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Energy Consumption

in Germany in 2021

Energy Consumption in 2021 Continues to Increase Due to the Covid-19 Pandemic and Weather Conditions

Contents

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Total Primary Energy Consumption

In 2021, the primary energy consumption in Germany amounted to a total of 12,265 petajoules (PJ) or 418.5 million tons of coal equivalents (Mtce); compared to the previous year, this equals an increase of 3.1 % (please see Table 1).

The level of energy consumption as well as its composition (energy mix) are also influenced by political and regulatory aspects. Significant for the medium-term to long-term development are, for example, the gradual phase-out from nuclear energy until the end of 2022, the scheduled fossil fuel phase-out (by the end of 2038) 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 4th trading period between 2021 and 2030 (linear reduction factor 2.2 % p.a. instead of 1.74 % p.a. as had been the case during the 3rd 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)) as well as binding targets for the progressive expansion of renewable energy (EU Renewable Energy Directive (Directive 2009/28/EC)).

In 2021 as well, the most important energy carrier continued to be mineral oil with a share of 32.3 %. It was followed by natural gas with a slightly increased share of 26.8 % (2020: 26.4 %). Renewables ended up at third place with a share of 15.9 %; in 2020, their contribution had still been 16.6 %. The primary energy consumption of hard coal and lignite in 2021 increased significantly by 16.5 % and 17.7 % respectively so that lignite covered once again 9.2 % and hard coal still 8.5 % of the domestic demand for primary energy in 2021. Compared to the previous year, the primary energy consumption of nuclear energy increased by 7.4 % in 2021 (the nuclear power plants Grohnde, Gundremmingen C, and Brokdorf were shut down in late December 2021). Thus, nuclear energy currently covers still about 6.1 % of the demand for primary energy. The surplus obtained from the flow of electric power to foreign countries increased slightly in 2021 (on balance almost 1.5 petajoules, which translates into 0.4 TWh, more electricity flowed into foreign countries in 2021 than had been the case in 2020). Consequently, the balance in the electricity exchange had a consumption-reducing effect (by 0.6 percentage points) on primary energy consumption also in 2021.

Table 1

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Primary Energy Consumption in Germany in 2020 and 2021 [1)]

Energy Carrier	2020	2021	2020	2021	Changes in 2021 Compared to 2020			Proportions in %	
	Petajoules (PJ)		Million Tons of Coal Equivalents (Mtce)		PJ	Mtce	%	2020	2021
Mineral Oil	4,087	3,961	139.4	135.1	-126	-4.3	-3.1	34.4	32.3
Natural Gas	3,136	3,288	107.0	112.2	152	5.2	4.9	26.4	26.8
Hard Coal	896	1,044	30.6	35.6	148	5.1	16.5	7.5	8.5
Lignite	958	1,128	32.7	38.5	170	5.8	17.7	8.1	9.2
Nuclear Energy	702	754	24.0	25.7	52	1.8	7.4	5.9	6.1
Renewable Energy	1,972	1,947	67.3	66.4	-25	-0.8	-1.2	16.6	15.9
Electricity Exchange Balance	-68	-69	-2.3	-2.4	-1	-0.1	...	-0.6	-0.6
Other	213	213	7.3	7.3	1	0.0	0.4	1.8	1.7
Total	**11,895**	**12,265**	**405.9**	**418.5**	**371**	**12.6**	**3.1**	**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); AGEE-Stat

1) In this context, CO_2 pricing was introduced in Germany's heating and transportation sectors in January 2021 within the scope of the Climate Protection Program 2030. Since then, both private and commercial consumers (non-ETS) have had to pay a CO_2 surcharge amounting to € 25 per ton of carbon dioxide content for such energy carriers as fuels, fuel oil, or natural gas. The CO_2 price within this national emissions trading system is to be gradually increased to € 55/t by 2025.

General Conditions for the Development in Consumption in 2021

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, and temperature fluctuations. The individual fundamental factors which played a specific role in the increase in primary energy consumption during the years 2020/2021 will be outlined briefly below.

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; in simple terms, this index reflects the cumulative number of the specific days on which the average temperature falls below a certain level (heating threshold temperature; here: 15 degrees Celsius).[2)]

In 2021, the number of degree days was above the values of the long-term average (arithmetic average between 1990 and 2020 taken from 16 measurement stations). The increased number of days with heating threshold temperatures of less than 15° C generally points towards a lower average temperature level in the reporting year and an associated increase in the observed energy demand (in particular, for the heating of residential premises).[3)]

When compared to the (unusually warm) previous year, the number of degree days increased as well by 435 to 3,570 because it was noticeably colder in 2021 than it had been in 2020. In 2021, the degree day figures were about 13.9 % higher than those of the previous year (low temperatures) so that energy consumption in 2021, also when compared to 2020, increased significantly just alone on the basis of the influence of the weather.

When considering the development of the degree day figures during the individual months, it becomes apparent that the year 2021, particularly between the months of January and May, was significantly cooler than the previous year. In contrast, and as measured by the degree day figures, the temperatures in September 2021 were significantly higher than those of 2020. The months between October and December 2021, which are relevant for the heating period, were once again cooler than had been the case during the respective months of the previous year. When compared to the long-term average, the year 2021 was consistently colder during the first five months whereas the second half of the heating period (between September and December) was warmer than the same period of the previous year (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 average[4)] and that 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 increased by 3.1 %; instead, the increase would have been 2.4 % in 2021. 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).

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 2020), the year 2021 was slightly colder; consequently, the harsher winter caused the heating period to be more pronounced. On an annual average (as measured by the degree days), the temperatures were 0.8 % 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 2020 would have been noticeably above the observed level provided that the weather conditions during this year had equaled those of the long-term average. In contrast, primary energy consumption in 2021 would have been below the observed value if one were to assume that the milder weather of the long-term average was the reference standard.

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 (for example, with the previous year), the weather conditions prevailing during the comparative period could, of course, 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

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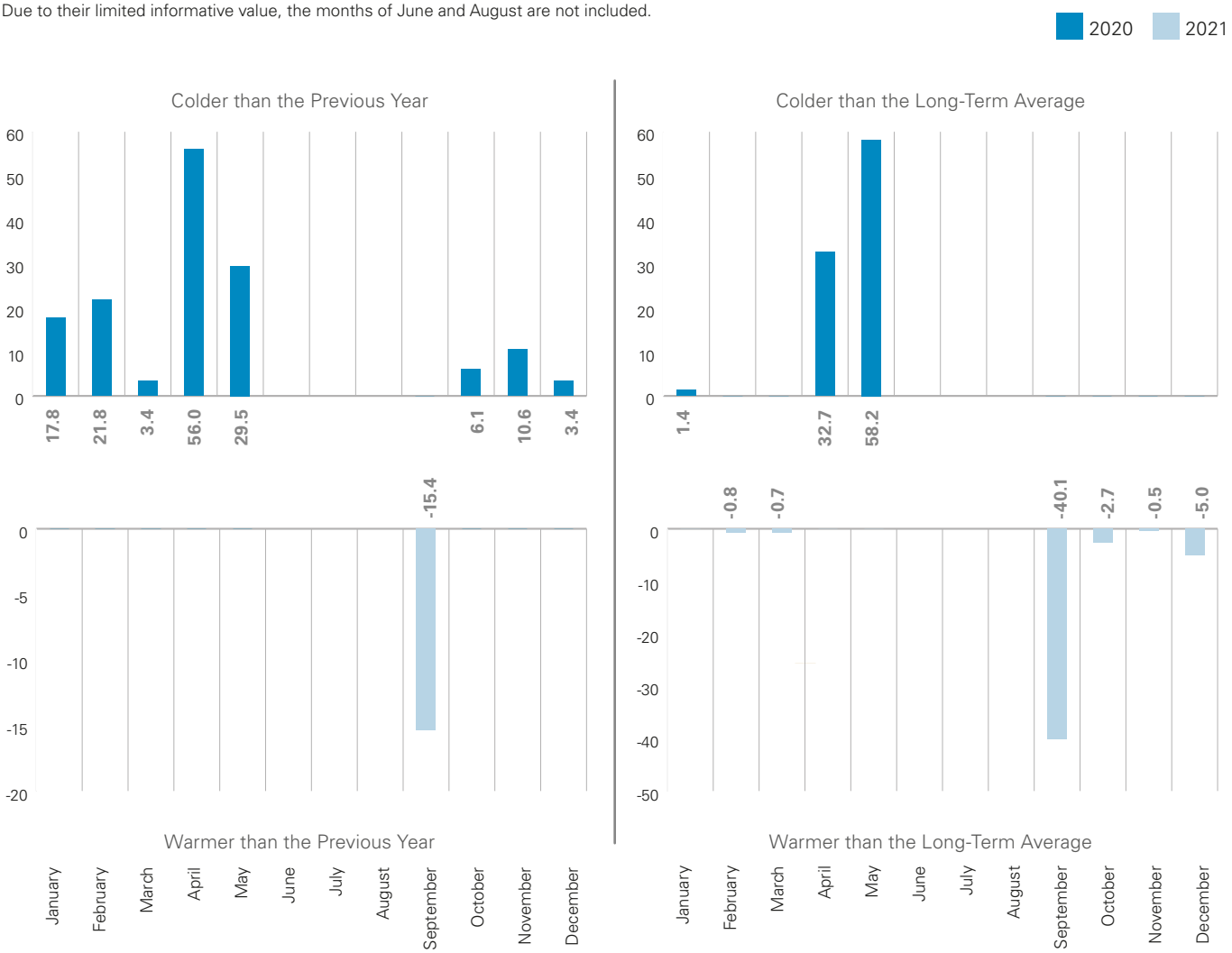
Monthly Degree Day Figures in Germany in 2021 (16 Measurement Stations)

Changes in 2021 compared to the previous year and to the long-term average (1990-2020) in %.
Due to their limited informative value, the months of June and August are not included.



Source: Germany's National Meteorological Service (DWD)

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 weaker 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. When it comes to mineral oil, the (stock level adjusted) trend was additionally influenced by the fact that consumers waited to refill their tanks because of the rapidly increasing prices for energy and/or fuel oil during the second half of the year 2021. Thus, the available

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" [Implementing a Procedure for the Periodic and Current Ascertainment of the Energy Consumption in Areas Not Recorded by Official Statistics] (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-statisiklangfassung.pdf?__blob=publicationFile&v=7 (download date: 2021-02-13; currently only available in German).*

Figure 2

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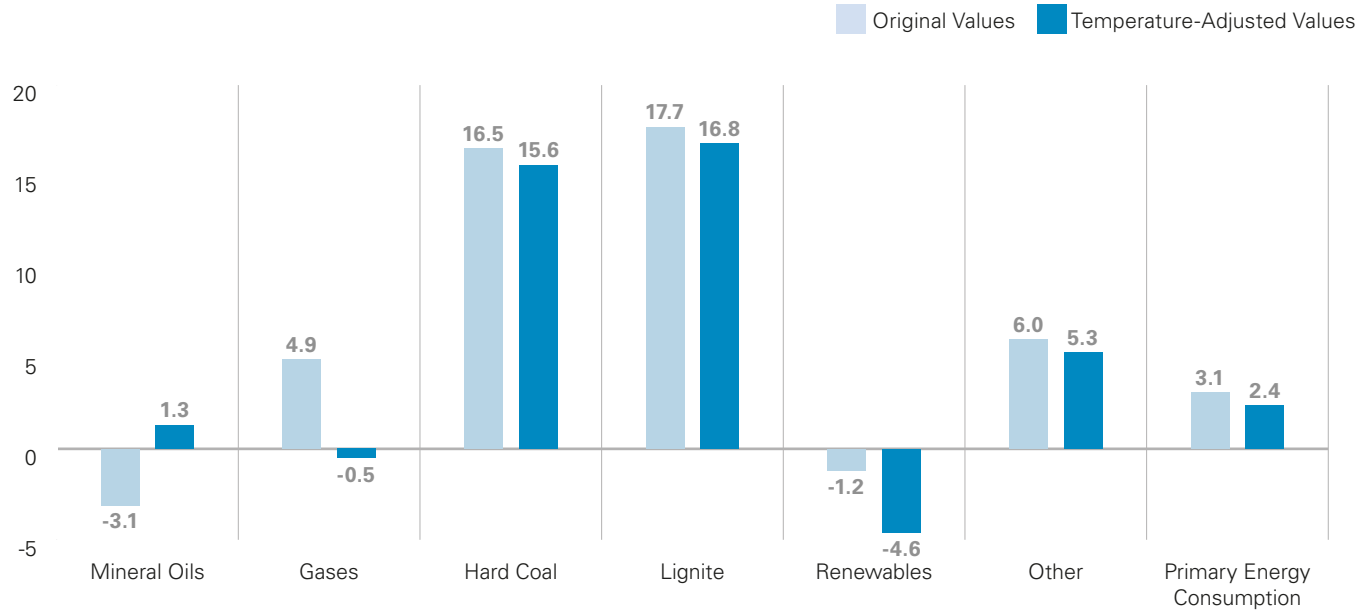
Primary Energy Consumption in Germany According to Energy Sources

Changes between 2021 and 2020 in %



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

quantities of the fuel oil that was already stored in tanks were considerably reduced in 2021; as a consequence, the actual consumption of fuel oil increased due to the cooler weather while the sales recorded in the energy balance went down.

Macroeconomic and Sectoral Factors

An export-oriented economy which imports a substantial share of its demand for energy carriers and raw materials as is characteristic for Germany depends, of course, to a large extent on global economic trends. According to estimates of the International Monetary Fund (IMF), the global economy ought to have increased by 5.9 % in 2021. For comparison: In 2020, the global economy had still shrunk by about 3.1 % which was due to the economic impact of the Covid-19 pandemic, but also due to an increasing number of trade barriers, bottlenecks in the supply chains, etc. The strong recovery of the global economy at large also benefited the growth perspectives of the German economy.

The price-adjusted gross domestic product (GDP) increased by about 2.7 % in 2021; however, this caused the economic recovery to be noticeably more moderate than had most recently been anticipated. At the same time, the growth in the GDP was not yet able to compensate for the Covid-19 related decline. In the preceding year, the gross domestic product had still dwindled by 4.6 %. In 2021, growth impulses came primarily from foreign trade. Exports of goods and services exhibited a strong incline in 2021 with a plus of 9.4 % (previous year: -9.3 %). At the same time, imports increased by 8.6 % when compared to 2020 (previous year: -8.6 %). Significant increases were also recorded for gross fixed capital formation[6)], which grew by 4.9 % when compared to the previous year, as well as for governmental consumption expenditure (2021: +3.4 %). In contrast, private consumption, which in the aftermath of lockdowns[7)] and other measures designed to fight the Covid-19 pandemic had experienced a 5.9 % decline in 2020, remained at previous year's crisis level and did not unfold any additional contribution to growth in 2021.

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

7) The first Covid-19 lockdown became effective on March 22, 2020; it ended with lifting the restrictions for the first time on May 4, 2020. The second Covid-19 lockdown began on November 2, 2020 ("Lockdown Light") and led to the second harsh Covid-19 lockdown which ended in May 2021.

Figure 3

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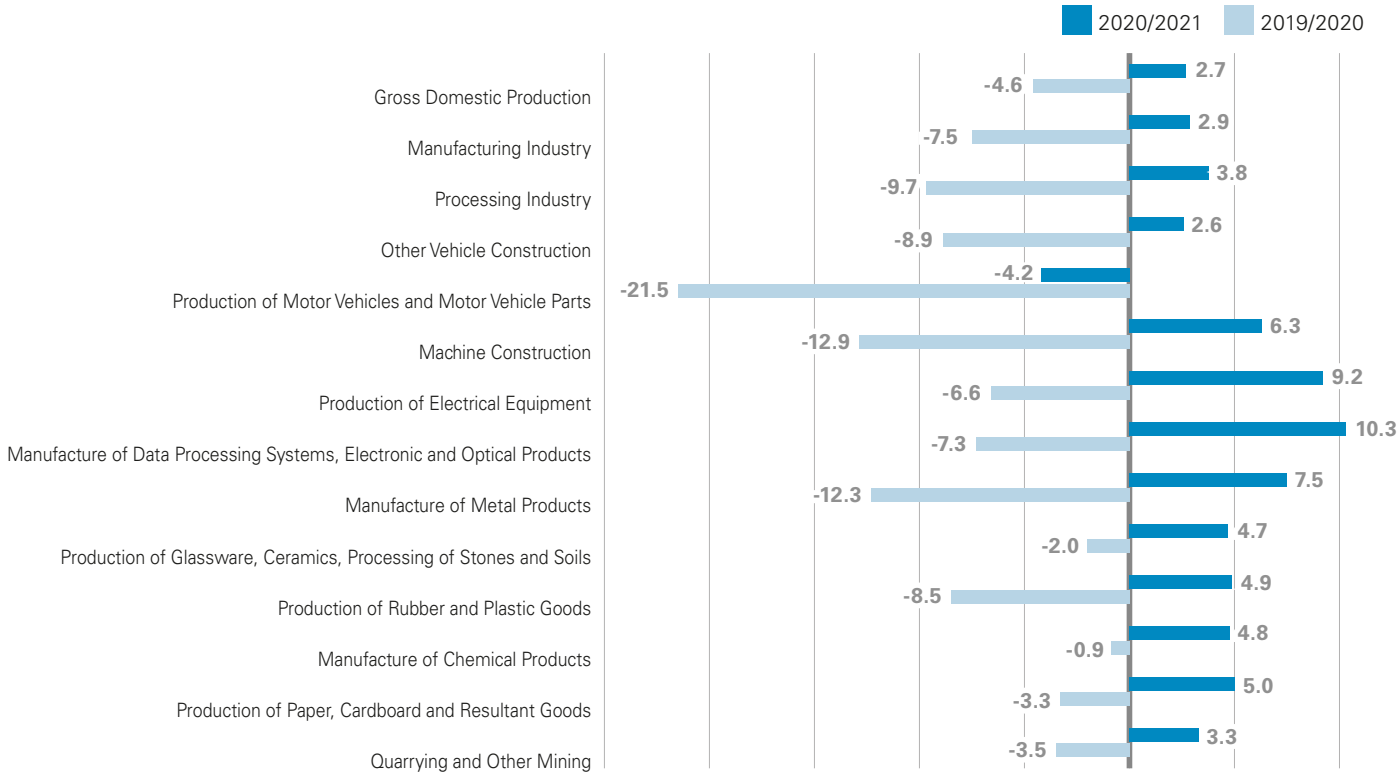
Production Index in Germany's Manufacturing Industry between 2020 and 2021

Changes Compared to the Previous Year in %



Source: Federal Statistical Office (Destatis)

It was, in particular, after the measures of the second lockdown designed to fight the Covid-19 pandemic had essentially ended when macroeconomic production experienced a recovery; especially during the months between March and September, it actually exceeded the figures that had been recorded for the same period of the previous years. Towards the end of the year 2021, production once again dropped back to the previous year's level and/or economic catching-up processes slowed down noticeably.

All told, the output in the producing industry grew by about 2.9 % in 2021 (2020: -7.8 %); in the manufacturing industry, the production (also measured by the production index) even increased by 3.8 % in 2021 (2020: -9.7 %).

The divergences ascertained for the macroeconomic utilization aggregates were directly reflected by the sectoral production (and they also exerted a decisive impact on the changes in the energy consumption during the period under review): Economic branches which either directly sell a significant proportion of their production abroad or act as prepaid suppliers for export-dependent sectors were able to benefit from the recovery in exports (unless any supply bottlenecks did not slow down the production). Something similar applies to economic branches which produce investment goods; these branches actually received positive growth impulses after having made capital investments. In contrast, economic branches which produce consumer goods and consumables as well as service sectors (without the construction industry) were affected by the weak development of private consumption (with 0.1 % growth compared to the previous year, the price-adjusted private consumption expenditure stabilized at a low level). Economic branches which depend on the overall situation in the construction sector also benefited only to a small extent from the economic recovery outlined above. Due to bottlenecks in the availability of labor force and building materials, construction investments increased only marginally. Compared to the year 2020, they went up (price-adjusted) by a mere 0.5 %.

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 2020 and 2021:

- In 2021, 10 of the 11 economic branches were able to attain increases in production when compared to the previous year, only the economic branch manufacture of motor vehicles, trailers, and semi-trailers once again recorded a decline in production (-4.2%) also in 2021 when compared to the previous year.

- Compared to the manufacturing industry as a whole, an increase in production which was significantly above average was observed in the economic branches manufacture of computers, electronic and optical products (+10.3 %) as well as production of electrical equipment (+9.2 %).

- In relation to the overall trend in the manufacturing industry, the highly energy-intensive branches metal manufacture and metal machining (+7.5 %), production of paper, cardboard, and paper products (+5.0 %), manufacture of chemical products (+4.8 %) as well as manufacture of glass, glassware, ceramics, and the processing of stones and soils (+4.7 %) also attained above average growth rates in 2021.

- Except for the manufacture of motor vehicles, trailers, and semi-trailers, whose production – as already mentioned above – decreased by 4.2 % in 2021 when compared to the previous year, growth rates below average were recorded for the also more energy-intensive sectors quarrying and other mining (+3.3 %) as well as other vehicle construction (+2.6 %).

As a result of the described production increases in virtually all branches of the manufacturing industry, a consumption-enhancing impulse can generally be expected for the use of energy in the reporting year 2021. The described impulse tends to be strengthened by the above average production increase in energy-intensive sectors.

Nonetheless, it should be remembered in this context that part of the energy consumption enhancing effect which emanates from the structural change in industry and the economic trend is compensated for by efficiency improvements and a higher utilization of production capacities.[8)]

Demographic Factors

Between 2020 and 2021, the population in Germany merely grew from 83.161 million people to around 83.197 million people; this equals an increase in population of less than 0.04 % (+33,000 people) and is close to a stagnation in the demographic development. For comparison: In the previous year, the population had still grown by 68,000 people (which equals an increase of more than 0.1 %). Under these premises (updated statistical figures are not yet available), the number of households is likely to slightly increase further as well. In 2020, about 40.5 million households existed in Germany, of which around 40.6 % were single-person households.

The increase in the number of households is not only due to the demographic development, but at the same time also due to the existing trend of living in smaller households. Currently, an average of approximately 2.03 persons lives in one household.

That is why the demographic development as such is likely to have had a negligibly small influence on the development of energy consumption in 2021.

Energy Prices

In addition, the energy prices also play an important role when it comes to the 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.

The Covid-19 pandemic and/or the associated effects on economic growth and the global demand for

8) Low capacity utilization rates due to an economic downturn typically lead to increases in the specific demand for energy due to the fact that the energetic losses of many production facilities (dryers, kilns, etc.) remain virtually unchanged. In times of underutilization due to macroeconomic constraints, continuously working tunnel kilns in the brick industry, for example, are operated with so-called "empty loads" in order to keep the production running; this means, on the one hand, that the absolute energy consumption remains virtually constant or decreases only marginally and, on the other hand, that the (specific) energy consumption per ton of bricks actually increases. Conversely, the increased utilization of production facilities reduces the specific energy consumption and counteracts, at least in part, the rising demand for energy caused by higher production volumes.

Table 2

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Prices of Selected Energy Sources

Changes 2021 to 2020 in %

	2020	2021				
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Average
	Import Prices					
Mineral Oil	-34.1	12.0	126.8	69.2	89.3	66.6
Natural Gas	-27.1	21.5	99.6	172.8	245.0	138.7
Hard Coal	-23.3	1.8	28.7	107.8	173.2	76.0
	Consumer Prices					
Fuel Oil, Light	-25.9	1.4	32.6	62.0	86.4	41.8
Natural Gas	0.3	2.1	2.2	5.1	9.7	4.7
Electricity	3.0	0.5	-0.1	1.8	3.1	1.4

Source: Federal Statistical Office (Destatis)

energy had a substantial impact on the condition of the global energy markets in the years 2020/2021. On average, the import prices for crude oil, natural gas, and hard coals increased significantly between 67 % and 139 % in 2021 (which was also due to the global demand which once again increased considerably as a consequence of overcoming the pandemic-related global economic downturn) after having still decreased noticeably in particular for petroleum and natural gas during the previous year (please see Table 2).

The development of the exchange rate actually cushioned, in part, the described increase of 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 about 3.5 % in 2021, i. e. the Euro appreciated against the US Dollar which, in turn, made imports of goods and services from the Dollar zone less expensive.

Notwithstanding the above, the prices for domestic consumers deviate to some extent noticeably from the development of import prices because these prices, in addition to governmental taxes as well as statutory charges and levies[9], 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 normally have no direct impact on the end consumer prices. The consumer price trend for specific customer groups and/or end users will be highlighted in more detail in the respective sections referring to the individual energy carriers.

Dependence on Energy Imports

When it comes to the German economy's vulnerability to energy crises, an outstanding role is assigned to the availability of energy resources and the associated possibility of their domestic production and utilization. On the one hand, higher domestic production volumes generally reduce the dependence on imports and, thus, lower the risk of disturbances or disruptions in the overall supply as well as the commodity price risk for the domestic economy.

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). In 2020, domestic primary energy consumption had been covered by imports which amounted to about 98 % for mineral oil and more than 94 % for natural gas. 100 % of the hard coals were sourced from imports. In contrast, 100 % of the lignite had been made available from indigenous resources, and renewables had also come almost entirely from

9) For example, the introduction of the national CO_2 pricing (2021: € 25/t CO_2) on the transportation and heating markets (national emissions trading) resulted in an increase in the consumer prices for fuels and fuel oils of approximately 10 ct/liter as per January 1, 2021.

domestic production. All told, nearly 77 % of the German energy supply had been dependent on imports in 2020.

This situation remained basically unchanged in 2021 as well. However, the domestic production of fossil fuels (without renewables) increased by a total of 173 PJ, which equals 8.4 %, when compared to the previous year. Lignite, whose production increased by 17.7 % (173 PJ), made a major contribution towards this development. In contrast, the domestic production of the remaining fossil fuels decreased slightly (mineral oil) or stagnated at the previous year's level (natural gas). The production of renewables went down by 0.2 % (4 PJ) due to the prevailing weather conditions.

When it comes to electrical energy, the export surplus remained virtually unchanged in 2021 as well; compared to the previous year, it increased by a mere 2.2 % (which equals 0.4 billion kWh). After having reached its peak in 2017 (-52.5 billion kWh), it had dropped continuously to -18.5 billion kWh in 2020.

According to first rough calculations, the changes outlined above (with an increase in the total primary energy consumption due to the economic trend and the weather conditions) were reflected by a slight decrease in the import quota (by 0.9 percentage points); nonetheless, the dependence on imports ought to still amount to more than 76 % also in 2021.

As already stated earlier in this report, the import prices for fossil fuels changed significantly. As a result, the substantially higher import prices as well as the growing volumes of imported energy (+0.9 %) caused the import calculation for coal, oil, and gas to increase substantially by 27.5 billion euros, or by approximately two thirds, from about 41.4 billion euros in 2020 to 69 billion euros in 2021.

A glance at the individual energy carriers reveals the following picture: The value of oil imports increased by more than 34 %, the value of natural gas imports even by 131 %. The value-based import balance for coals increased by more than 103 %. When it comes to electric power, the (value-based) export surplus increased by about 157 % (please see Table 3).

Table 3

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Balance of Foreign Trade with Energy Carriers in Germany between 2016 and 2021

	2016	2017	2018	2019	2020	2021	Changes in 2021 Compared to 2020	
							Billion Euros	%
Coal, Coke, and Briquettes	3.5	5.2	5.0	4.1	2.3	4.7	2.4	103.4
Petroleum, Petroleum Products, and Related Goods	29.0	36.1	43.8	42.8	26.9	36.0	9.1	34.0
Gas [1]	16.1	15.0	18.0	15.9	12.3	28.3	16.0	130.8
Total Fossil Fuels	**48.6**	**56.3**	**66.8**	**62.9**	**41.4**	**69.0**	**27.5**	**66.4**
Electric Power	-1.7	-1.8	-1.9	-1.6	-0.9	-2.2	-1.4	156.5
Total	**46.9**	**54.5**	**64.9**	**61.3**	**40.6**	**66.7**	**26.2**	**64.5**

1) Including transit volumes

Source: Federal Statistical Office (Destatis)

Dependence of the German Economy on Energy Imports from Russia

In 2021, more than 69 % of the German energy supply depended on imports. For comparison: In 1990, the dependence had still been about 57 %. In 2021 as well, the most important domestic sources of energy continued to be lignite and renewable energy carriers which came almost entirely from domestic production. This means that the dependence on imports for the remaining energy carriers (hard coal, natural gas, and mineral oils) is significantly above the average value. While 100 % of the nuclear energy has been imported[1)] for quite some time now, more than 95 % of the mineral oil and 89 % of the natural gas were sourced from imports[2)] in 2021. When it comes to hard coal, the import quota increased parallel to the phase-out from domestic production; since 2019, the domestic demand for hard coal has been covered completely by imports.

When it comes to the German economy's vulnerability to energy crises, an outstanding role is assigned to the availability of energy resources and the associated possibility of their domestic production and utilization. On the one hand, higher domestic production volumes – this includes, in particular, the expansion of renewable energy sources – generally reduce the dependence on imports and, thus, lower the risk of disturbances or disruptions in the overall supply as well as the commodity price risk for the domestic economy and the consumers. In principle, though, energy imports do not pose any risk. The key determinants of the supply risk are the concrete supply and procurement structure of imports as well as the geopolitical assessment of the country-specific risk of delivery stops.[3)]

Germany's energy imports (2021: Approximately 12,500 PJ) concentrated in the order of their importance on natural gas (44 %), crude oil (27 %), mineral oil products (12 %), and hard coal (9 %). If one were to consider the regional diversification (supply structure) against the backdrop of the current Ukraine conflict, then it becomes obvious that the most important energy imports, above all grid-bound natural gas at a rate of about 55 %, hard coal at almost 50 %[4)], and crude oil at about 34 % come from Russian supply sources.

For Germany, the overall picture emerges that the increasing dependence on imports had been accompanied in the past by a considerable shift in the import structure towards production regions with a high geopolitical risk classification (natural gas, crude oil, and hard coal from Russia) (the so-called "cluster risk"). In light of the current geopolitical developments, the supply risks for Germany have been underestimated over a long period of time.

The value of the total imports of energy resources (coal and coal products, crude oil and mineral oil products, gas as well as electrical energy, but no nuclear fuels) to Germany peaked at a level of 104 billion euros in 2021; compared to the previous year, it increased (due to dramatically increased prices) by more than 40 billion euros (+63 %). According to the Federal Statistical Office, the energy bill just for the import volumes of natural gas, crude oil (without mineral oil products), and hard coal (run-of-mine) from Russian supply sources alone amounted to approximately 25 billion euros in 2021 (of which 9.8 billion euros accounted for natural gas, 9.7 billion euros for crude oil, and 2.2 billion euros for hard coal).

Greater diversification of the supply sources and/or the recourse to imported energy volumes which originate from regions that are classified as being safer cannot generally reduce the risk of delivery

1) However, the classification of nuclear energy as an imported energy resource is not mandatory because due to the available fuel reserves, which will still last for several years, it is also possible to essentially classify nuclear energy as a domestic energy source in energy statistics in line with international conventions (IEA, Eurostat).
2) Due to the progressive depletion of deposits, the domestic production volume of natural gas and crude oil will continue to drop in the future.
3) For more details, please see EEFA (2010). "Sicherheit unserer Energieversorgung – Indikatoren zur Messung von Verletzbarkeit und Risiken" [Security of Our Energy Supply – Indicators for Measuring Vulnerability and Risks] (study on behalf of the World Energy Council Germany; currently only available in German).
4) If one were to consider the segment of electricity production, then the proportion of supplies from Russia would amount to 70 %.

stops and short-term supply disruptions.[5] In this scenario, though, the economic risk of price and exchange rate fluctuations on the global market continues to persist for the national economy and/or could only be cushioned by a stronger recourse to domestic, particularly renewable, energy sources in the long run.

In the short term, the options to ramp up domestic energy production are rather limited. Resorting back to the still existing domestic hard coal reserves (the last mine had been decommissioned in December 2018) is almost impossible for legal, technical, and economic reasons. Abandoning the phase-out plan for nuclear energy at short notice (extending the operating life of nuclear power plants) causes operational and safety-related problems. Against this backdrop, the only short-term option available would be the expansion of lignite production and/or lignite-fired electricity production within the scope of the existing capacities and/or one might reconsider the pace of the legally specified fossil fuel phase-out. The decommissioning path set out by the German Coal-Fired Power Generation Termination Act (KVBG) earmarks the closure of several power plant units already for the current year. When it comes to climate protection requirements, the expansion of renewable energy sources associated with natural gas as a transitional energy and flanked by the creation of the requisite infrastructures, for example, in the power grid sector, as well as the ramp-up of the hydrogen economy present a reasonable and useful strategy.

For imported energy, a short-term energy switch is possible as well. However, particularly when it comes to the supply of electric power, natural gas imported from Russia could only be partially replaced by power plant coal which is more accessible and less expensive. About two thirds of the natural gas fired power plant capacity (cogeneration of heat and power) are used for the grid-bound supply of heat. Taking recourse to coal(-based electricity) is not a suitable short-term strategy, in particular, when it comes to serving the heating market and covering the energy demand for mobility purposes because it is here where primarily fuels, natural gas, and fuel oil are required. For these sectors, changing the supply/import sources, if necessary, along with the acceptance of higher energy prices, would essentially be an option that could be considered as a potential course of action.[6]

5) *As a matter of fact, the stockpiling (storage) of such important energy carriers as crude oil, coal, or natural gas also contributes towards a safer and more reliable energy supply, and it also helps bridge at least short-term delivery stops.*
6) *BDEW (2022). "Kurzfristige Substitutions- und Einsparpotenziale Erdgas in Deutschland." [Short-Term Substitution and Savings Potentials for Natural Gas in Germany]: https://www.bdew.de/media/documents/BDEW_Analyse_Kurzfristige-Gassubstitution-Deutschland_17032022_korr.pdf (currently only available in German).*

Primary Energy Production in Germany

Except for renewables and petroleum, domestic energy production increased for all other energy carriers in 2021 which resulted in an overall increase of approximately 4.9 % to 3,552 PJ or 121.1 Mtce (please see Table 4). The strongest increase in domestic production was recorded for lignite with a quantitative plus of about 173 PJ (+17.7 %). Natural gas production also increased slightly when compared to the previous year; namely, by 0.5 % to about 164 PJ in 2021. At the same time, the domestic production of petroleum dropped over the past few years which was due to the increasing depletion of old fields and deposits. This trend continued during the reporting year 2021: Compared to the previous year, petroleum production decreased by 4.5 % (4 PJ) in 2021.[10)]

Renewable energy carriers were not able to expand their position as the most important indigenous energy source ahead of lignite any further in 2021. Despite the construction of new plants, domestic production from renewables dropped marginally in 2021 which was due to the reduced supply of wind when compared to the previous year; namely, by 0.2 %. Their proportion of the total domestic production decreased from 57.6 % to 54.7 % while the energy market as a whole exhibited growth. With a proportion of 32.4 %, lignite recorded significant increases in its shares (2020: 28.9 %). Nonetheless, both energy carriers continued to rank far ahead of natural gas and petroleum.

When taking primary energy consumption in 2021 into account, the overall proportion of domestic production increased; namely, from 28.5 % in 2020 to now about 29 % (please see Table 4). This development was, at the same time, also due to the fact that in the course of the economic recovery after the pandemic-related slump in the previous year, primary energy consumption increased by 3.1 % in 2021; this was a less significant increase than was recorded for the domestic production of primary energy carriers.

Table 4

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Primary Energy Production in Germany in 2020 and 2021

	Production				Changes in 2021 Compared to 2020		Proportions	
	2020	2021	2020	2021			2020	2021
	Petajoules (PJ)		Million Tons of Coal Equivalents (Mtce)		PJ	%	%	
Mineral Oil	81	77	2.8	2.6	-4	-4.5	2.4	2.2
Natural Gas, Petroleum Gas	163	164	5.6	5.6	1	0.5	4.8	4.6
Hard Coal	0	0	0.0	0.0	0	0.0	0.0	0.0
Lignite	979	1,153	33.4	39.3	173	17.7	28.9	32.4
Renewable Energy	1,949	1,945	66.5	66.3	-4	-0.2	57.6	54.7
Other Energy Carriers	213	213	7.3	7.3	1	0.3	6.3	6.0
Total	**3,385**	**3,552**	**115.6**	**121.1**	**167**	**4.9**	**100.0**	**100.0**
For information purposes: Proportion of Primary Energy Consumption							28.5	29.0

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

Sources: German Association of Energy and Water Industries (BDEW); German Brown Coal Industry Association (DEBRIV); Federal Office for Economic Affairs and Export Control; en2x - Wirtschaftsverband Fuels und Energie e. V.; Working Group on Renewable Energy Statistics (AGEE-Stat)

10) It 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 Arbeitsgemeinschaft Energiebilanzen (AG Energiebilanzen) – Working Group on Energy Balances (Energy Balances Group), the primary energy consumption of mineral oil in Germany amounted to 3,961 PJ (135.1 Mtce) in 2021, which was 3.1 % below the previous year's level.

Except for light fuel oil and diesel fuel as well as other products, all products (domestic sales)

Table 5

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Consumption and Volume of Mineral Oil in Germany in 2020 and 2021

		2020	2021 [1]	Change
		in Million Tons	in Million Tons	in %
Total Consumption		**95.5**	**92.4**	**-3.3**
Self-Consumption and Losses [2]		6.0	6.2	2.8
Domestic Consumption		89.5	86.2	-3.7
Proportion of:	Gasoline	16.3	16.3	0.4
	Diesel Fuel	35.1	34.5	-1.7
	Aviation Fuels	4.7	5.9	24.2
	Fuel Oil, Light	15.6	10.8	-30.8
	Fuel Oil, Heavy [3]	0.8	1.2	47.5
	Naphtha	11.8	13.1	11.2
	Liquid Gas	3.5	3.7	6.0
	Lubricants	0.8	0.9	5.9
	Other Products	10.9	9.5	-12.9
	Recycling (to be deducted)	-5.8	-6.0	3.2
	Biofuels [4] (to be deducted)	-4.1	-3.7	-11.4
Total Volume		**89.5**	**86.2**	**-3.7**
Domestic Production		1.9	1.8	-4.5
Refinery Production		97.3	95.7	-1.7
Generated from:	Input of Crude Oil	84.0	82.8	-1.4
	Input of Products	13.3	12.9	-3.0
Foreign Trade Products (Balance)		12.5	10.0	
	Imports	34.8	35.3	1.3
	Exports	22.3	25.3	13.4
Compensation [Balance (Bunker, Differences)]		-14.2	-13.2	
Refining Capacity		105.7	105.7	0.0
Utilization of Refining Capacity in %		79.5	78.3	
Primary Energy Consumption of Mineral Oil (Mtce)		**4,087**	**3,961**	**-3.1**

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 - Wirtschaftsverband Fuels und Energie e. V.

recorded a plus. 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, the consumption of diesel fuels decreased by 1.7 % to 34.5 million tons. Nonetheless, sales of diesel fuels continued to be almost twice as high as those of gasoline (16.3 million tons) whose demand increased slightly by 0.4 % in 2021. The consumption of aviation fuels increased considerably during the reporting year; namely, by 24.2 %, after it had exhibited a decline of almost 54 % in the wake of the Covid-19 pandemic. Thus, sales in this segment in 2021 (about 5.9 million tons) still fell more than 40 % and, thus, far below the "normal volumes" which had been observed before the outbreak of the Covid-19 crisis. All told, the demand for fuels (2021: About 56.7 million tons), which accounted for an approximate share of 65.8 % in Germany's total oil consumption, was more than 1.1 % (which equals 0.6 million tons) higher in 2021 than it had been in 2020.

With a decrease of more than 30 %, sales of light fuel oil experienced a clear downward trend. In light of the weather, which was significantly cooler in 2021 when compared to the previous year (for more details, please see Section "Temperature and Weather Influence" hereinabove), this trend was probably caused to a lesser extent by "real" consumption reductions resulting from continuing efficiency improvements (due to the use of modern oil condensing heating systems or due to the substitution of oil fired heating systems with heat pumps or natural gas condensing systems) rather than, above all, the depletion of existing fuel oil stocks on part of private households and commercial customers. In 2020, stocks had been replenished at low prices.

Prices for light fuel oil increased at an annual average between 2020 and 2021 from 49.9 c/liter to 70.7 c/liter, which equals an increase of about 41.8 %. Due to these price increases in conjunction with lower outside temperatures, the fuel stock volumes were likely to have been reduced by about 2.6 million tons (which translates into 113 PJ); this depletion occurred first and foremost in private households. If this were indeed the case, then the actual consumption would most likely be correspondingly higher than the volume of fuel oil which was statistically recorded and/or sold in 2021.

With a minus of 1.7 %, refinery production decreased to a level of 95.7 million tons in 2021. Towards this end, refinery production from crude oil, which accounted for a share of about 86.5 %, went down by 1.4 % whereas the processing of products actually decreased by 3 %. In light of the declining production, the refining capacity of 105.7 million tons, which (compared to the previous year) remained unchanged once again, was actually utilized at 78.3 % in 2021; in 2020, the degree of utilization had still amounted to almost 80 %.

Foreign trade in mineral oil products changed significantly in 2021. On balance, imports predominated in 2021; with 35.3 million tons, they topped the exports of 25.3 million tons by only about 10 million tons.

Due to its very limited domestic petroleum resources, Germany is primarily dependent on crude oil imports which fell below the previous year's level by 1.6 % with 81.4 million tons in 2021. In 2021, the by far most important supplier countries for crude oil continued to be Russia with a further increased share (34.1 %) and Kazakhstan (12.5 %). Norway assumed third place among the major countries of importation in 2021 with a share of crude oil imports that increased by 0.8 percentage points to 9.8 percentage points. The United Kingdom, which had still ranked second among the most important supplier countries in the previous year, dropped to fifth place with a supply share of 9.3 % (7.6 million tons) in 2021. Another important supplier country in 2021 were the USA with a supply share of 9.6 % (relating to the total import volume) (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 against the backdrop of a generally shrinking market; it went down from 43 % (2020) to less than 41 % in 2021. In contrast, the OPEC states (2020: 16.3 %) recorded minor increases in their shares (2021: 17.4 %) whereas the countries bordering the North Sea reduced their supply share to about 26.3 %.

In 2021 as well, international oil prices and the Euro/US Dollar exchange rate exhibited a volatile development; in other words, they experienced considerable short-term fluctuations (please see Figure 4).

Table 6

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Germany's Crude Oil Imports in 2020 and 2021 According to Countries of Origin

Important Supplier Countries/Production Regions	2020	2021	Changes 2020/2021	2020	2021
	in Million Tons		in %	Proportions in %	
Russia	28.1	27.7	-1.4	34.0	34.1
United Kingdom	9.5	7.6	-20.0	11.5	9.3
Norway	8.0	7.8	-2.7	9.7	9.6
Kazakhstan	7.4	8.0	7.7	9.0	9.8
USA	9.4	10.2	8.6	11.3	12.5
Nigeria	4.3	1.7	-59.9	5.1	2.1
Other Countries	16.0	18.4	14.7	19.4	22.6
Total	**82.7**	**81.4**	**-1.6**	**100.0**	**100.0**
OPEC	13.5	14.2	5.0	16.3	17.4
North Sea [1] (excld. FRG)	24.1	21.4	-10.9	29.1	26.3
Former CIS	35.7	33.2	-7.0	43.1	40.8
Other	9.5	12.6	32.8	11.5	15.5
Total	**82.7**	**81.4**	**-1.6**	**100.0**	**100.0**

1) Including other EU countries

Discrepancies in the totals are due to rounding off

Sources: Federal Office of Economics and Export Control (BAFA); RohölINFO, December 2021; Federal Statistical Office (Destatis)

Figure 4

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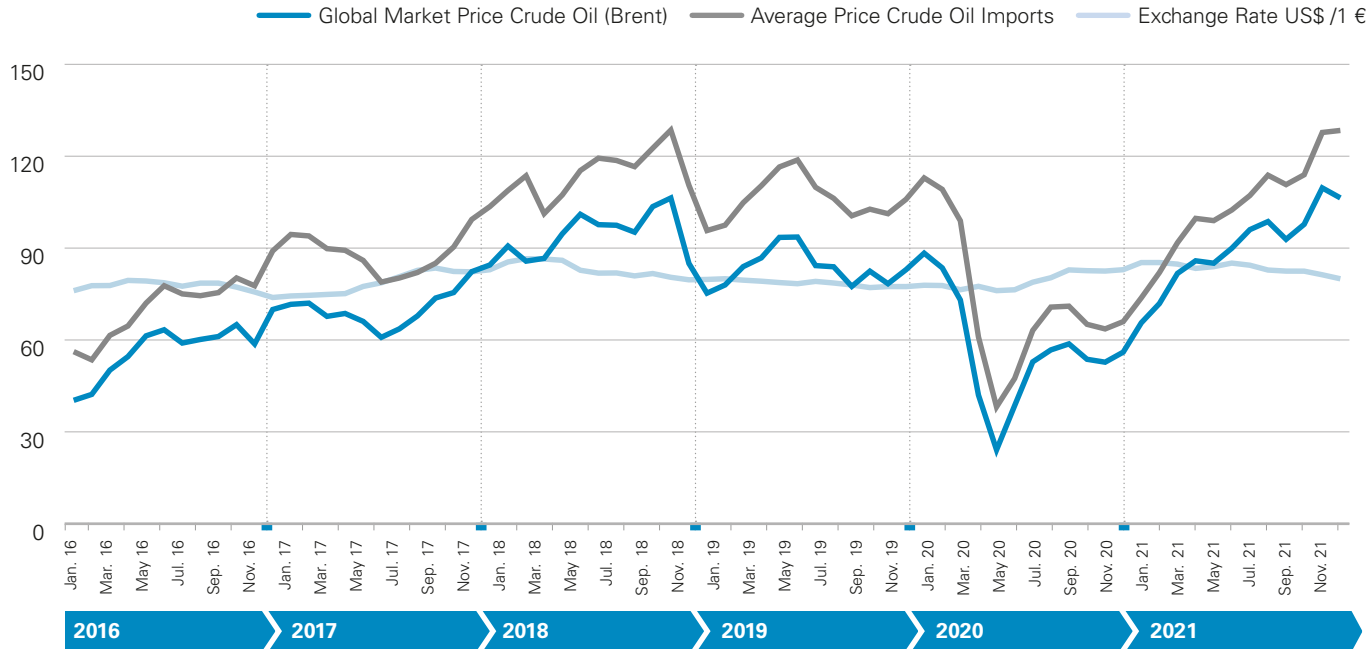
Global Market Prices for Crude Oil (Brent) [1], Border-Crossing Prices for German Crude Oil Imports [2], and Exchange Rates between 2016 and 2021

January 2010 = 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 - Wirtschaftsverband Fuels und Energie e. V.

While the prices for crude oil grade Brent UK, which is important for Europe, with an annual average of about 50 US dollars per barrel (US-$/bbl; 1 barrel = 159 liters) in 2020 had still been about 14 US dollars below the previous year's values, they increased to almost 71 US dollars in 2021. But even though these prices exhibited such a strong increase, they were still far removed from the peak levels which had been attained in 2011/2012 (amounting to about US-$ 112/bbl). The development during the course of 2021 clearly indicates the above mentioned price increases in a more pronounced manner. Based on its lowest value in January (with about US-$ 55/bbl), the crude oil price went up again and reached its annual peak of US-$ 83.54/bbl in October. Subsequently, a slight decline in the price to about US-$ 74/bbl was observed once again until December 2021. Compared to the Covid-19 related low in May 2020 (about US-$ 18/bbl), the oil price based on dollars was noticeably higher during all months of the current year 2021.

German crude oil import prices 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 2021, the exchange rate (indirect quotation) had decreased to about US-$ 1.13/€ at the end of the year (December 2021). A direct monthly comparison with the previous year shows opposing trends: From January to July 2021, the exchange rate (indirect quotation) ranged in the ballpark between about 3 % and nearly 11 % above the level of the respective months of the previous year. In the second half of the year (August to December), however, a devaluation between almost 0.2 % and more than 7 % (in December 2021) was observed when compared to the same months of the previous reporting period.[11] Consequently, the appreciation of the Euro slightly cushioned the increase in crude oil prices on the global market for German consumers during the first half of the year (until July) whereas as of August, the devaluation of the Euro resulted in a more substantial increase in prices for domestic consumers. All told, German crude oil import prices (on an annual basis and calculated in Euro/bbl) increased to a slighty lesser extent (+56.7 %) than the global market prices (in US-$/bbl) for crude oil (+62.5 %) between 2020 and 2021.

Figure 5

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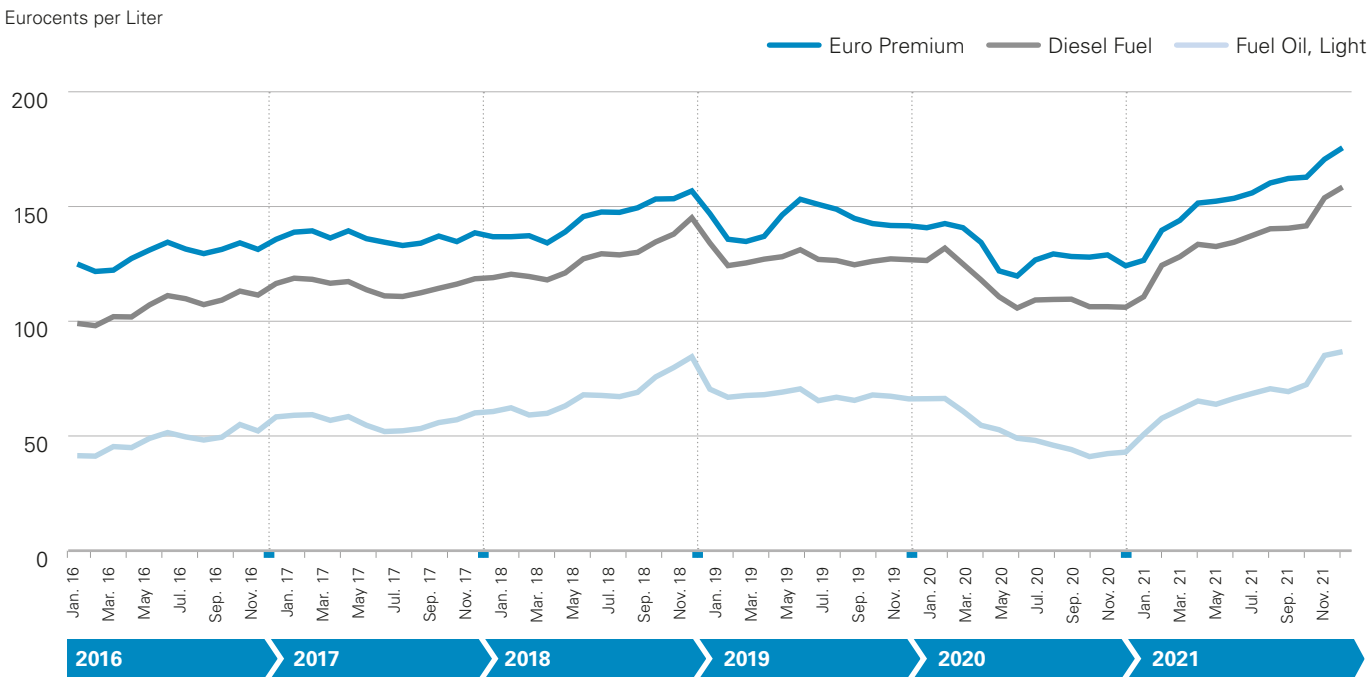
Prices for Fuels and Light Fuel Oil in Germany between 2016 and 2021



Sources: en2x - Wirtschaftsverband Fuels und Energie e. V.; Federal Statistical Office (Destatis)

11) On an annual average in 2021 and when compared to the year 2020, the exchange rate increased by 3.6 % to US-$ 1.18/€ (appreciation of the €).

Converted into euros and tons, German crude oil import prices went up from an annual average of € 278/t in 2020 to more than € 436/t in 2021. Irrespective of the import volumes, which decreased by nearly 1.6 % in 2021 when compared to the previous year while the crude oil prices for German consumers increased by almost 57 % over the same period of time, the overall costs for crude oil imports went up considerably by more than 54 %; namely, from about 23 billion euros to 35.5 billion euros.

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). While the prices for premium gasoline, diesel fuel, and light fuel oil had decreased noticeably at an annual average between 2019 and 2020, which was primarily due to the economic and sectoral impact of the measures to fight the Covid-19 crisis, the renewed demand for these products caused the prices to increase significantly in 2021: On an annual average, the prices for premium gasoline increased by more than 22 %, for diesel fuel by almost 25 %, and for light fuel oil even by about 42 %.

Yet at the end of the year 2021, a price-reducing trend became apparent once again for all three products so that in December 2021, all consumer prices fell below the level which had still been observed in November of the same year. Despite this decline, the prices recorded for December noticeably exceeded the level which had still been observed at the beginning of the year (January 2021). For example, the price for light fuel oil in December 2021 was 27.3 cents per liter higher than the price that had been recorded in January 2021 (which equals an increase in prices of almost 20 %). Over the same period of time, the price for diesel fuel to be paid at gas stations increased by about 24 % (+29.6 cents per liter) and the price for light fuel oil went up by more than 41 % (+23.9 cents per liter).

As measured by the producer price index, the prices for mineral oil products in Germany were at an annual average and in total 27.6 % higher in 2021 than in 2020.

Natural Gas

According to preliminary data, natural gas consumption in Germany increased by 4.9 % to about 1,012 billion kWh in 2021. Thus, natural gas consumption was as high as it had last been recorded for the years 2005/2006.

Domestic production of natural gas went up once again as of mid-2021; with an estimated volume of almost 51 billion kWh, the previous year's value will be exceeded by approximately 0.5 %. One reason for the sharp decline in the previous year (-16 %) was the revision of a natural gas processing plant for a period of nine weeks (during the second half of 2020) which had noticeably reduced the entire domestic production in 2020. Inspection and maintenance work to this extent is carried out only about every 10 years. In 2021, domestic production of natural gas covered about 5 % of Germany's natural gas consumption. Approximately 95 % of the natural gas used 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 our neighboring countries. That is why only the foreign trade balance (net imports) will be examined closer here. In 2021, the import volume of natural gas remaining in Germany (imports minus exports) amounted to about 901 billion kWh. Thus, the net import volume increased noticeably when compared to the previous year; namely, by 4.9 %.

After the year 2020 when the filling levels of the underground storage facilities for natural gas connected to Germany's natural gas grid had continuously been relatively high, the storage facilities started into the year 2021 with an average filling volume. Due to the long and comparably cold winter, the storage facilities started from a very low level and were refilled relatively late. As per December 15, 2021, the German storage facilities were filled to a level of about 58 %. Towards this end, the situation reveals a heterogeneous picture: Germany's storage facilities exhibit a broad spectrum of filling levels. On balance, about 61 billion kWh of natural gas were withdrawn from storage facilities in 2021.

For comparison: 56 billion kWh of natural gas had still been stored in 2020.

When it comes to the utilization of natural gas in the individual consumption sectors, the following trends become apparent for 2021 (please see Table 7):

- Industry's demand, which had experienced a sharp decline in 2020 due to the effects of the Covid-19 pandemic, increased significantly above all during the second and third quarter of 2021. In the course of the economic recovery since the end of the pandemic-related lockdown, natural gas consumption in the industrial sector (mining and manufacturing industries, mineral oil processing, other energy producers) grew according to first estimates by approximately 1.5 % to 372 billion kWh. The differentiation selected here also includes the use of natural gas in natural gas fired power plants operated by the industrial enterprises themselves as well as the non-energetic consumption of natural gas. By its nature, consumption in the industrial sector is less temperature dependent, but rather dependent on economic trends.

- Natural gas consumption of companies in the trade, commerce, and service sector increased noticeably as well. In contrast to industry, more than four fifths of the natural gas in this consumption segment are used for space heating purposes. Hence, the lower temperatures caused the demand for natural gas of the trading, commercial, and service companies to increase. Economic effects reinforced this growth. All told, a consumption plus of almost 12.5 % can be anticipated in the trade, commerce, and service sector for 2021.

- When it comes to private households (including the housing companies supplying them with space heating and hot water), a significant increase in consumption is to be anticipated due to the cooler weather during the first half of 2021. Current data indicate an increase of more than 13 % to 312 billion kWh for 2021. The increase in consumption was additionally reinforced by the continued construction of new homes that are directly heated with natural gas.

Table 7

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Volume and Use of Natural Gas in Germany in 2020 and 2021

	Unit	2020	2021 [1]	Change in %
Domestic Production	Billion kWh	50.3	50.5	0.5
Imports [2]	Billion kWh	1,684.9	1,673.3	-0.7
Total Volume of Natural Gas	Billion kWh	1,735.3	1,723.9	-0.7
Exports [2]	Billion kWh	826.0	772.4	-6.5
Storage Balance [3]	Billion kWh	56.0	60.8	-
Domestic Sales of Natural Gas	Billion kWh	**965.3**	**1,012.2**	**4.9**
Primary Energy Consumption	**Billion kWh**	**965.3**	**1,012.2**	**4.9**
	Petajoules (H_u)	**3,135.9**	**3,288.2**	**4.9**
	Mtce (H_u)	**107.0**	**112.2**	**4.9**
Structure of Natural Gas Generation by Origin				
Domestic Production [4]	%	5.2	5.0	
Import Quota	%	94.8	95.0	
Structure of Natural Gas Consumption According to Consumer Groups				
Industry (Including Industrial Power Plants)	Billion kWh	367.0	372.5	1.5
Power Supply (Including CHP Plants)	Billion kWh	133.5	93.1	-30.3
Provision of District Heating and Cooling (Including CHP Plants)	Billion kWh	58.1	94.1	61.9
Private Households	Billion kWh	275.9	312.1	13.1
Trade, Commerce, Services	Billion kWh	113.1	127.3	12.5
Transportation	Billion kWh	1.8	2.0	12.6
Total Sales of Natural Gas	**Billion kWh**	**949.5**	**1,001.0**	**5.4**
Self-Consumption and Statistical Differences	Billion kWh	15.8	11.2	-28.9
Natural Gas Consumption	**Billion kWh**	**965.3**	**1,012.2**	**4.9**

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 Geoenergy (BVEG); German Association of Energy and Water Industries (BDEW)

- The use of natural gas as a fuel in power plants and heating stations supplying electricity decreased in 2021. Even though the reduced supply of wind initially required the additional use of natural gas for electricity production during the same period of time, the global market prices for power plant gas which increased rapidly during the second half of the year (as well as higher prices for CO_2 emissions certificates with at the same time significantly increased electricity exchange prices) increasingly forced gas fired power plants out of the market. As a result, the use of natural gas for electricity production as a whole (i. e. including industrial power plants) decreased according to preliminary calculations by 20 %.[12)]

- More natural gas was also used by district heating suppliers for the generation of heat. It was, in particular, the great demand for heat during the first half of the year which required the increased use of this fuel. Preliminary figures indicate a plus of 61.9 % when it comes to the use of natural gas as a fuel in the heating and thermal power stations supplying the general public (≥1 MW_{el}) so that an increase to about 94 billion kWh can be observed here. Another contributing factor in this was the construction of new homes which are indirectly (namely, via district heating) heated and/or supplied with natural gas.

- Sales of natural gas to the transportation sector are also likely to have increased by 12.6 % in 2021 so that a consumption level of 2 billion kWh was attained here.

Compared to 2020, the proportion of natural gas of the total primary energy consumption increased by 0.4 percentage points to 26.8 % in 2021.

According to initial figures, about 10.1 billion kWh of biogas processed to natural gas quality were fed into the German natural gas grid in 2021. In 2020, it had been around 9.9 billion kWh of which almost 8 billion kWh went into combined power generation. Around 1.4 billion kWh were used as a fuel, another approximately 0.5 billion kWh were sold on the heating market (space heating, hot water). The remaining quantities were used, for example, as materials, exported, or used otherwise. In accordance with the AG Energiebilanzen's balancing scheme, these quantities are recorded both on the volume side and the consumption side under renewable energy and not under natural gas.

The number of companies active in the gas industry increases continuously. A closer look reveals that in 2021, seven enterprises were active as natural gas producers, 31 as storage operators, 16 as transmission grid operators, 703 as gas distribution grid operators, and 1,051 as distribution companies in the end customer business.[13)] The number of employees in the gas industry increased slightly by 2.4 % and amounted to 41,300 persons at the end of the year 2021.

Since the liberalization of the energy markets, spot and futures markets for natural gas have developed rapidly. All told, gas trading at the European hubs exhibits significant growth. At these virtual trading points, essential supply and demand based price signals are created for the European and, thus, also the German market today. With short-term action gaining increased relevance on spot markets and in other trading centers, a price spread has been in place between the border-crossing prices for crude oil and natural gas since 2010. The price trend for oil no longer plays any role in the development of the procurement costs for gas today.

Over the course of the year 2021, the import prices for natural gas (in euros per gigajoule) shot up considerably. Between 2020 and 2021, the border-crossing price (on an annual basis) increased from € 3.41/GJ (which equals 1.23 ct/kWh) to € 7.08/GJ (2.55 ct/kWh); thus, it more than doubled (+108 %) when compared to the previous year. The annual average, however, was still below the peak level which had been observed in 2012 (€ 8.08/GJ and/or 2.90 ct/kWh). A glance at the monthly development reveals a different picture: Just between January and

12) This significant decline in the use of fuels for electricity production from natural gas – which, all told, only decreased by about 5 % when compared to the previous year – is first and foremost due to changes in the power generation structure. For example, electricity production in natural gas fired cogeneration plants increased by more than 5 % in the reporting year because more heat was produced as a result of the weather, whereas the uncoupled production of electricity in gas fired power plants dropped by approximately a quarter. The increased share of efficient cogeneration in the entire electricity production from natural gas caused the use of fuels to fall disproportionately.

13) It is not possible to add up the company figures because many of the companies are active at multiple stages of the value creation chain and are, thus, recorded several times.

Figure 6

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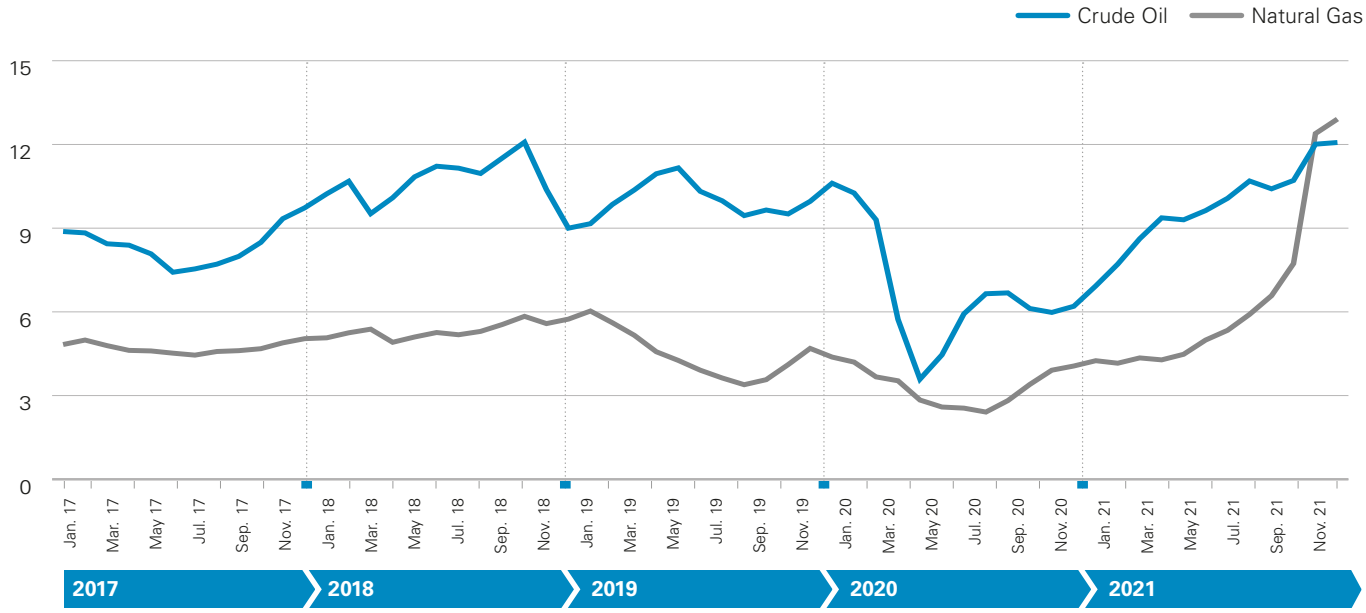
Monthly Border-Crossing Values for Crude Oil and Natural Gas between 2017 and 2021

Border-Crossing Values in Euros per Gigajoule



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

December 2021 alone, the average price for natural gas imports increased from € 4.16/GJ (1.5 ct/kWh) to € 14.79/GJ (5.33 ct/kWh). This equals a price increase of 256 % (please see Figure 6). At the same time, the import price for December 2021 marked a new all-time high. Compared to the old peak level that had been attained in March 2012, the price increase in December 2021 amounted to about € 6.60/GJ (2.36 ct/kWh), which translates into almost 80 %.

The development of import prices has different effects on domestic sales prices (please see Figure 7). Different procurement periods for various customer groups result in diverging price trends. In addition, the relative price changes for bulk consumers are higher because of the lower overall price level. Parallel to the import prices for natural gas, the price level for natural gas at the energy exchange (spot market) increased significantly; namely, from € 9.56/MWh to € 47.09/MWh (+393 %).[14)]

Against the backdrop of the drastic increase in import and wholesale prices for natural gas particularly as of the fourth quarter of 2021, the end customer prices and/or sales prices to consumers also increased substantially over the course of the year; albeit to a different extent. For example, sales prices to power plants tripled (January 2021 to December 2021: +298 %) whereas the prices for industrial clients doubled over the same period of time.[15)] When interpreting these figures, it should be noted that the purchase prices for large industrial clients (annual supply of more than 500 GWh) increased by about 141 % 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), the prices increased by about 31 %.

Due to early procurement, the gas prices for the trade, commerce, and service sector increased by about 9.3 %. For private households, an average increase in prices of approximately 3.4 % was observed in 2021 when compared to the previous year (please see Figure 7).

The diverging development of the energy exchange and distribution prices for various customer groups is associated with the composition of end customer

14) 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: January 2022) (currently only available in German).
15) Also based on the annual average, sales prices for natural gas to power plants as well as to industrial clients more than doubled between 2020 and 2021.

Figure 7

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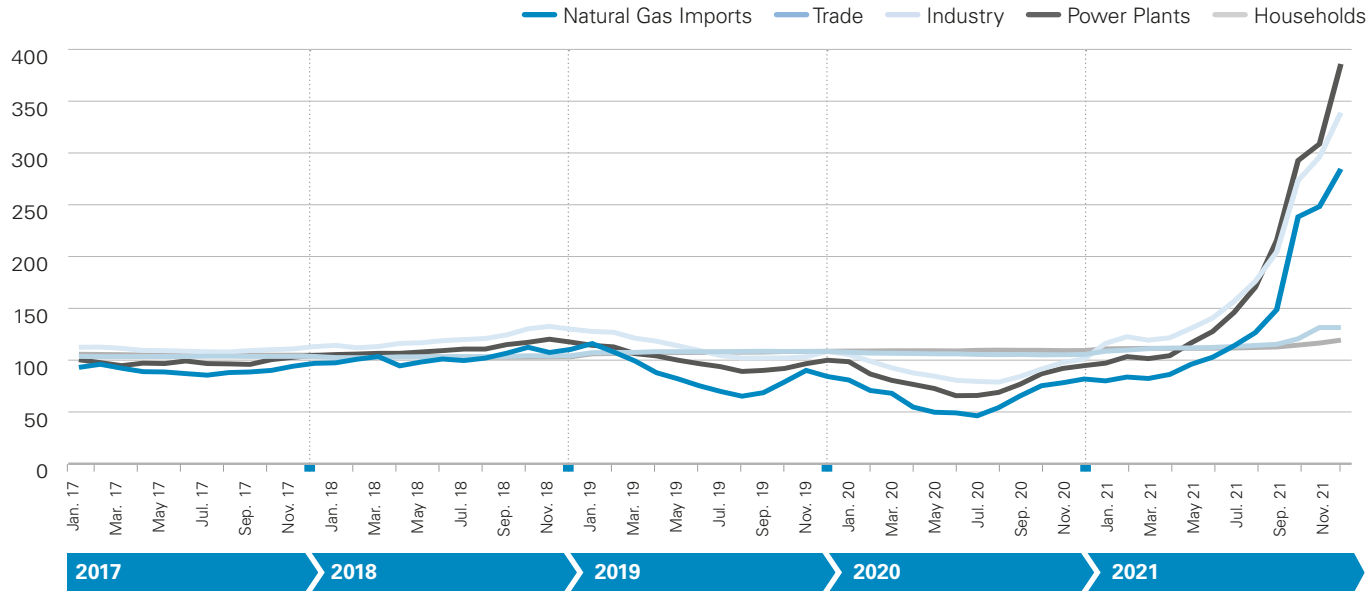
Prices for Natural Gas Imports and Natural Gas Sales in Germany between 2017 and 2021

January 2010 = 100 (Basis of Producer Price Indices 2015 = 100)



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

prices and different contract periods. Procurement costs on the wholesale market actually reflect only a part of the end customer price. The latter also includes network charges designed to finance the grid infrastructure as well as taxes and duties which are only subject to slight fluctuations; this means that the price trends at the energy exchange have a weaker impact on price changes for end customers.

However, the diverging price trends for various customer groups are mainly attributable to different contract periods. For longer contract periods, the requisite gas volumes are purchased in advance on futures markets already at the beginning of the contract period in order to meet the obligation to deliver over the course of the contract period (the so called "back-to-back procurement"). As a general rule, procurement periods as well as contract periods tend to be shorter for large consumers while they are longer for household customers and small businesses. A longer contract period actually means that short-term fluctuations of purchase prices are levelled out and thus, with falling market prices, have a delayed impact on retail prices for end customers. However, this also applies conversely to increasing purchase prices which influence the retail price for end customers as well; albeit to a lesser extent and delayed.

Hard Coal

According to preliminary estimates and compared to the previous year, Germany's primary energy consumption based on hard coal significantly increased once again in 2021 – by about 16.5 % to 1,044 PJ (35.6 Mtce). The continuous downward trend, which had persisted for a period of seven years, was stopped for the first time in 2021. This reversal of the trend was supported by an increase in prices for other energy carriers and by the fact that due to the weather, less electricity which essentially came from wind turbines was fed into the grid (please see Table 8).

Compared to the previous year, the two most important sectors in which hard coal is used (power plants and the steel industry) exhibited a clear recovery – each with double-digit percentages – last year. The use of hard coal in form of coking coal and coke in the steel industry, for example, increased by more than 12 % to 432 PJ (almost 15 Mtce). Decisive for this trend were, above all, the economic recovery and the associated increase in crude iron production which went up by more than 14 % to almost 26 million tons in 2021.

The use of hard coal in power plants that generate electricity and heat increased even more significantly and went up by almost 24 % to 514 PJ (almost 18 Mtce). Over the course of the year, the monthly rates of change for the generation of electricity in hard coal fired power plants were consistently positive and, except for the months of January and December, also in the high double-digit range. The marked increase in the use of hard coal for electricity production in Germany caused hard coal based electricity production to outpace the steel sector once again when it comes to the relevance of hard coal.

Despite historic highs in the fuel prices for hard coal and natural gas and extremely higher prices for CO_2 emissions certificates (according to the European Energy Exchange EEX, Leipzig), the use of power plant coals in the operational ranking of power plants ("merit order") was favored over natural gas in the course of last year. While the average annual price for power plant coals free at Northwest European ports (ARA – Antwerp, Rotterdam, Amsterdam) more than doubled (+116 %) to more than US-$ 120.00/t in 2021 when compared to the previous year (about US-$ 50.00/t), the wholesale prices for natural gas tripled for the front year and quadrupled in day-ahead trade (for the market zone Trading Hub Europe).

With 54.7 billion kWh in 2021, hard coal fired power plants, thus, delivered considerably more electricity than in the previous year. Their electricity production

Table 8

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Volume and Use of Hard Coal in Germany in 2020 and 2021

	2020		2021 [1]		Change
	PJ	Mtce	PJ		in %
Primary Energy Consumption	**896**	**30.6**	**1,044**	**35.6**	**16.4**
Power Plants and Thermal Power Stations	415	14.2	514	17.6	23.9
Steel Industry	385	13.1	432	14.7	12.3
Heating Market	54	1.9	56	1.9	3.3
Import of Hard Coal and Coke	42	1.4	42	1.4	0.0
Hard Coal Production	**0**	**0.0**	**0**	**0.0**	**0.0**

1) Preliminary data; some figures are estimates

Discrepancies in the totals are due to rounding off

Sources: German Coal Importers Association; The German Coal Industry's Statistical Office; bsn - Industry Association for Hard Coal and Post-Mining

Table 9

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German Hard Coal Imports[1] According to Supplier Countries in 2020 und 2021 (January to December)

	2020	2021 [2]	Change	2020	2021
	in Million Tons		in %	Proportions in %	
Poland	1.2	1.6	34.2	3.8	3.9
Czech Republic	0.2	0.3	41.6	0.6	0.7
Russia	14.4	20.5	42.8	46.0	49.9
South Africa	0.4	1	146.6	1.3	2.4
USA	5.8	7.1	23.0	18.6	17.3
Canada	1.2	1.3	9.0	3.8	3.2
Columbia	2	2.3	17.4	6.4	5.6
Australia	3.8	5.5	42.5	12.1	13.4
Other EU Countries [3]	2.3	1.5	-34.8	7.4	3.6
Total Imports	**31.3**	**41.1**	**31.1**	**100.0**	**100.0**
Total Year (Expansion) [4]	**26.8**	**35.2**	**31.1**		

1) Including coke imports; coke converted into coal
2) Preliminary
3) As-is values for 2019; projected values for 2020 based on imports accrued during the specific period of time

Discrepancies in the totals are due to rounding off

Sources: German Coal Importers Association; The German Coal Industry's Statistical Office; Federal Statistical Office (Destatis)

increased by 27.7 % in 2021 after having decreased by more than 25 % during the previous year. By the end of the year, the installed capacity of hard coal fired power plants amounted to 18,488 MW. Within the scope of the first and second bidding round for the fossil fuel phase-out, more than 6.2 GW of the hard coal fired power plant capacity were either decommissioned or withdrawn from the market in 2021. Another 3,633 MW are currently in the grid reserve so that at the beginning of the year 2022, just 14,855 MW will still be active on the market. An additional power plant capacity of 2 GW, which had won the tender in the third bidding round, will be withdrawn from the market over the course of the year 2022.

In terms of volume, the heating market, which encompasses the consumption of hard coal in foundries, district heating plants, small businesses, and private households, played a subordinate role. The use of hard coal in these sectors increased by 3.3 % to 56 PJ (1.9 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 compared to the previous year, Germany's hard coal imports increased by about 31 % to 41.1 million tons in 2021. Of this figure, 62.8 % (25.8 million tons) accounted for power plant coals, 28.9 % (11.9 million tons) for coking coals, 2.6 % (1.0 million tons) for anthracite coals and briquettes, and around 5.7 % (2.4 million tons) for coke.

During the period under review between January and December 2021, Russia was once again, as had already been the case in the previous years, the most important country of origin with an approximate share of 50 % in Germany's total hard coal imports (please see Table 9). As measured by absolute figures, imports from Russia increased by 43 % to 20.5 million tons. With a proportion of 17.3 % (7.1 million tons),

the United States continued to be the secondmost important country of origin; compared to the previous year, the increase amounted to 23 %. In a sectoral breakdown according to the individual coal types, Russia dominated the field as the most important country of origin by far for power plant coal with a share of 70 %. When it comes to coking coal imports, Australia ranked first with a share of 45 %. And coke imports came mostly from Poland with a share of 56 %.

In 2021, the development of global hard coal production was characterized by the recovery of the global economy and the associated greater demand, particularly in Asia. According to initial estimates, hard coal production ought to have increased by 5.2 % to 7.4 billion tons when compared to the previous year; in a historical context, this would be the highest volume of hard coal ever produced to date on the entire globe. For 2022, the International Energy Agency (IEA) expects a further increase in the global production and foresees a continuation of these high levels at least until 2024.

The People's Republic of China continued to be number one in global production; it ranked far ahead of its competitors with an increase of 5 % to just above 4 billion tons. Thus, China's proportion of the global production amounted to 54 %. With an increase of 7 % to 771 million tons, India expanded its second place in the international ranking even further.

About 17 % of the global production were distributed through maritime trade; the majority was used in the producer countries. In addition, a smaller portion accounted for domestic trade with neighboring countries and includes cross-border transports via inland navigation vessels and/or via rail transports. Compared to the previous year, maritime trade increased by nearly 6 % to 1.2 billion tons. This growth was specifically due to the recovery of the global economy. The most important exporting countries in maritime trade were Australia with 368 million tons, Indonesia with 365 million tons, and Russia with 187 million tons. Together, these countries attained an approximate proportion of 78 % of the entire global seaward hard coal trade. In the maritime trade of 2021, the highest increases in exports when compared to the previous year were attributable to the United States (+43 %), Russia (+13 %) as well as Indonesia (+7 %).

Figure 8 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 coals[16)] went up from almost US-$ 59/tce (annual average 2020) to approximately US-$ 140/tce in 2021. The import price for steam coals amounted to US-$ 79/tce in January 2021 and increased to about US-$ 270/tce in October 2021. After this all-time high, the price for steam coals dropped once again to approximately US-$ 160/tce by the end of the year.

Figure 9 shows 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 steam coals and power plant coals experienced a significant increase during the second half of the year 2021 when compared to 2020. The import price for hard coal coke attained a level of € 452/t in December 2021 after it had still amounted to about € 183/t in January 2021. With more than € 182/tce, the import price for hard coal (steam coals) also peaked at a new high during the fourth quarter of 2021.

16) 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 8

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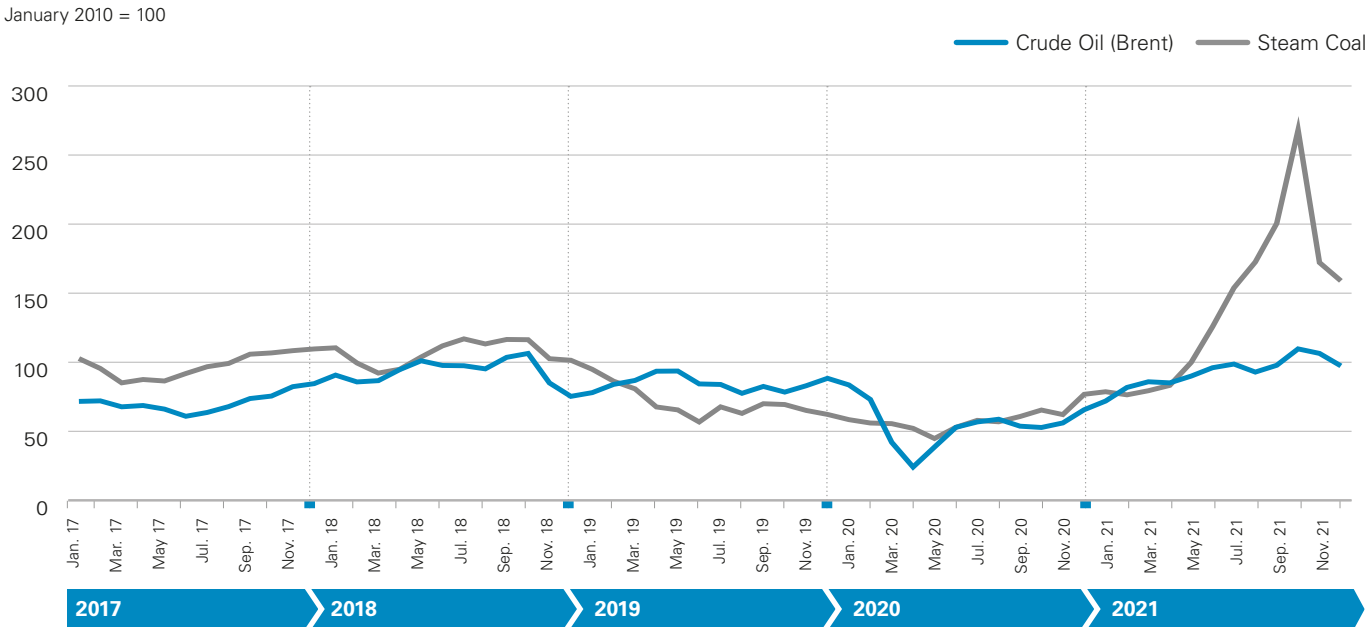
Global Market Prices for Crude Oil (Brent) and Steam Coal between 2017 and 2021



Sources: German Coal Importers Association; en2x - Wirtschaftsverband Fuels und Energie e. V.

Figure 9

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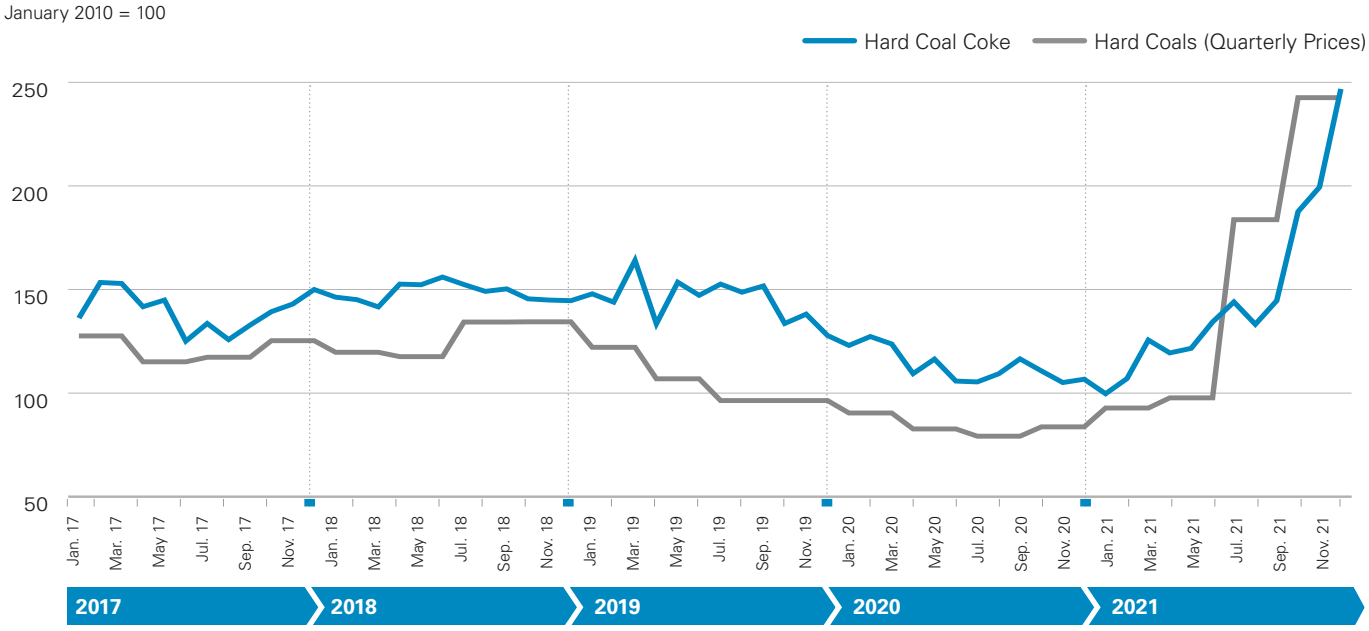
Development of Selected Hard Coal Import Prices between 2017 and 2021



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

Lignite

With about 126.4 million tons (39.3 Mtce) in 2021, lignite production as a whole was almost 18 % above the previous year's yield. Yet the increase was quite different in the individual mining districts:

The Rhineland area (+22 %) and Central Germany (+32 %) exhibited particularly high growth; but even in Lusatia (+8 %), the production rate was significantly higher than in the previous year.

Table 10

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Volume and Use of Lignite in Germany in 2020 and 2021

	Unit	2020	2021 [1]	Change in %
1. Domestic Raw Lignite				
Total Lignite Production	**Million Tons**	**107.4**	**126.4**	**17.7**
	Mtce	**33.4**	**39.3**	**17.7**
	PJ	**979.2**	**1,152.6**	**17.7**
2. Foreign Trade				
Total Imports	1,000 tce	29.1	23.3	-20.1
Total Exports	1,000 tce	787.4	896.8	13.9
Foreign Trade Balance	1,000 tce	-758.3	-873.6	-
3. Primary Energy Consumption				
	Mtce	32.7	38.5	17.7
	PJ	958	1,128	17.7
4. Sales				
Total Sales	**Million Tons**	**93.8**	**112.7**	**20.1**
to Power Plants Supplying the General Public	Million Tons	93.1	111.7	20.0
to Other Customers	Million Tons	0.7	1.0	37.8
Use for Refinement	Million Tons	11.5	11.9	3.8
Use in Lignite Mining Power Plants	Million Tons	2.1	2.0	-2.1
Change in Stocks	Million Tons	0.0	-0.2	-
5. Electricity Production from Lignite				
Power Plants Supplying the General Public	Billion kWh	89.2	107.4	20.4
Industrial Power Plants	Billion kWh	2.6	2.7	3.8
Total Electricity Production from Lignite	**Billion kWh**	**91.7**	**110.1**	**20.1**

1) Preliminary data; some figures are estimates

Discrepancies in the totals are due to rounding off

Source: The German Coal Industry's Statistical Office

Overall, it was still around 4% lower in 2021 than in 2019. The mining of lignite and its use in power plants that generate electricity follow the provisions specified by the German Coal-Fired Power Generation Termination Act (KVBG) and the schedule for the phased, premature exit from coal fired power generation in Germany by the end of 2038.

This change generally corresponds to the development of deliveries to power plants supplying the general public (a total of 111.7 million tons; +20 %) which receive around 90 % of the production.

With a total of about 110 TWh, power generation based on lignite was higher than in the previous year. Lignite's share in power generation increased once again to approximately 18 % (previous year: 16 %). This development was primarily due to the fact that significantly fewer amounts of electric power coming from wind turbines were fed into the grid in 2021 when compared to the previous year; in 2020, this figure had been considerably higher because of the weather conditions particularly during the month of February. In addition, the base effect emanating from the Covid-19 pandemic and the changes in the competitive situation due to soaring prices for natural gas had a substantial impact on the result of 2021. Compared to 2019, electricity production based on lignite was still about 4 % lower. However, lignite fired power plants continued to make an indispensable contribution towards a secure and reliable electricity supply not just during those times when electricity production from wind and solar power was low.

The manufacture of refined products based on lignite was only able to partially make good the significant losses of the previous year. Production increased in total by approximately 5 % to nearly 5.5 million tons in

Table 11

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Lignite Balance for Germany in 2020 and 2021
in 1,000 tce

		2020	2021 [1]	Change
				in %
Domestic Production		33,412	39,343	17.8
+	Imports	29	24	-17.2
=	**Volume**	**33,441**	**39,367**	**17.7**
+/–	Change in Stocks (Reduction: +, Replenishment: -)	22	-18	-
–	Exports	787	898	14.1
=	**Primary Energy Consumption**	**32,676**	**38,451**	**17.7**
–	Use in Power Plants	29,850	35,204	17.9
–	Other Conversion Input	3,770	3,913	3.8
+	Conversion Output	3,800	3,977	4.7
–	Consumption during Production and Conversion as well as Non-Energetic Consumption	192	350	82.3
=	**Final Energy Consumption**	**2,644**	**2,961**	**12.0**
	Industry	2,265	2,561	13.1
	Households, Trade, Commerce, Services, Concessionary Coal	379	400	5.5

1) Preliminary data; some figures are estimates

Source: The German Coal Industry's Statistical Office

2021. The growth in production amounted to +4 % for briquettes, +6 % for pulverized coals, +1 % for fluidized bed coals, and +10 % for coke.

With about 39.3 Mtce (1,153 PJ), the energy content of the extracted lignite exceeded the previous year's result by about 18 %. The contribution of lignite to domestic energy production amounted to more than 32 %. Lignite, thus, continues to be an important domestic energy carrier.

With 38.5 Mtce (1,128 PJ), lignite-based primary energy consumption was 17.7 % higher than the previous year's result, but about 5 % lower than what had been achieved in 2019 (please see Table 10). Lignite, thus, met approximately 9.2 % of the entire domestic demand for energy in 2021. The long-term trend of a decline in the consumption of lignite continued.

With a total consumption of about 3 Mtce in 2021, the final energy sectors used in total more lignite and lignite products than in the previous year (+12 %). The drastic decline of the previous year was only compensated to some extent. When it comes to industry, the use of lignite increased by about 13 % while sales to private households increased to a lesser extent (+6 %) (please see Table 11).

At the end of 2021, the number of employees working in the German lignite industry amounted to almost 18,000 people. This figure includes about 1,160 apprentices and nearly 4,300 employees who worked in the lignite companies' power plants supplying the general public. Employment statistics listed 8,481 employees in the Rhineland District, 7,362 in Lusatia, and 2,052 in Central Germany. After the end of coal mining and after the end of the power plant Buschhaus's standby mode for backup purposes, only about 50 employees still worked on behalf of the lignite industry in the Helmstedt District.

The Electric Power Industry

In 2021, the supply of electric power was characterized by the most diverse influencing factors. These factors included, for example, pandemic-related restrictions in the economy and public life at the beginning of the year, the long period of cooler weather that persisted until May, economic catching-up processes during the second and third quarter of the year as well as significant price increases on the energy markets and in the trading of CO_2 certificates (particularly during the second half of 2021). Against this backdrop, the consumption of electric power (gross domestic electricity consumption) increased by 2.4 % to currently 568.8 billion kWh which was specifically due to the economic situation. At the same time, Germany's surplus obtained from electricity exports (which had experienced a substantial decline over the past few years) increased slightly in 2021 when compared to the previous year; namely, by 0.4 billion kWh to 19.3 billion kWh. For electricity production, this trend also resulted in a plus of almost 14 TWh (+2.4 %) which was an increase to 588.1 TWh during the reporting year 2021 (after it had still dropped by 5.5 % (about 33.7 TWh) in the previous year which was to some extent due to the Covid-19 pandemic).

Power generation from the individual energy carriers exhibited a distinctly different trend in 2021 as well. In 2021, less electricity was generated from renewables as a whole as well as from natural gas than in the previous year. In contrast, electricity production in coal fired power plants increased considerably when compared to 2020. The contribution of nuclear energy to power generation in Germany went up by 7.4 % (please see Table 12).

In 2021, lignite fired power plants generated more than 110 billion kWh of electricity. This equals an increase of 20.2 % after production in 2020 had still decreased by almost one fifth when compared to 2019. According to preliminary data, a net power plant capacity of 19,740 MW was installed at the end of the year; however, another 910 MW of which were decommissioned as per December 31, 2021, so that the installed capacity was further reduced to 18,830 MW at the beginning of the year 2022. Nevertheless, 1,886 MW of this reduced capacity are now in the standby mode of lignite for backup purposes and, thus, no longer active on the electricity market.

With 54.7 billion kWh in 2021, hard coal fired power plants also delivered significantly more electricity than in the previous year. Their electricity production increased by 27.7 % in 2021 after having decreased by almost one fourth during the previous year. By the end of the year, the installed capacity of hard coal fired power plants amounted to 18,488 MW. Within the scope of the first and second bidding round for the fossil fuel phase-out, more than 6.2 GW of hard coal fired power plant capacity were either decommissioned or withdrawn from the market in 2021. Another 3,633 MW are currently in the grid reserve so that at the beginning of the year 2022, just 14,855 MW will still be active on the market. An additional power plant capacity of 2 GW, which had won the tender in the third bidding round, will be withdrawn from the market over the course of the year 2022. Additional blocks which are to be replaced by gas fired cogeneration plants will also be decommissioned in 2022.

In 2021, an expected total of 89.7 billion kWh of electricity were generated from natural gas in the power plants of electricity suppliers (supplying the general public), in the power plants of industrial enterprises as well as in the combined heat and power plants of other electricity producers (feeding electricity into the grid). The total electricity production of gas fired power plants went down by 5.3 %. It was, in particular, the considerable increase in spot market prices for power plant gas which had electricity production from natural gas forfeit its competitive edge over the more carbon-intensive coal fired power plants (despite the fact that the prices for CO_2 also went up simultaneously during the second half of the year). The associated improved profit situation (contribution margin) of coal fired power plants caused gas fired power plants to be increasingly forced out of the market particularly during the second half of the year. The indicators which are typically used for measuring the contribution margin of power plants in a specific market environment (fuel prices, CO_2 price, EEX spot market price, degree of efficiency) are the so-called "clean spark spread" (gas fired power

Table 12

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Gross Electricity Production in Germany between 1990 bis 2021 According to Energy Carriers

	1990	2016	2017	2018	2019	2020	2021	2020/ 2021	1990/ 2021
	in Billion kWh							Average Annual Change in %	
Lignite	170.9	149.5	148.4	145.6	114.0	91.7	110.3	20.2	-1.4
Nuclear Energy	140.8	112.2	92.9	82.6	57.5	42.8	54.7	27.7	-3.0
Hard Coal	152.5	84.6	76.3	76.0	75.1	64.4	69.1	7.4	-2.5
Natural Gas	35.9	80.6	86.0	81.6	90.0	94.7	89.7	-5.3	3.0
Mineral Oil	10.8	5.7	5.5	5.1	4.8	4.7	4.7	0.4	-2.6
Renewables	19.7	189.7	216.3	222.4	241.2	251.1	233.6	-7.0	8.3
Other	19.3	27.3	27.5	27.3	25.4	24.8	26.0	4.8	1.0
Gross Electricity Production	**549.9**	**649.7**	**652.9**	**640.5**	**607.9**	**574.2**	**588.1**	**2.4**	**0.2**
Electricity Flows from Foreign Countries	31.9	28.3	27.8	31.7	40.1	48.0	50.6	5.2	1.5
Electricity Flows into Foreign Countries	31.1	78.9	80.3	80.5	72.8	66.9	69.9	4.4	2.6
Foreign Electricity Exchange Balance	0.8	-50.5	-52.5	-48.7	-32.7	-18.9	-19.3	-	-
Gross Electricity Consumption	**550.7**	**599.1**	**600.5**	**591.8**	**575.2**	**555.3**	**568.8**	**2.4**	**0.1**
Change versus Previous Year in %	*X*	*0.0*	*0.2*	*-1.4*	*-2.8*	*-3.5*	*2.4*		
	Structure of Gross Electricity Production in %								
Lignite	31.1	23.0	22.7	22.7	18.7	16.0	18.8		
Nuclear Energy	27.7	17.3	14.2	12.9	9.5	7.5	9.3		
Hard Coal	25.6	13.0	11.7	11.9	12.3	11.2	11.8		
Natural Gas	6.5	12.4	13.2	12.7	14.8	16.5	15.2		
Mineral Oil	2.0	0.9	0.8	0.8	0.8	0.8	0.8		
Renewables	3.6	29.2	33.1	34.7	39.7	43.7	39.7		
Other	3.5	4.2	4.2	4.3	4.2	4.3	4.4		
Gross Electricity Production	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		

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); AGEE-Stat (for renewables)

Figure 10

AGEB
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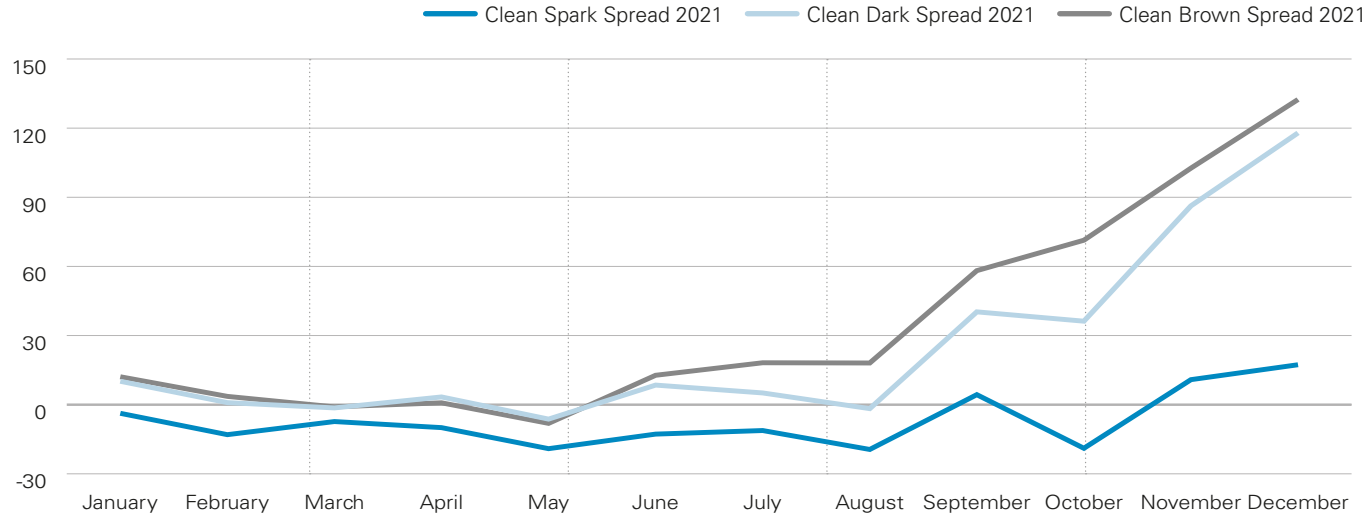
Profit Situation of Different Power Plant Types

2021, 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) as well as the "clean brown spread" (lignite fired power plants).[17] Figure 10 shows the changes in the profit situation of coal fired power plants in relation to natural gas fired power plants over the course of the year 2021.

Compared to the previous year, the installed capacity of gas fired power plants increased slightly to 30,160 MW. However, 1,569 MW of which are currently in the grid reserve. Another 1,056 MW are in the capacity reserve which is why they do not participate in the market as well.

During the reporting year, Germany's nuclear power plants generated 69.1 billion kWh of electricity which was 7.4 % more than in the previous year.
An increased demand for electricity when compared to the previous year, lower amounts of electricity that were fed into the grid from renewable energy sources as well as the significantly increased CO_2 price bolstered the higher utilization of nuclear power plants and accounted for the growth rate indicated above. The most recent decommissionings of nuclear power plants took place in line with the plans for the nuclear energy phase-out as per December 31, 2021. In concrete terms, the units Grohnde, Brokdorf, and Gundremmingen C with a combined capacity of 4,058 MW were decommissioned; thus, the installed capacity of nuclear energy went down from 8,113 MW to 4,055 MW at the beginning of 2022.

In total, about 233.6 billion kWh of electricity were generated from renewable energy during the reporting year 2021. Renewable energy's contribution to meeting the gross domestic electricity consumption, thus, amounted to 39.7 % in 2021 (2020: 43.7 %).

Despite the declining electricity production due to the reduced supply of wind, wind energy continued to be the most important renewable energy source in Germany. With an anticipated 89.5 billion kWh, onshore wind turbines produced 14.6 % less electricity than in 2020. Even though offshore wind turbines with a total output of 24.4 billion kWh also supplied less electricity in 2021 than had been the case in the previous year (-10.7 %), the decline in production was smaller than that of onshore wind turbines. In 2021, the installed capacity of wind energy on shore increased by almost 1,700 MW to currently 56,100 MW. No wind turbines were newly connected

17) The calculation of "clean spreads" represents an approximation of the costs incurred from the conversion of fuels into electric power while also taking the CO_2 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.

to the grid off shore in 2021. Here, the new expansion phase will not commence before the years 2023 to 2025. Thus, the offshore wind capacity installed in Germany remains at 7,774 MW.

With 50 billion kWh in 2021, photovoltaic systems supplied about 1 % more electricity than in the previous year. 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; irrespective of whether the latter is reimbursed pursuant to the German Renewable Energies Act (EEG) or not. An additional photovoltaic capacity of approximately 5,800 MWp was newly installed in 2021; thus, the total capacity installed at the end of the year amounted to 59,500 MWp. Hence, the installation of new photovoltaic capacities managed to grow again by more than 5 GW for the first time since 2012. Only during the boom phase between 2010 and 2012 had the annual capacity additions been higher.

According to preliminary data, 44.8 billion kWh of electricity were produced from solid, liquid, and gaseous biomass (including landfill gas, sewage gas as well as sewage sludge) in 2021; this was slightly less than during the previous year (-1 %). Its total contribution to the German electricity producers' mix of energy sources, thus, amounted to approximately 7.6 %.

After the past three years (which exhibited rather low precipitation), electricity production from hydropower increased for the first time again in 2021. With a total of 19.1 billion kWh, hydroelectric power plants in Germany produced about 4.2 % more electricity than in the previous year.

In 2021, energy storage facilities connected to the German power 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 7.6 billion kWh of electric power and fed 5.6 billion kWh back into the grid again. So far, pumped storage plants assumed the largest proportion in this development. While the pumping capacity was 7.5 billion kWh, 5.5 billion kWh were withdrawn from the plants. The total withdrawal capacity of these storage facilities amounted to 7.2 GW of which 6.5 GW accounted for pumped storage plants.[18)]

The trend of a continuously increasing negative balance in Germany's electricity exchange has been interrupted since 2018. According to the German Association of Energy and Water Industries (BDEW), whose data exhibit a slightly divergent differentiation when compared to the data published by the Federal Statistical Office, the balance once again (albeit marginally) fell below the previous year's value with an export surplus of 20.8 billion kWh in 2021 (2020: 21 billion kWh) (please see Figure 11). The structure of the load flows between Germany and foreign countries changed as well: The largest amounts of electricity flowed in the direction of Switzerland and Austria, followed by the Netherlands and Poland (Switzerland: 16.6 billion kWh, Austria: 14.8 billion kWh, Netherlands: 9.1 billion kWh, and Poland: 8.7 billion kWh). The largest import volumes of electricity in 2021 came from France to Germany, followed by Denmark, the Netherlands, and Austria (France: 9.8 billion kWh, Denmark: 8.2 billion kWh, the Netherlands: 7.6 billion kWh, and Austria: 6.5 billion kWh).[19)]

All told, 73.2 billion kWh of electricity flowed from German power grids to foreign countries (2020: 68.6 billion kWh) while Germany sourced 52.4 billion kWh from abroad (2020: 47.6 billion kWh). Obviously, both the export and import volumes increased in 2021. Reasons for this are the additional cross-border interconnector to Belgium as well as the submarine cable to Norway for which flow data are available for

18) In addition, there is a large number of home energy storage systems. According to Germany's Federal Energy Storage System Association (BVES), almost 70 % of all photovoltaic systems are installed together with a home energy storage system. According to data published by the BVES, the cumulative capacity amounted to 1,210 MW at the end of 2020 (a total of about 285,000 home energy storage systems were installed in Germany). The number of home energy storage systems may even increase by up to 60 % and range between 385,000 and 445,000 systems by the end of 2021. It can also be noticed that the storage size is growing (in 2019, the average capacity per storage system had been 8 kWh; in 2020, this figure already amounted to 8.5 kWh).

19) In official statistics, the regional breakdown of the foreign trade in electricity is subject to confidentiality. That is why the data published by the BDEW are referred to at this point. Germany's energy balance does not require any differentiation between supplier and sourcing countries and generally uses the data contained in official statistics. It should also be kept in mind that the estimated primary energy consumption (please see Table 1 of this report) is based on an early estimate of Germany's energy balance for 2021 (last update in early February 2022). At this point in time, official data on the development of foreign trade had not yet been fully available for the reporting year 2021 and/or had to be supplemented by estimates. Consequently, the BDEW's data on the development of foreign trade in electric power differ from one another not only because of the selected data source, but also because of the more recent status of the appropriate information (data from January to December 2021).

Figure 11

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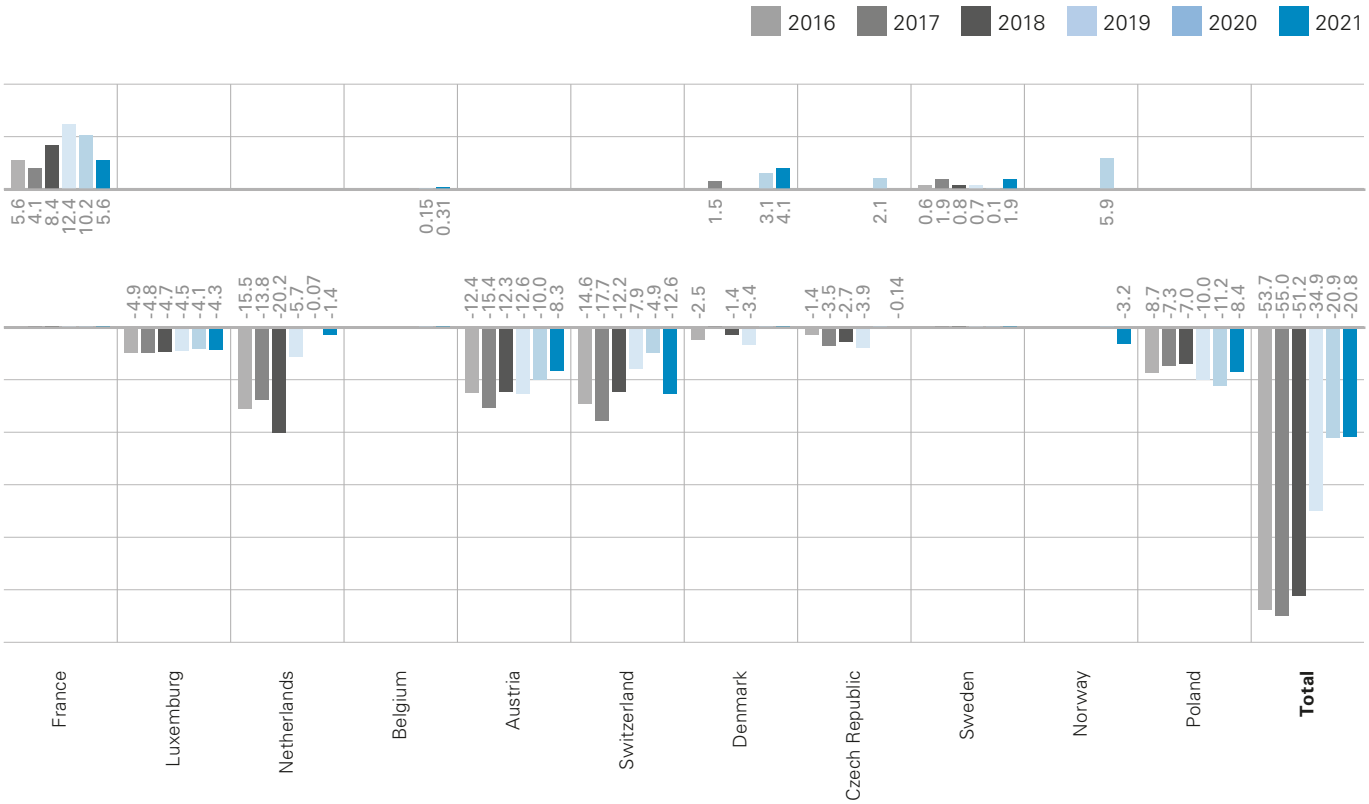
Germany's Electricity Exchange Balance with Neighboring Countries between 2016 and 2021

Electricity Flows in Billion kWh



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

the first time ever for the full year of 2021. It should be noted in this context that most of the cross-border electricity flows are not any contractually agreed upon deliveries, but rather transit volumes and loop flows. For example, a part of the electricity that flows from Germany to the Netherlands actually moves farther in the direction of Belgium and the United Kingdom.

According to initial estimates, electricity consumption in the mining and manufacturing industries (without considering those amounts of electricity which in the energy balance are attributed to the conversion sector such as, for example, refineries or coking plants, etc.) went up by 2.5 % from 206.7 billion kWh in the previous year to 211.8 billion kWh in 2021; this increase happened in the aftermath of economic recovery processes. Some sectors which were not able to benefit from the economic recovery to a sufficient extent recorded a decrease in their (absolute) electricity consumption. In 2021, these sectors included the manufacture of motor vehicles (-12.6 %), the manufacture of other chemical products (-5.3 %), the manufacture of paper and paper products (-1.8 %), quarrying (-0.5 %) as well as the manufacture of non-ferrous metals and the casting of non-ferrous metals (-0.1 %). In all other branches, the increase in production overcompensated the consumption-reducing effects (efficiency improvements, intrasectoral structural change). The economic recovery had a particular impact on electricity consumption in the economic sectors manufacture of basic metals (+10.3 %), metalworking (+8 %), manufacture of basic chemicals (+5.9 %), manufacture of machinery and equipment (+4 %) as well as manufacture of glass, glassware, and ceramics (+3.8 %).

For the private households sector, estimates revealed a slight increase of 2.2 % in consumption when compared to the previous year to approximately 131 billion kWh (2021). For the trade, commerce, and service sector, the first preliminary estimates also indicated an increase in electricity consumption by about 1.5 % to 137 billion kWh due to the economic situation. This consumption figure continued to be about 5 billion kWh (-3.3 %) below the electricity

Table 13

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Electricity Balance of Germany's Power Supply between 2018 and 2021

	2018	2019	2020	2021[1)]	Changes 2020/2021
	Billion kWh			Change in %	Change in %
Gross Electricity Production	**640.5**	**607.9**	**574.2**	**588.1**	**2.4**
Self-Consumption in Power Plants	-31.0	-31.1	-27.7	-31.7	14.5
Net Electricity Production	**609.5**	**576.8**	**546.6**	**556.5**	**1.8**
Electricity Flows from Foreign Countries	31.7	40.1	48.0	50.6	5.2
Electricity Flows into Foreign Countries	80.5	72.8	66.9	69.9	4.4
Net Domestic Electricity Volume	**560.8**	**544.1**	**527.7**	**537.2**	**1.8**
Pump Current Consumption	8.3	8.1	8.8	7.0	-19.7
Grid Losses and Unrecorded Factors	26.8	27.5	26.9	26.7	-0.9
Net Electricity Consumption	**525.6**	**508.6**	**492.0**	**503.4**	**2.3**
Proportion of:					
Mining and Manufacturing Industries	226.1	218.4	206.7	211.8	2.5
Households	126.6	125.7	128.0	130.8	2.2
Commerce and Trade, Public Institutions	149.0	141.8	135.2	137.1	1.5
Transportation	11.7	11.6	11.5	12.4	7.2
Energy Consumption in the Conversion Sector (without Own Power Plant Consumption)	12.3	11.0	10.6	11.3	7.1
Gross Domestic Electricity Consumption	**591.8**	**575.2**	**555.3**	**568.8**	**2.4**

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)

consumption which the companies and enterprises of the trade, commerce, and service sector had used for production purposes and/or the provision of services in 2019. In 2020 (more recent data are not yet available), electric power in the trade, commerce, and service sector had primarily been used for such purposes as lighting (32 %), drive and propulsion systems (21 %), information and communication technology (19 %), process heat and hot water (15 %) as well as cooling and refrigeration (13 %).

Electricity consumption for mobility purposes (road and rail transport) ought to have also exceeded the previous year's figure by about 7.2 %, whereby the consumption volumes of electrical energy in this segment still hovered at a low level with about 12.4 TWh (2021).

All these figures resulted in a total net electricity consumption of 503.4 TWh in Germany for the reporting year 2021. In 2020, the net electricity consumption had still amounted to 492 TWh (this equals a plus of 2.3 %) (please see Table 13).

The number of companies which work in the electric power industry has been growing continuously since the start of the liberalization process in 1998. In late December 2021, 1,143 companies (+1.5 % when compared to the previous year) were active on the market as electricity producers, 4 as transmission grid operators (±0.0 %), 896 as power distribution grid operators (-0.8 %), 137 as power storage facility operators (>1 MWel and/or >1 MWh), and 1,364 as electricity suppliers (+1.0 %). (It is not possible to add up and combine the indicated numbers because many of the companies are active at multiple stages of the value creation chain and are, thus, recorded several times.)

The number of employees in the companies of the electricity industry, which amounted to 143,000 persons, increased slightly in 2021 when compared to the previous year (+0.4 %).

Figure 12

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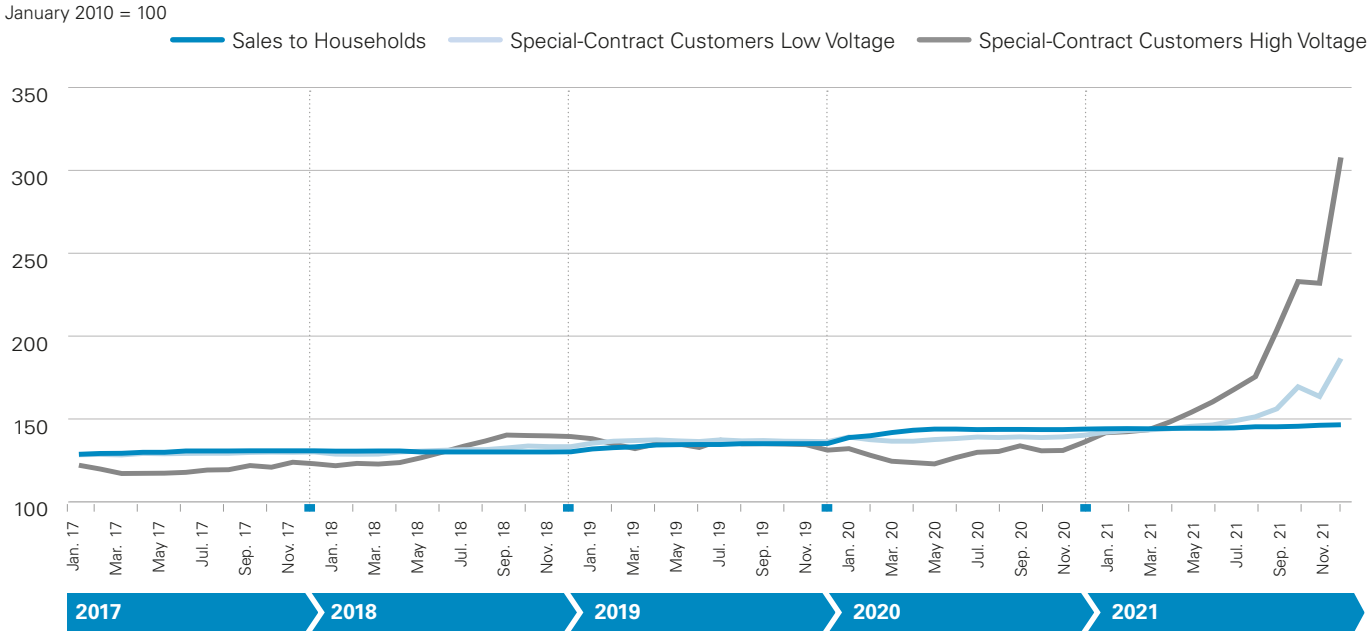
Electricity Producer Price Index for Special-Contract Customers and Sales to Households in Germany between 2017 and 2021



Source: Federal Statistical Office (Destatis)

Electricity prices for industrial clients (supply at the medium voltage level, annual consumption between 160,000 kWh and 20 million kWh) increased in total by more than 20 %, which was primarily due to an increase of approximately 45 % in procurement, distribution, and grid usage costs. At the same time, the burdens imposed on industry in the form of taxes, duties, and levies increased by approximately 2.2 % in 2021. As a result, the proportion of governmental charges included in the electricity price for industrial customers, which had still amounted to 52.3 % in 2020, decreased to about 42.5 % in 2020 (including the electricity tax).

Electricity prices for household customers increased by 1.1 % to an average of 32.16 ct/kWh in 2021 when compared to the previous year (between January and December 2021, the electricity price increased by 1.7 % for this customer group). Thus, the price for household customers reached a new record high. This was caused by an increase in procurement and distribution costs whereas the grid charges increased only marginally in 2021 and taxes, duties, and levies dropped slightly to 6.50 ct/kWh; the latter was primarily due to the capping of surcharges imposed by virtue of Germany's Federal Renewable Energy Act (EEG). Another reason was the temporary lowering of the value added tax which had relieved the electricity price for household customers between July 1 and December 31, 2020. With an overall proportion of 51 %, taxes, duties, and levies continued to represent the largest item on the electricity bills of private customers (please see Figure 12).

If one were to take a look at the monthly development of the stock market prices for electricity since 2009, then this curve initially exhibited fluctuations in the procurement costs which had always ranged between € 22/MWh and € 57/MWh from January 2009 to December 2019. As of 2020, this picture changed considerably: 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 stock market 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 continued to increase unabatedly over the course of the reporting year 2021. In an exponential curve, the electricity price at the EEX went up from € 52.80/MWh in January 2021 to € 221/MWh in December 2021 which marked a new all-time high. Thus, the prices at the electricity exchange developed parallel to the fuel prices (power plant gas and power plant coal) and to the costs for CO_2 certificates (please see Figure 13).

For the electric power industry, which after all represents the by far largest group of emitters in Germany, the development of certificate prices for CO_2, which are determined within the scope of European emissions trading, plays a significant role. High CO_2 prices improve the competitiveness of modern, low-emission gas and steam power plants and, at the same time, force carbon-intensive and/or less efficient power plants out of production. A closed time series of CO_2 certificate prices is now available for the second trading period between 2008 and 2012 as well as the third trading period between 2013 and 2020.

The fourth trading period of the EU emissions trading system commenced in early January 2021. Important changes in the ten years' trading period, which will last until the end of 2031, include, for example:

- Emission rights will be allocated in two phases (from 2021 to 2025 and from 2026 to 2030) whereby the actual amounts of the rights to be allocated will be determined at the beginning of the respective phases.

- The linear reduction factor (defining the annual decrease of allocated amounts across all branches) which had still amounted to 1.74 % p.a. during the third trading period will increase to 2.2 % p.a. during the current trading period.

- The allocation of emissions certificates free of charge will be further reduced; namely, from 30 % (2021) to zero percent in 2030 whereby exceptions will continue to exist, for example, for economic branches which are affected by "carbon leakage."

- The major portion of emission allowances (57 % of the total amount) is to be allocated via auctions.[20)]

All told, the new regulations entail that the emissions budget will decrease more rapidly in the future than had been the case before. The associated shortage in the amounts of certificates ought to result in a permanent "stabilization" of the CO_2 price at a higher level than had been observed during the second or third trading period.

On average, a CO_2 price of 53.30 euros per ton was observed at the EEX (spot market) in 2021; thus, it more than doubled when compared to the previous year (+115 %). Even more clearly visible was the price increase when considering the development over

Figure 13

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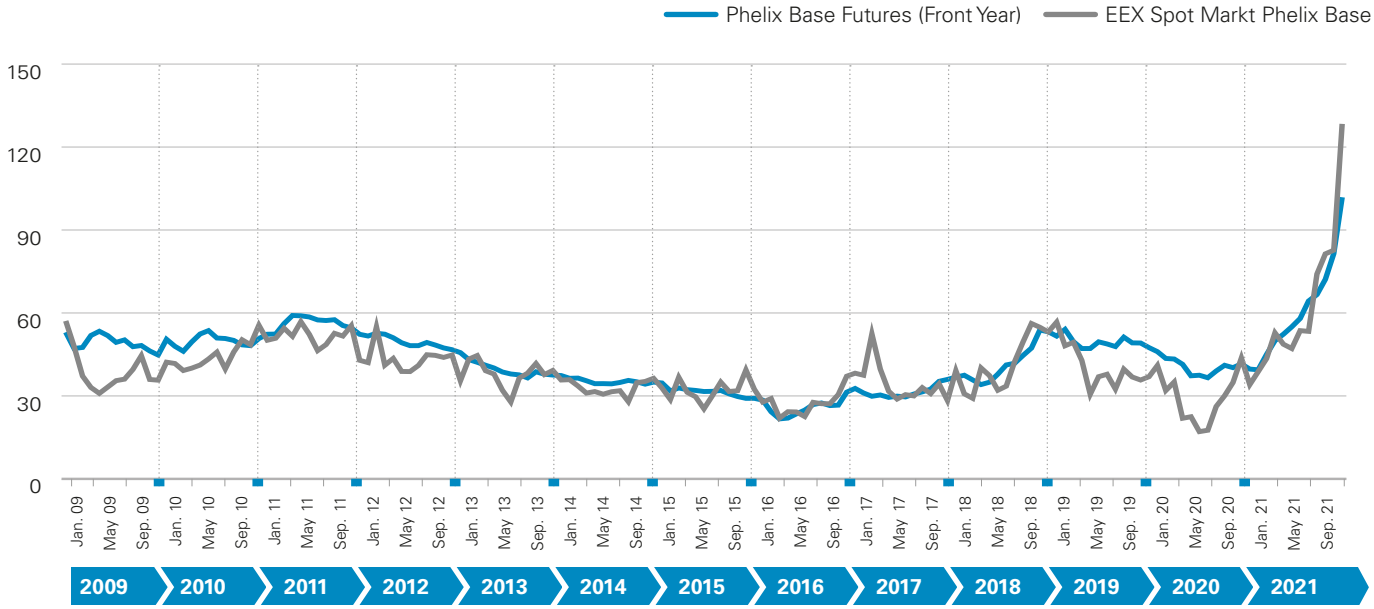
Development of Electricity Prices on the EEX Spot Market and Futures Market (Front Year) between 2009 and 2021

Electricity in EUR/MWh



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

20) For further details on the fourth trading period, please see, for example, the website of the German Emissions Trading Authority (DEHST): https://www.dehst.de/EN/european-emissions-trading/installation-operators/2021-2030/2021-2030_node.html (download date: 2022-02-24).

the course of the year. Since November 2020, the CO_2 price had increased continously. The price for CO_2 certificates increased from about 33.40 euros per ton in January 2021 to almost 80 euros per ton in December 2021. This equals a price increase of 46.50 euros per ton and/or a plus of 139 % (please see Figure 14).

Figure 14

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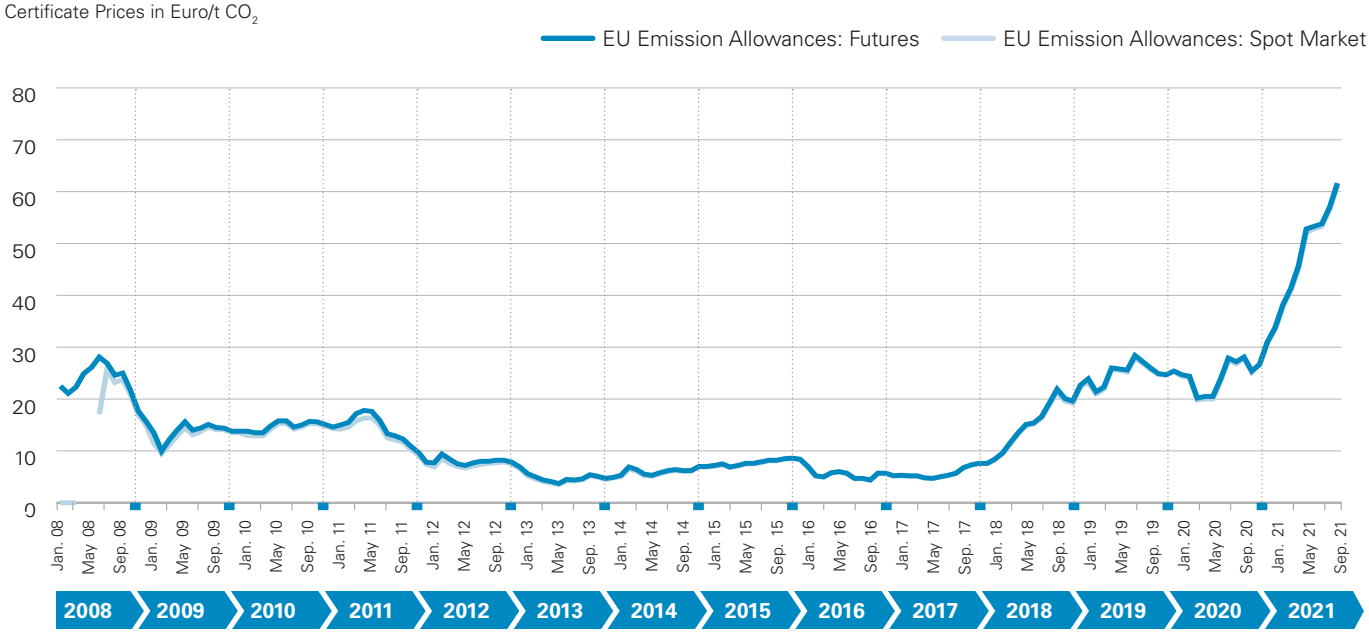
European Emission Allowances on the EEX Spot Market between 2008 and 2021



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

Renewable Energy[21]

In 2021, the primary energy consumption of renewable energy sources amounted to a total of 1,947 PJ (please see Table 14). When compared to the previous year (1,972 PJ), this equals a decline of 1.2 % which translates into an absolute decrease of 25 PJ. The decisive factors that influenced this development were the low wind conditions and, at the same time, the colder weather which resulted in the fact that less power was generated from wind energy and more biogenic fuels were consumed for heating purposes.

Due to the below average wind conditions, electricity production from renewables dropped by 7 % in 2021. With a total of 234 billion kWh, less renewable power was produced than in 2019 (241 billion kWh) and significantly less than in 2020 (251 billion kWh). Even though both onshore and offshore wind turbines contributed almost half of the renewable power with a combined output of 114 billion kWh, the production of wind power decreased by 18.3 billion kWh (-14 %) when compared to the previous year.

The expansion of wind energy also remained at a low level in 2021: While the power generation capacity off shore remained unchanged, the installation of additional net capacities on shore peaked at about 1.7 GW. Thus, onshore and offshore wind turbines with a total nominal electrical capacity of 56.1 GW and 7.8 GW respectively were in operation at the end of 2021.

Electricity production from photovoltaics peaked at about 50.0 billion kWh in 2021. Because of global radiation, the previous year's level was exceeded only slightly (49.5 billion kWh). Due to the installation of additional net capacities in new photovoltaic systems, which with about 5.0 GW was slightly above the previous year's level (4.8 GW), the overall peak capacity increased to 58.7 GW. It was, thus, for the first time ever higher than the nominal capacity of onshore wind turbines.

In 2021, electricity production from hydropower went up by 0.7 kWh to 19.1 billion kWh whereas electricity production from biomass including biogenic waste (50.4 billion kWh) recorded a slight decline (-0.5 billion kWh). What needs to be mentioned in this context is a special statistical feature; namely, the international convention of the efficiency principle: In the absence of a physically ascertainable calorific value, a fictitious efficiency of 100 % is assumed for the conversion of energy in the balance for the energy carriers hydropower, wind power, and photovoltaics. The efficiency principle implicates that, for example, the primary energetic contribution of electricity production from wind energy (conversion input of 410 PJ) is indicated in a dimension comparable to electricity production from biomass (conversion input of 388 PJ including biogenic waste) despite the fact that electricity production from wind energy was more than twice as high.

The total primary energy consumption of biomass and biogenic waste amounted to 1,177 PJ in 2021 (previous year: 1,147 PJ). This equals approximately 60 % of the total primary energy consumption from renewables. About 43 % of which were used in the conversion sector, i. e. essentially for the generation of electricity and district heat including the amount needed to cover the in-house consumption of the production plants. Towards this end, almost half of the energy carriers that were used were gaseous ones whereas solid fuels including the biogenic portion of residential waste accounted for the other half. As a result of the cooler weather in 2021, fewer amounts of these energy carriers were used for electricity production while their use for the generation of district heat increased.

The majority (about 57 %) of the energetic biomass used accounted for final energy consumption which increased by 35 PJ (+5.6 %) to 665 PJ in 2021. Almost two thirds of the biomass were consumed by private households as well as in the trade, commerce, and service sector (431 PJ) while the share of the transportation sector (123 PJ) amounted to approximately 19 % and the share of the industrial sector (111 PJ) to about 17 %. Due to lower outside

21) This text is based on the work conducted by the Working Group on Renewable Energy Statistics (AGEE-Stat); last update: 2022-02-18. For further information on the development of renewables in 2021, 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 2021" [Renewable Energy in Germany – Data on the Development in 2021]: https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/hg_erneuerbareenergien_dt.pdf (currently only available in German).

Table 14

Renewable Energy in Germany in 2020 and 2021 According to Its Use and Energy Sources

	Hydropower			Wind Energy (Onshore and Offshore)			Solar Energy			Geothermal Energy			Biomass			Waste			Total		
	2020	2021	Changes	2020	2021	Changes	2020	2021	Changes	2020	2021	Changes	2020	2021	Changes	2020	2021	Changes	2020	2021	Changes
	Petajoules		%	Petajoules		%	Petajoules		%	Petajoules		%	Petajoules		%	Petajoules		%	Petajoules		%
Domestic Production	66	69	4	476	410	-14	210	210	0	73	81	11	993	1,044	5	130	131	0	1,949	1,945	-0.2
Foreign Trade Balance													23	3	-88				23	3	-88.4
Primary Energy Consumption	**66**	**69**	**4**	**476**	**410**	**-14**	**210**	**210**	**0**	**73**	**81**	**11**	**1,016**	**1,046**	**3**	**130**	**131**	**0**	**1,972**	**1,947**	**-1.2**
Use in Power Plants (Electricity)	66	69	4	476	410	-14	178	180	1	8	9	8	338	331	-2	60	57	-4	1,126	1,056	-6.3
Use in Power and Heating Plants (Heat)							0	0	7	4	4	9	47	50	6	47	50	7	98	104	6.3
Consumption during Conversion, Losses													25	24	-4	0	0	0	25	24	-3.8
Final Energy Consumption							**32**	**30**	**-5**	**61**	**68**	**11**	**607**	**642**	**6**	**23**	**23**	**0**	**723**	**764**	**5.6**
Industry							0	0	0	0	0	0	88	88	0	23	23	0	112	112	0.0
Transportation													141	123	-12				141	123	-12.2
Households, Trade, Commerce, Services							32	30	-5	61	68	11	378	431	14				471	529	12.3

All values are preliminary (last update: February 2022)

Source: AGEE-Stat

temperatures when compared to the previous year, it was above all the use of biomass in private households and in the trade, commerce, and service sector which increased disproportionately (+53 PJ and/or +14 %, primarily fuelwood products) whereas the admixture of biofuels in the transportation sector exhibited an overall decline (-18 PJ and/or -12 %).

The other renewable energy carriers solar thermal energy, deep geothermal energy, and ambient environmental heat including near-surface geothermal energy accounted for a share of about 5 % in the primary energy consumption from renewables. It was primarily the heat pump sector which exhibited strong growth: According to the German Federal Heat Pump Association (BWP), about 154,000 heat pumps for heating purposes as well as 23,500 hot water heat pumps were newly installed and put into operation in 2021. Consequently, the renewable environmental heat generated by means of heat pump technology increased by 11 % to 68 PJ (including 4 PJ of directly used deep geothermal heat).

When compared to the previous year, though, solar thermal heat generation decreased by approximately 5 % to a level of 30 PJ in 2021. This was caused by the fact that the global radiation already referred to hereinabove (in the context of power generation from photovoltaic sources) was actually lower in 2021 than in the previous year. Since at the same time, according to the German Solar Industry Association (BSW-Solar), the number of newly installed solar collectors with about 81,000 new systems stagnated at a level comparable to that of 2020, the total collector surface installed in Germany increased only slightly to 21.8 million square meters (which equals +1.7 %).

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 15). While wind energy lost significant shares (-3.1 percentage points) due to the low wind conditions when compared to 2020, all other renewable energy carriers, in particular biomass (+2.2 percentage points to 53.7 % in 2021), were able to increase their contribution. Renewable waste, solar energy, hydropower, and geothermal energy were able to expand their contribution between 0.1 % and 0.4 % in the order of their importance on a slightly shrinking market.

Figure 15

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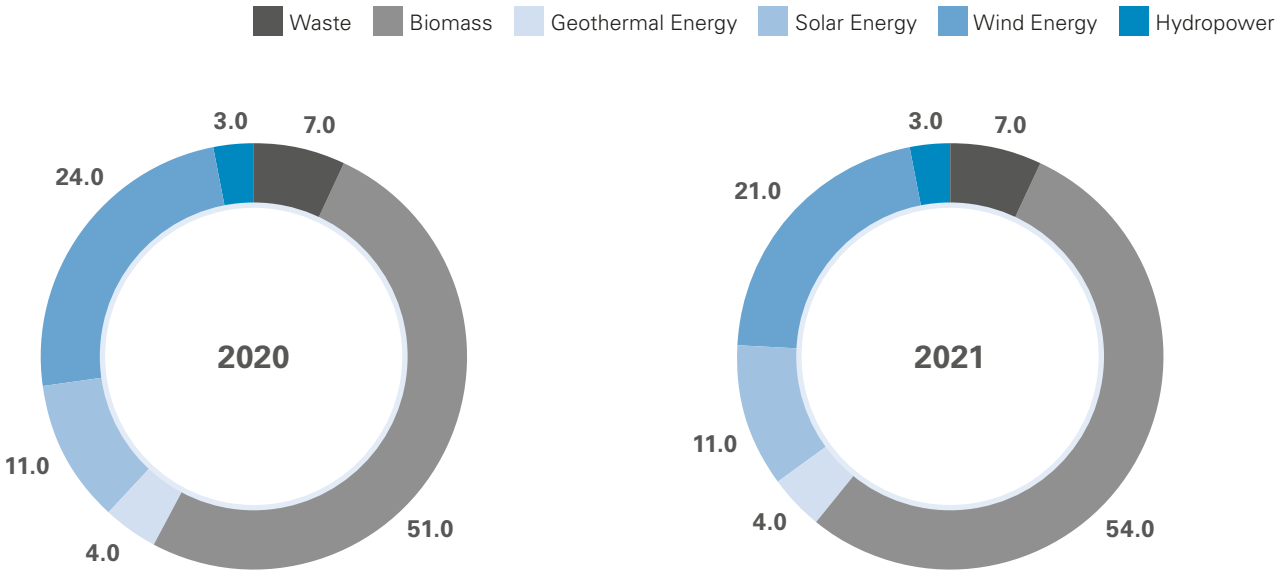
Structure of Renewable Energy Sources in Germany between 2020 and 2021

Shares in Total Renewable Energy in %



All values are preliminary (last update: February 2022)

Source: AGEE-Stat

Energy Efficiency in Germany

Already within the scope of Germany's national sustainability 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 Concept 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 light of a 2.7 % increase in the price-adjusted macroeconomic performance and an associated, even somewhat more significant increase in energy consumption by 3.1 %, Germany's macroeconomic energy productivity with regard to the original values ascertained for primary energy consumption deteriorated by approximately 0.4 % in 2021 when compared to the previous year. Temperature and stock level adjusted, however, it improved slightly when compared to the previous year; namely, with a plus of 0.3 %. In the current reporting year 2021, this improvement of the (adjusted) macroeconomic energy productivity was, thus, noticeably below the level exhibited by the long-term trend (between 1990

Table 15

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Macroeconomic Energy Productivity in Germany between 1990 and 2021

	Unit	1990	2018	2019	2020	2021[1]	Average Annual Change in %	
							2020 to 2021	1990 to 2021
Gross Domestic Product (Price Adjusted: Reference Year 2015)	Concatenated Volume Figures in Billion Euros	1,959.1	3,211.1	3,245.0	3,096.7	3,179.9	2.7	1.6
Population [2]	1,000	79.8	82.9	83.1	83.2	83.2	0.0	0.1
Primary Energy Consumption (Unadjusted)	Petajoules	14,905	13,129	12,805	11,895	12,265	3.1	-0.6
Primary Energy Consumption (Adjusted) [4]	Petajoules	15,051	13,408	12,951	12,078	12,366	2.4	-0.6
Total Electricity Consumption [3]	Billion kWh	550.7	591.8	575.2	555.3	568.8	2.4	0.1
Energy Productivity (Unadjusted)	Euros/GJ	131.4	244.6	253.4	260.3	259.3	-0.4	2.2
Energy Productivity (Adjusted) [4]	Euros/GJ	130.2	239.5	250.6	256.4	257.1	0.3	2.2
Electricity Productivity	Euros/kWh	3.6	5.4	5.6	5.6	5.6	0.2	1.5

1) Some figures are estimates
2) Average population based on the 2011 census (result as per the closing date May 9, 2011: 80,219,695 inhabitants)
3) Including pump current generation
4) Values adjusted for temperature, mineral oil adjusted for inventory

Discrepancies in the totals are due to rounding off

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

Figure 16

AGEB
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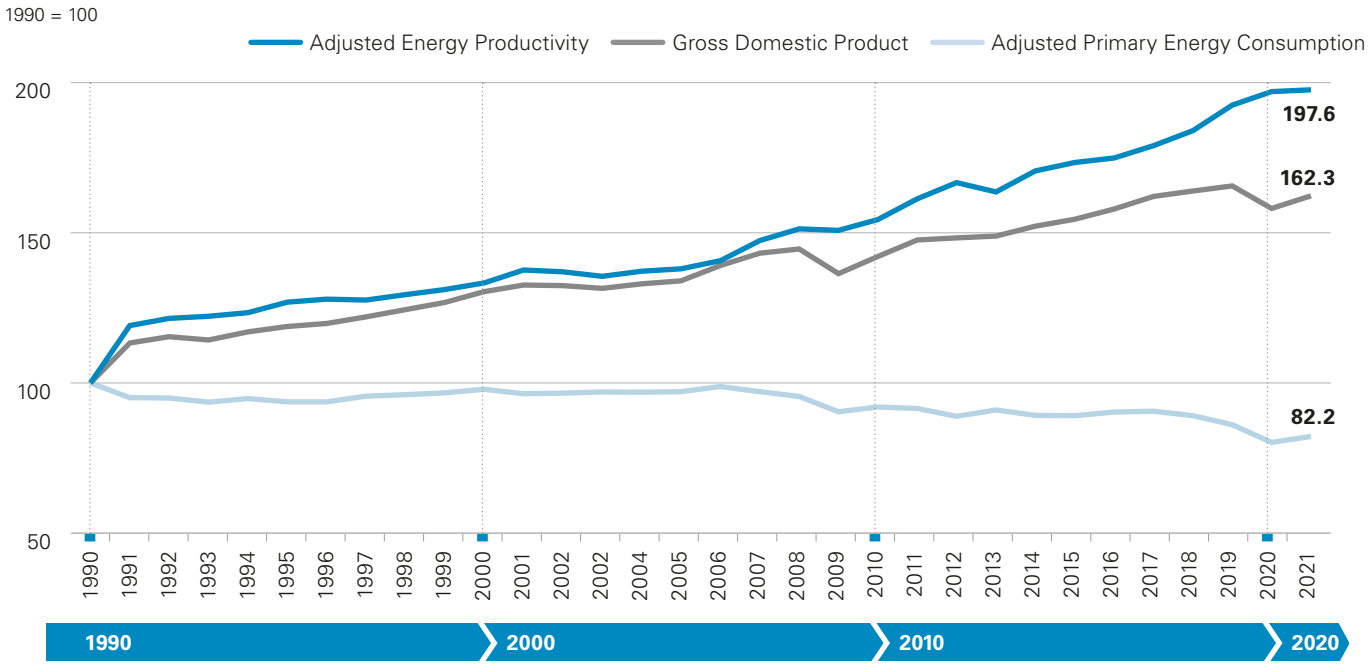
Gross Domestic Product, Primary Energy Consumption, and Energy Productivity in Germany between 1990 and 2021



All values for 2021 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)

and 2021: About 2.2 % p.a.). All told, the decoupling process between the overall economic development and energy consumption (related to the adjusted values) continued even further in 2021; albeit at a slower pace (please see Table 15 and Figure 16).

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. 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: https://ag-energiebilanzen.de/wp-content/uploads/2020/05/ageb_jahresbericht2019_20200505_engl_web.pdf.

In addition, the highly aggregated focus on macroeconomic energy efficiency prevents a clear view of many other factors which characterize energy consumption. With 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 17). Towards this end, the long-term changes between 2021 and 1990 aptly demonstrate the considerable influence of the decreased energy intensity (in other words,

Figure 17

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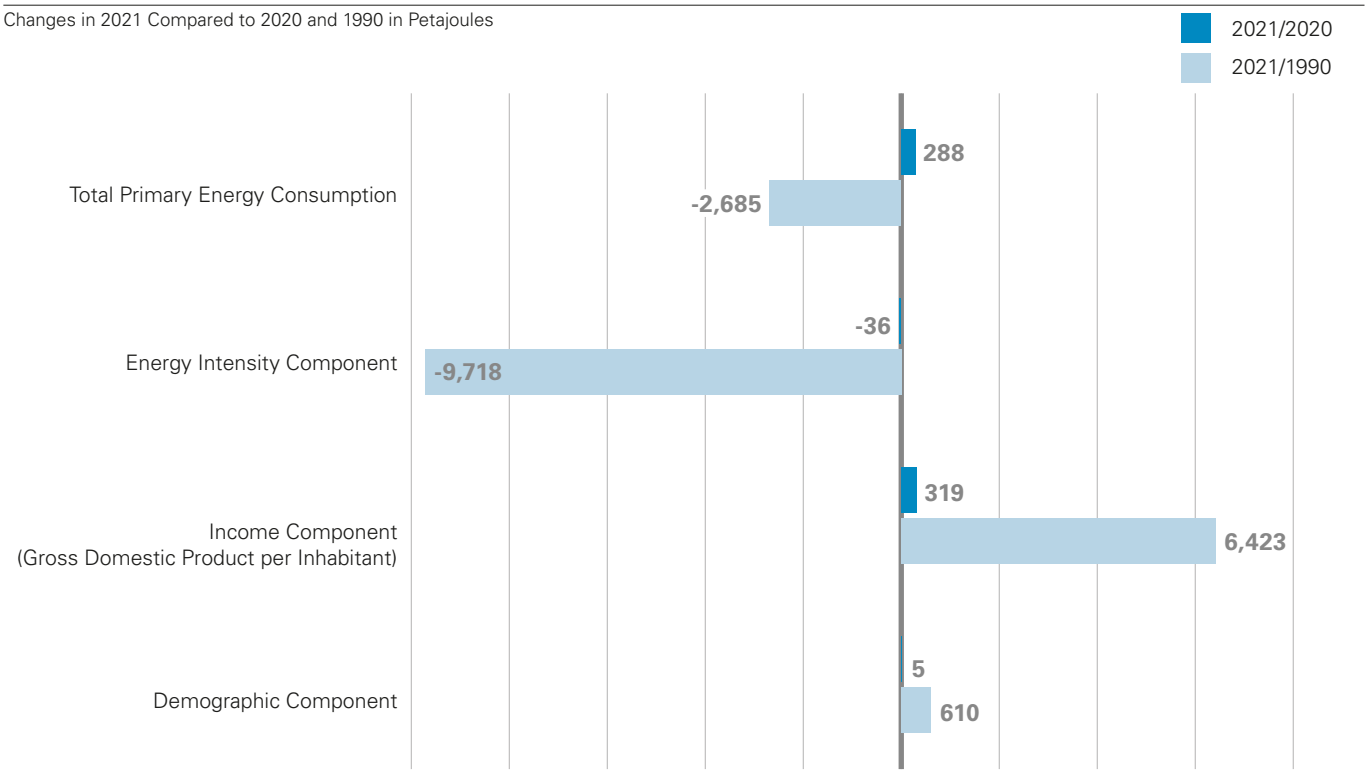
Contributions of Diverse Influencing Factors to the Changes in the Adjusted Primary Energy Consumption in Germany

Changes in 2021 Compared to 2020 and 1990 in Petajoules



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

the improvement of energy efficiency) on the reduction of the (temperature-adjusted) primary energy consumption (-9,718 PJ). This way, it was possible to significantly overcompensate the consumption-enhancing effects of macroeconomic growth (+6,423 PJ) and the increase in population (+610 PJ). All told, the adjusted primary energy consumption decreased by 3,685 PJ between 1990 and 2021.

The correlations outlined above apply in a similar way to the short-term consideration of the changes between 2020 and 2021: Yet other than in a long-term comparison, it was now primarily the revitalized economic activity (+319 PJ) in the aftermath of the Covid-19 related economic downturn in 2020 which had a significant consumption-enhancing effect during the reporting year, whereas efficiency gains in the use of energy exerted only a relatively small influence on primary energy consumption (-36 PJ). The consumption-enhancing effect of the population component (+5 PJ altogether) was negligibly small, with the result that the (adjusted) primary energy consumption increased by 610 PJ (when compared to 2020).

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, 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 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 slightly; namely, by 0.2 % in 2021 (compared to 2020), which was due to the market-related significant increase in electricity consumption (by 2.4 % to 568.8 TWh) and due to a simultaneous increase in the economic growth that was even greater than before (+2.7 %). When taking the long-term period between 1990 and 2021 into account, the electricity productivity increased by an annual average of 1.5 %. Please note: The total energy productivity (adjusted) increased by 2.2 % p.a. over the same period of time (for more details on this topic, please see Table 15 as well as Figures 18 and 19).

The impact of select components (economic growth, population trend, and electricity productivity) on the changes in electricity consumption in Germany between 1990 and 2021 and/or 2020/2021 is illustrated in Figure 20, which concludes this section. The diagram shows that the increase in the total electricity consumption, which went up by 13.5 billion kWh in 2021 when compared to 2020, was primarily caused by consumption-enhancing effects of the economic growth (+14.7 billion kWh). Not surprisingly, the virtually stagnating population trend had no significant impulse on electricity consumption (+0.2 billion kWh). In contrast, higher electricity productivity (electricity intensity component) caused the macroeconomic consumption of electrical energy to decrease by 1.4 billion kWh.

Also when considering the entire period between 1990 and 2021, the long-term increase in electricity productivity did not result in an absolute reduction of the electricity consumption. On the contrary, gross electricity consumption increased in total by about 18 billion kWh between 1990 and 2021. The increase in the electricity productivity (-262 billion kWh) within the same period of time was the reason why it was possible to limit the above mentioned increase in gross electricity consumption (compared to 1990) to about 18 billion kWh despite the fact that there was a considerable increase in consumption due to the growing economy (+256 billion kWh) and demographic influencing factors (+24 billion kWh). Compared to 1990, electricity consumption actually increased by a total of 3.3 %; it was, thus, (after the Covid-19 related low in 2020) still about 1.1 % (which equals 6.4 billion kWh) below the level of 2019.

Figure 18

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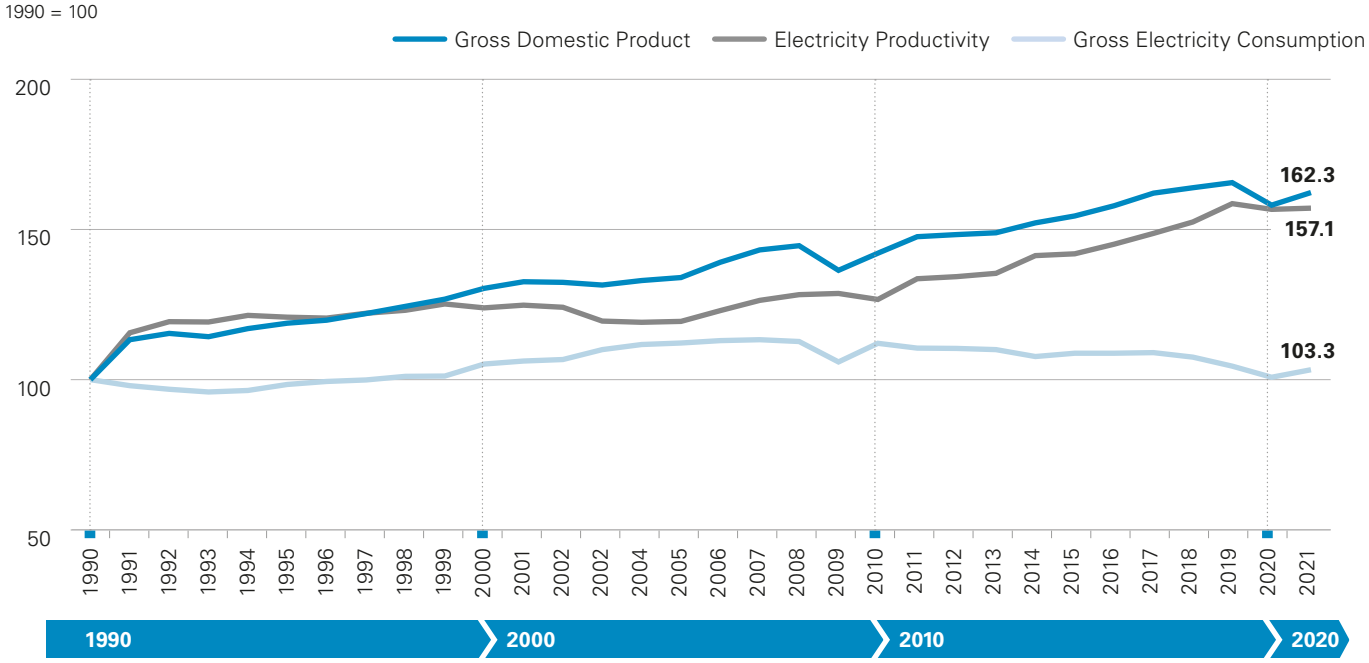
Gross Domestic Product[1], Gross Electricity Consumption, and Macroeconomic Electricity Productivity[2] in Germany between 1990 and 2021



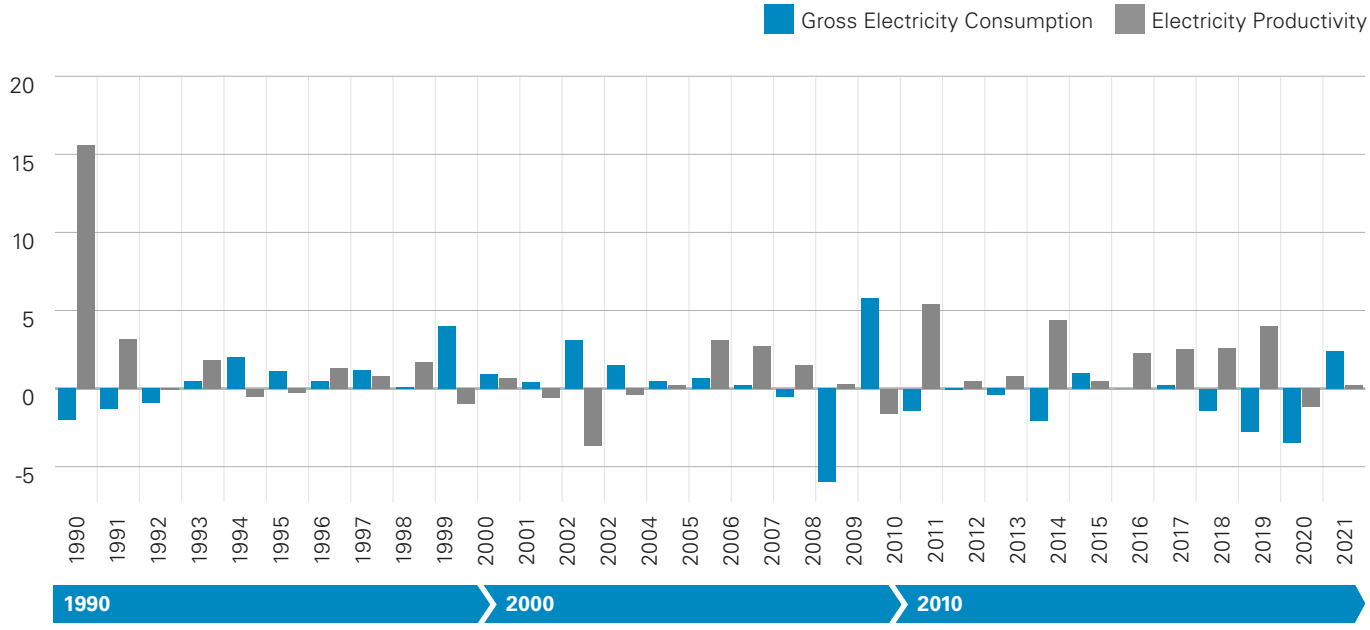
All values for 2021 provisional
1) Price-adjusted
2) Gross domestic product per unit of gross electricity consumption

Sources: Working Group on Energy Balances (AGEB); 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 19

AGEB
AG Energiebilanzen e.V.

Changes in Gross Electricity Consumption and Electricity Productivity between 1991 and 2021



All values for 2021 provisional

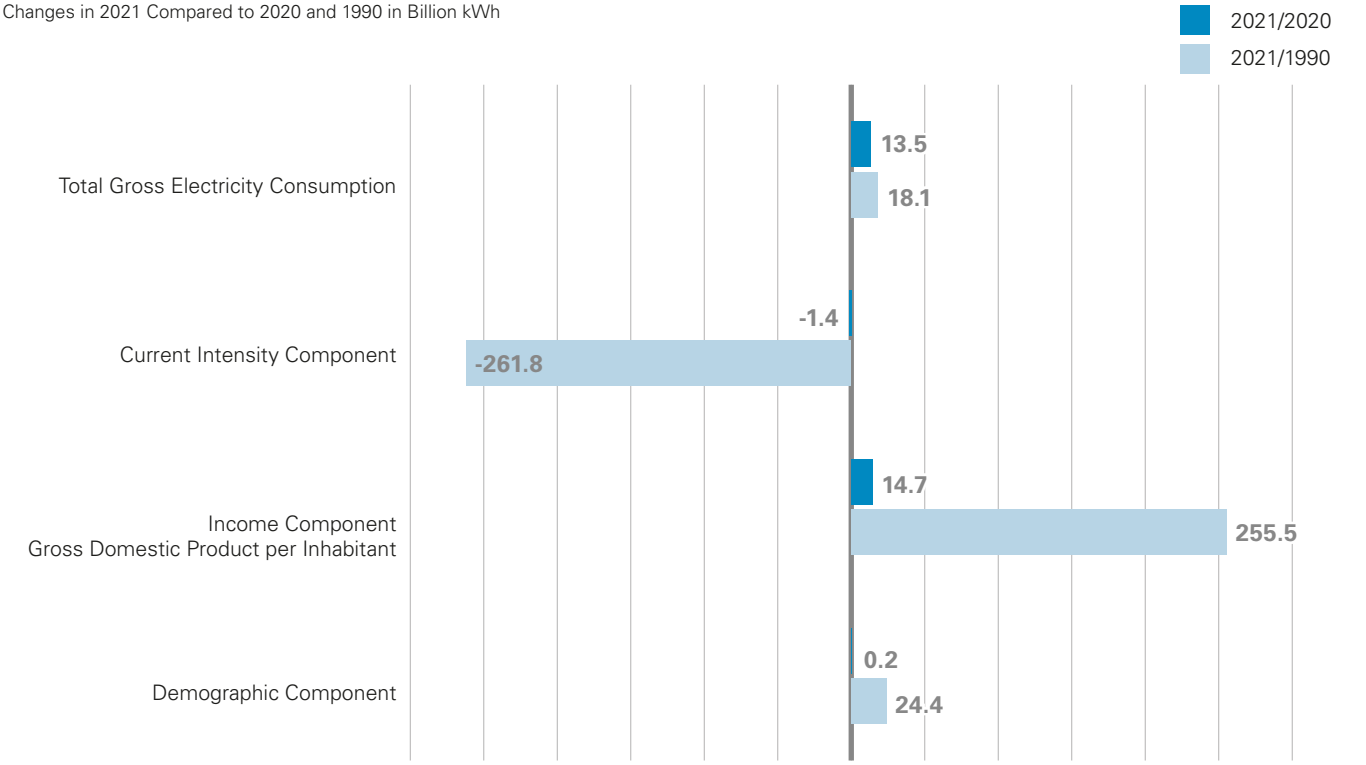
Sources: Federal Statistical Office (Destatis); German Association of Energy and Water Industries (BDEW); Working Group on Energy Balances (AGEB)

Figure 20

AGEB
AG Energiebilanzen e.V.

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

Changes in 2021 Compared to 2020 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)

CO_2 Emissions

According to initial calculations, power generation and heat generation plants supplying the general public emitted about 216 million tons of CO_2 in 2021. Compared to 2020, this equals an increase in CO_2 emissions of around 16 %. The largest share of this increase in emissions in 2021 occurred in electricity production (electric power generated in pure condensation units and cogeneration plants) which increased its carbon dioxide emissions by almost 18 million tons while the generation of wind power was low. The production of district heat and the associated amounts of CO_2 emissions also recorded a substantial increase in 2021 (primarily because of the significantly cooler weather).

When it comes to power generation in the plants of mining facilities and the manufacturing industry, despite continuous efficiency improvements and substitutions of energy carriers, the production of electricity and heat went up between 2020 and 2021 which was primarily due to the overall economic situation. According to initial estimates, CO_2 emissions just in this segment alone ought to have exceeded the previous year's level by almost 2 million tons (about 7.5 %) in 2021.

From the preliminary data and estimates compiled in this report on the energy consumption trend in 2021, the following general assumptions can be made for the development of energy-related carbon dioxide emissions in other sectors, primarily those related to final energy consumption:

- In 2021, the significant increase in fuel sales (gasoline, diesel fuels, and aviation fuels) as well as shifts within the sales mix are likely to result in an increase in CO_2 emissions of about 3.4 million tons (and/or +2.2 % when compared to 2020) in the transportation sector.[22] By far the largest contribution to this increase in emissions was the recovery of the aviation sector and the associated growth in air traffic in this segment (due to the economic recovery and the larger number of tourist trips, the increasing freedom to travel again because of gradually overcoming and recovering from the Covid-19 pandemic, for example, through vaccinations, etc.). Just in the aviation sector alone, carbon dioxide emissions are likely to have increased by 23.5 % when compared to 2020.

- In the manufacturing industry (without electricity production in industrial power plants and without the energy used in refineries, blast furnaces, and coking plants), however, it is anticipated that (directly) energy-related CO_2 emissions are likely to have increased by more than 3.7 million tons in 2021 when compared to the previous year due to the growth in industrial production. Just the increased input of hard coals and hard coal coke as well as other fossil fuels in crude steel production alone, which in total grew by more than 5.3 million tons to almost 41 million tons (+14.9 %) in 2021 when compared to the previous year, ought to have burdened the industry's emissions balance by an additional 3.7 million tons (without the contribution of blast furnaces which in the energy balance are attributed to the conversion sector) in the reporting year. If one were to add the emissions of blast furnaces, then energy-related CO_2 emissions went up by a roughly calculated more than 5.6 million tons when compared to 2020. For other economic branches as well, for example, the manufacture of glass, glassware, and ceramics; the production of paper, cardboard, and paper products; or the manufacture of food and tobacco products, an increase in emissions is anticipated for the reporting year 2021. Yet in some sectors which had to struggle particularly hard with supply shortages in the delivery of precursors and primary products in 2021 such as, for example, the manufacture of motor vehicles, trailers, and semi-trailers or the manufacture of machinery and equipment, a production-related decline in CO_2 emissions is anticipated.

22) It must be noted in this context that the sales volumes for diesel fuel and gasoline deliver only an incomplete picture of the effects of "fuel tourism" which seeks to benefit from differences in fuel prices in regions close to national borders (fuel volumes with which foreigners refuel their tanks in Germany and which are, if applicable, used abroad are recorded therein whereas the sales volumes do not include those fuel volumes which are refueled abroad and used in Germany); consequently, the requisite calculations of CO_2 emissions in the transportation sector may also be distorted. All the more so as the aforementioned "fuel tourism" has moved in the opposite direction during the past few years due to the substantial increase in the taxes on fuels in some neighboring countries (for example, France, Belgium, the Netherlands).

- Due to the slightly cooler weather when compared to the previous year, a higher consumption of energy and an associated corresponding emissions trend would have been expected in the private households sector for the heating of residential homes in 2021. In fact, though, the total energy consumption of private households based on the calculations for the early estimate of the energy balance increased only slightly in 2021 (+0.5 %). According to the available (still preliminary) data, emissions of private households could have decreased by approximately 7 % due to substitutions in the energy mix and despite the moderate increase in consumption. When interpreting these findings, however, it must be noted that the energy balance, for example, in the private households sector only records the sold quantities (and not the actual consumption) of storable energy carriers. In 2021, private households substantially reduced their fuel stocks due to significantly increased prices for light fuel oil during the second half of the year. Consequently, in particular those quantities of fuel oil were consumed which are not included in the sales figure of the energy balance. According to our estimates, those withdrawals from stocks which are relevant for consumption and emissions amounted to about 103 PJ (i. e. approximately 7.5 million tons of CO_2) in 2021. If one were to adjust the balance data just for fuel oil alone by this estimated withdrawal from the stocks, then the CO_2 emissions would not have decreased (as the original balance data suggest at first glance); but instead, they would have actually increased by about 1.2 million tons (which equals 1.3 %) when compared to the previous year.[23)]

- Finally, an increase in emissions (2021: +123,000 tons, calculated on the basis of energy balance figures) is to be anticipated also for the trade, commerce, and service sector. Based on consumption figures for the use of light fuel oil, a significant increase in CO_2 emissions of approximately 0.9 million tons (which translates into 2 %) compared to the previous year can be ascertained for this economic branch. The emissions reduction in the trade, commerce, and service sector referred to hereinabove is primarily due to the fact that the economic performance, related to the price-adjusted gross value creation, grew by approximately 2.5 % in 2021 after having decreased by 3.3 % in the previous year as a consequence of the lockdown measures which to a large extent had affected the service sectors and the retail trade.

By differentiating between the individual sectors according to the German Federal Climate Protection Act (KSG), the previous year's forecast published by the Federal Environment Agency (UBA) estimated the CO_2 emissions for 2020 at about 644 million tons, of which approximately 595 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.[24)] Thus, energy-related CO_2 emissions had actually decreased by about 9.8 % in 2020 (primarily as a consequence of the sectoral and macroeconomic effects of measures that had been undertaken to fight and counterbalance 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 an increase in energy-related CO_2 emissions can be anticipated once again for the year 2021.[25)] Just on the basis of the estimated energy balance data for the reporting year 2021 alone, it is likely to be expected that energy-related CO_2 emissions actually increased by a rate of 2.8 % (this would equal an increase in CO_2 emissions between 17 million tons and 18 million tons when compared to the previous year). If one were to use "real" consumption figures for the calculation of energy-related CO_2 emissions – as already mentioned above – instead of the original energy balance data particularly when it comes to sales of light fuel oil to private

23) For other storable energy carriers (such as liquid gas, wood, or coal), which are also used by private households, a similar estimate of changes in stocks is currently impossible due to data and/or information gaps.

24) For more details, please see the Federal Environmental Agency (UBA); previous year's estimate of German greenhouse gas emissions for the year 2020; last update: 2021-03-15. Internet: https://www.umweltbundesamt.de/dokument/emissionsuebersichten-in-den-sektoren-des (download date: 2022-02-17; currently only available in German).

25) When considered in detail, the calculations on the development of energy-related CO_2 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.
Most recent data on the development of greenhouse gas emissions were published on March 15, 2022, after the editorial deadline of this report. These data can be downloaded from the internet under the following link: https://www.umweltbundesamt.de/themen/klima-energie/treibhausgasemissionen (download date: 2022-03-16; currently only available in German).

households and the trade, commerce, and service sector (hence, if one were to adjust the sales volumes indicated in the energy balance in these sectors by the respective changes in stocks and/or inventories), then this would produce a different result: According to this (adjusted) calculation, energy-related CO_2 emissions increased by approximately 5.3 % and correspondingly by about 31 million tons in 2021 (when compared to the previous year).

In this context, a continuing problem should once again be highlighted which from an emission perspective is associated with the fact that those emissions which originate from domestic electricity production and are accompanied by the high export surplus are to be allocated to Germany according to the territorial principle while conversely the emissions that would most likely be associated with the generation of electricity in those supplied countries are displaced which consequently results in lower emissions in those countries. But it is questionable what the emissions balance will reveal when viewed from an international perspective. This depends decisively on the specific emissions of the export flow in relation to the specific emissions of the electricity displaced in the individual recipient country.

Summary of the Trends

According to preliminary calculations made by the Arbeitsgemeinschaft Energiebilanzen (AG Energiebilanzen) – Working Group on Energy Balances (Energy Balances Group), energy consumption in Germany increased by 3.1 % to 12,265 petajoules (PJ), which translates into 418.5 million tons of hard coal equivalents (Mtce), in 2021. Despite the increased consumption outlined above, primary energy consumption is still about 4.2 % below the level of 2019.

Responsible for the increased energy consumption were, above all, economic recovery processes (after the pandemic-related weaker economy of the previous year, the price-adjusted gross domestic product grew by 2.7 % in 2021) as well as the cooler outdoor temperatures. However, the development of the energy prices in 2021, especially during the second half of the year, led to substantial incentives to reduce energy consumption. After the global market prices for oil, natural gas, and hard coal had fallen significantly over the course of the year 2020 which was also essentially due to pandemic-related weaker demand, the prices increased noticeably in magnitudes ranging between 67 % and 139 % in 2021. Although the appreciated value of the Euro compared to the US Dollar helped cushion the increase slightly, the global market price trend had a direct impact on consumer prices; in particular, for heating oil and fuels. Depending on the individual consumer groups (for example, private households as well as the trade, commerce, and service sector), consumer prices for grid-bound energy carriers (natural gas, electric power, district heat) were, though, not yet fully affected by this development on the procurement markets due to long-term supply contracts. Compared to 2020, prices for end consumers also increased as a result of raising the value added tax back to 19 % as well as introducing the CO_2 pricing system for fossil fuels in the transportation and heating markets.

The drastic increase in consumer prices for light fuel oil meant that private and commercial consumers delayed the filling of their fuel oil tanks and (also due to the cooler weather) substantially reduced their stockpiles over the course of the year 2021 (it is estimated that private households and enterprises of the trade, commerce, and service sector consumed 113 PJ of light fuel oil from the existing stocks in 2021).

Without the influence of the weather (and without considering the changes in the stockpiles of light fuel oil), primary energy consumption in 2021 would have been about 2.4 % above the level of 2020.

As measured by the original values, the macroeconomic energy productivity decreased only slightly in 2021 (according to preliminary calculations). With a rate of -0.4 %, it dropped from € 260.3 GDP2005/GJ (2020) to € 259.3 GDP2005/GJ (2021). The average annual increase in the macroeconomic energy productivity between 1990 and 2021 is 2.2 %. Based on the temperature and inventory adjusted primary energy consumption, the macroeconomic energy productivity increased slightly in 2021 when compared to the previous year; namely, by 0.3 %.

A glance at the individual energy carriers reveals the following picture: The consumption (and/or sale) of mineral oil (-3.1 %) and renewables (-1.2 %) decreased as the only energy sources in 2021. In contrast, the consumption in particular of lignite (+17.7 %) and hard coal (+16.5 %) increased significantly. Nuclear energy and natural gas also exhibited increased shares in a growing market in 2021 and went up by 7.4 % and 4.9 % respectively.

With a share of 32.3 % in primary energy consumption, mineral oil continued to be the most important energy carrier also in 2021, followed by natural gas which managed to increase its share to 26.8 % (+0.4 percentage points when compared to 2020). Renewable energy carriers ranked third with a current share of 15.9 % (0.7 percentage points less than in 2020) in primary energy consumption, followed by lignite with 9.2 % (+1.1 percentage points) and hard coal with 8.5 % (+1 percentage point). The share of nuclear energy covering the primary energy consumption increased to 6.1 % in 2021.

When it comes to renewable energies, the changes diverged considerably in 2021 as well: While the primary energy consumption of wind energy (due to the lower wind yield when compared to the previous

year) decreased by 3.1 % in 2021, consumption from biomass (+2.2 %) and geothermal energy (+0.4 %) increased in 2021. The remaining renewable energies (geothermal energy, renewable waste, and solar energy) stagnated and/or recorded only minimal increases (between 0.1 % and 0.2 %).

Similar to primary energy consumption, gross electricity consumption also increased noticeably again in 2021 as a consequence of the economic recovery and/or gradually overcoming the negative economic repercussions of the Covid-19 crisis in 2020. However, the increase of 2.4 % to about 568.8 billion kWh was not as significant as had been the increase in the primary energy consumption as a whole. Compared to the previous year, the macroeconomic electricity productivity improved by +0.2 % in 2021 and increased to a value of € 5.59 per kWh. Overall, the performance of the improved macroeconomic energy productivity dropped again noticeably when compared to the average of the years between 1990 and 2021 (by approximately +1.5 % p. a.). This can be taken as evidence that the continuous improvement of power efficiency is increasingly reaching its technical limits and that the growing reliance on electric power often represents a strategy that uses the modernization of processes to cut back on fossil fuels.

Gross electricity production increased by about 2.4 % to approximately 588 billion kWh in 2021 and, thus, mirrored the development of gross electricity consumption (which increased by 2.4 % to 568.8 billion kWh). The structure of electricity production according to the individual energy carriers continued to change as well: While electricity production based on the use of hard coal (+27.7 %), lignite (+20.2 %), and nuclear energy (+7.4 %) rose, it dropped for renewable energy carriers by about 7 %. At the same time, electricity production based on natural gas decreased by 5.3 % in 2021 after having increased by 5.3 % (4.7 TWh) between 2019 and 2020.

All told, renewables were able to maintain their top position with a total production volume of about 233.6 billion kWh and a share of nearly 39.7 % in the power generation mix. Lignite was in second place with a share of 18.8 % and natural gas in third place with a share of 15.2 % in the electric power generation mix. Nuclear energy contributed about 11.8 % to the total electricity production and hard coal about 9.3 % in 2021. When it comes to gross electricity consumption, renewables accounted for a share of 41.1 % in 2021; in the previous year, this share had still amounted to approximately 45.2 %.

The surpluses in the exchange of electricity with foreign countries[26] hardly changed in 2021 when compared to the previous year (2021: Nearly 21 billion kWh; 2020: About 20.8 billion kWh). Particularly high export surpluses were recorded for the exchange with Switzerland (12.6 billion kWh), Poland (8.4 billion kWh), and Austria (8.3 billion kWh). Surpluses in the flow of electric power from abroad traditionally come from France; whereby the import surplus from this region decreased significantly from approximately 10 billion kWh (2020) to about 5.6 billion kWh in 2021.

At the moment, it is not yet possible to precisely ascertain the energy-related CO_2 emissions for 2021 on the sole basis of final statistical data. However, a rough estimate of the development of energy-related CO_2 emissions can be made on the basis of current estimates and preliminary data on the changes in primary energy consumption according to the respective CO_2 content of the individual energy sources that are referred to and edited in this report. In total, the overall structure of energy consumption shifted again noticeably in favor of fossil fuels in 2021.

Against this backdrop and while considering the increase in primary energy consumption, energy-related CO_2 emissions ought to have increased by about 2.8 % in 2021 according to rough calculations based on the estimated data from the energy balances. The largest surge in CO_2 emissions came from the increased use of lignite and hard coal for the generation of electric power and heat (+18 Mt of CO_2). Also in industry (without the conversion input of blast furnaces as well as the fuel input for the production of electricity in industrial power plants), CO_2 emissions increased by 3.7 Mt (which equals about 4.2 %), primarily due to the growth in production. In the transportation sector, emissions also increased significantly again, primarily due to the growth in aircraft movements (+3.4 Mt and/or 2.2 % when compared to 2020). In contrast, CO_2 emissions of the

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

private households and the trade, commerce, and service sectors dropped, on a purely mathematical basis, that is, on the basis of the estimated energy balance for 2021, by a total of 6.1 Mt.

For the interpretation of these findings, however, it should be kept in mind that the energy balance for Germany only records the sales volumes and not the quantities that were actually consumed. If one were to remove the (estimated) movements in the inventory of light fuel oil from the sales figures entered in the balance sheet, then this would translate, on the basis of what would then be the resultant "real" development in consumption, into an increase in CO_2 emissions by 11.6 Mt (+9.5 %). The increase is, among other things, due to the significantly colder weather conditions and/or the resultant higher energy consumption for heating residentially and commercially used rooms (the degree day figures went up by 13.9 % when compared to 2020) as well as the growth in the economic output of the trade, commerce, and service sector by about 2.6 % when compared to the previous year.

Corrected by the outlined inventory effects of light fuel oil, the energy-related CO_2 emissions (not weather-adjusted) would have increased by about 5.3 % in 2021 (this equals an emissions level of about 31 Mt of CO_2).