, in turn, had a major impact on energy consumption. In 2023, the consumption-enhancing effect of the growing population became less important than the outlined consumption-reducing influencing factors, and/or was overcompensated significantly.

A glance at the individual energy carriers reveals, also in light of the developments already described above, the following picture for 2023: When compared to the previous year, the consumption of renewables increased by 3.1 % in 2023. In contrast, all other energy carriers exhibited a dwindling consumption trend. The use of nuclear energy declined by 79 % whereby the remaining contribution was solely due to the so-called stretch-out operation of the last three nuclear power plants (Neckarwestheim 2, Emsland, and Isar 2) and their final decommissioning on April 15, 2023. During the same period of time, the consumption of lignite decreased by more than 23 %, the consumption of hard coal by about 19 %. The consumption (and/or sales) of mineral oil (-6.8 %) and natural gas (-2.4 %) dropped as well.

Consequently, renewables, natural gas, and mineral oil gained market shares in the overall shrinking energy market. In 2023, mineral oil covered a total of 35.6 %

(2022: 35.1 %) of the primary energy demand and, thus, continued to be by far the most significant energy carrier. The demand for natural gas accounted for a share of 24.7 % in 2023 (2022: 23.3 %) while renewables covered 19.6 % of the primary energy demand (2022: 17.5 %). Whereas in the order of their relevance, nuclear energy (2.5 %), hard coal (1.7 %), and lignite (1.1 %) lost market shares. In 2023, hard coal still covered 8.7 %, lignite 8.3 %, and nuclear energy 0.7 % of the demand for primary energy. The outlined structural changes in the composition of primary energy consumption reveal that the energy mix in 2023 became less carbon-intensive than in 2022.

As measured by the original values, the macroeconomic energy productivity continued to improve in 2023 (according to preliminary calculations). It increased by 8.4 % so that more than € 304 GDP₂₀₁₅ were generated in 2023 while utilizing one gigajoule of primary energy (GJ); in 2022, this value had still amounted to almost € 281 GDP₂₀₁₅/GJ. The average annual increase in the macroeconomic energy productivity between 1990 and 2023 currently amounts to 2.6 %.

Similar to primary energy consumption, gross electricity consumption also declined substantially in 2023 as a consequence of the price as well as the attitudinal and behavioral induced savings and production cutbacks in energy-intensive sectors. Gross electricity consumption dropped to 526 million kWh and was, thus, 4.6 % below the value of 2022 and, in the same magnitude (4.6 %), below the value of 1990. Thus, gross electricity consumption now fell even 0.5 % below the lowest level that has been measured so far in 2003 (528 billion kWh).

Compared to the previous year, the macroeconomic electricity productivity improved by 4.5 % in 2023 and rose to a value of € 6.20/kWh after it had been around € 5.90/kWh in 2022 (according to the data indicated in the final energy balance for Germany). All told, the performance of the improved macroeconomic energy productivity surpassed this year (due to the special crisis-related developments which have been referred to repeatedly above) the long-term development

that can be seen in the average value for the years between 1990 and 2023. Between 1990 and 2023, it was possible to increase the electricity productivity on average by about 1.7 % per annum.

Gross electricity production decreased by approximately 11 % to about 514 billion kWh in 2023. The structure of electricity production according to the individual energy carriers continued to change as well: While electricity production based on the use of nuclear energy (-79 %), lignite (-25 %), hard coal (-36 %), and mineral oil (-14 %) declined noticeably, electricity production based on renewables recorded a plus of 7 %. Electricity production based on natural gas decreased by 1.7 % in 2023 after having already declined by 12.5 % (11 billion kWh) between 2021 and 2022.

All told, renewable energies were able to maintain their top position with a total production volume of 272 billion kWh and a share of 53 % in the power generation mix; for the first time ever, renewables actually managed to provide more than half of the electric power produced in Germany. Lignite was in second place with a contribution of 17 % and power generation from natural gas was in third place with a contribution of approximately 15 % to the power generation mix. Hard coal contributed about 8 % to the total electricity production and nuclear energy still 1.4 % in 2023.

When it comes to gross electricity consumption, renewable energies accounted for a share of 51.8 % in 2023; in the previous year, this share had still amounted to approximately 46.2 %.

The electricity exchange balance³²⁾ experienced major changes in 2023. For the first time ever in 20 years, the export surplus turned into an import surplus. All told, Germany imported about 11 billion kWh more electricity from neighboring countries than it exported abroad in 2023. For comparison: In 2022, the export surplus had still amounted to 27 billion kWh.

Particularly high import surpluses were recorded, in the order of their relevance, for the exchange with France (9.3 billion kWh), Denmark (6 billion kWh), and Norway (4.5 billion kWh). Import surpluses also occurred in the electricity exchange with Sweden, the Netherlands, the Czech Republic, and Belgium in 2023. In contrast, the electricity exchange with Switzerland (4 billion kWh), Luxemburg (3.9 billion kWh), and Austria (3 billion kWh) resulted in export surpluses. The outlined changes in the exchange of electricity are, to a great extent, driven by the market and/or a sign of a functioning single European electricity market. Importing electric power instead of generating it in Germany's hard coal or lignite fired power plants represents an economically viable option if and to the extent that more favorable production possibilities (also from renewables) are available in foreign countries.

At the moment, it is not yet possible to precisely ascertain the energy-related CO₂ emissions for 2023 on the sole basis of final statistical data. However, a rough estimate of the development of energy-related CO₂ emissions can be made on the basis of the preliminary estimates of Germany's energy balance for 2023 (data status: February 15, 2024) in combination with the respective CO₂ content of the individual energy sources. In total, the overall structure of energy consumption has shifted again noticeably in favor of renewable and CO₂-reduced fossil energy carriers in 2023.

In light of the significant decrease in primary energy consumption in combination with the described shifts within the energy carrier mix as well as the sectoral consumption structure, energy-related CO₂ emissions ought to have decreased by some 11.8 % in 2023 according to rough calculations based on estimated energy balances. This reduction would correspond, based on the estimated values of the German Environment Agency (UBA) for the previous year 2022, to an absolute reduction of energy-related CO₂ emissions by 74 million tons.

³²⁾ The data on international electricity trading which are used in this report generally relate to the physical exchange of electricity with foreign countries.