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# Energy Consumption

in Germany in 2018

# Significant Decline in Energy Consumption in Germany in 2018

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## Comprehensive Overview of the Trend

According to preliminary calculations made by the Arbeitsgemeinschaft Energiebilanzen (AG Energiebilanzen) – Working Group on Energy Balances (Energy Balances Group), energy consumption in Germany decreased by 3.5 % to 12,963 petajoules (PJ), which translates into 442.3 million tons of coal equivalents (Mtce), in 2018. Thus, energy consumption in Germany dropped to the lowest level since the early 1970s.

The decline in energy consumption in Germany was primarily due to increased prices for energy, the mild weather as well as improvements in energy efficiency. In light of the weakening economic development and the moderate growth in population, the usual consumption-enhancing effect of the factors economic climate and growth in population was actually not that relevant in 2018. Without the consumption-decreasing impact of the mild weather, consumption would have fallen only 2.4 % below the previous year's level.

As measured by the original values, the macroeconomic energy productivity improved considerably in 2018. With a rate of 5.2 %, it more than doubled when compared to the previous year (+2.5 %). Even the temperature-adjusted rate of 4.0 % in 2018 was still significantly above the long-term average of 2.0 %.

Except for renewable energy (+1.1 %), consumption of all other energy carriers declined more or less significantly. For example, the consumption of hard coals went down by 11.2 %, that of mineral oil by 5.0 %, and that of lignite by 2.9 %, followed by natural gas with a minus of 1.6 %. Electricity production from nuclear energy decreased slightly by 0.4 %.

With a share of 34.3 % in primary energy consumption, mineral oil continued to be the most important energy carrier; followed by natural gas which managed to increase its share to 23.7 %. Renewable energy carriers ranked third with a current share of 14.0 % – ahead of lignite with 11.3 % and hard coal with 10.0 %. The share of nuclear energy which was needed to cover primary energy consumption increased slightly to 6.4 % in 2018.

When it comes to renewables, the changes diverged considerably in 2018: While the primary energy consumption of biomass decreased slightly by 0.7 % and that of biogenic waste went down by a substantial one tenth, hydropower exhibited a drastic decline by a substantial 18 % which was due to the sustained drought in 2018. Conversely, the long duration of sunshine caused the use of solar energy (primarily PV) to increase significantly by a remarkable 16.5 %; at the same time, geothermal energy went up by 7.6 % and wind energy by 5.6 %.

Just like primary energy consumption, gross electricity consumption also went down in 2018; albeit the decline of 0.7 % to almost 595 billion kWh was significantly weaker. Compared to the previous year, the macroeconomic electricity productivity improved by 2.1 % in 2018, which was a substantial 70 % higher than the annual average of 1.2 % between 1990 and 2017.

With a reduction of nearly 1.2 % to about 646 billion kWh in 2018, gross electricity production decreased slightly stronger than gross electricity consumption. The structure of electricity production according to energy carriers exhibited a noticeable change: While electricity production based on the use of hard coal (-10.4 %), natural gas (-3.9 %), and lignite (-1.9 %) declined, renewable energy carriers once again accounted for a strong plus of 4.3 %. With a total production volume of almost 226 billion kWh, which translates into a share of nearly 35 % in electricity production, renewables were able to further expand their top position to a significant extent ahead of lignite (22.5 %), natural gas and hard coal with 12.9 % each as well as nuclear energy (11.8 %). When it comes to electricity consumption, renewables accounted for a share of about 38 % in 2018.

In light of the fact that electricity production declined slightly stronger than electricity consumption, the surpluses obtained from the exchange of electricity with foreign countries[1] decreased to about 51 billion kWh (2017: 55 billion kWh). Particularly high export

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

surpluses were recorded for the exchange with the Netherlands (20.2 billion kWh), Austria (12.3 billion kWh), and Switzerland (12.2 billion kWh); while Poland (7.0 billion kWh) and Luxembourg (4.2 billion kWh) lagged considerably behind. Surpluses in the flow of electric power from abroad traditionally come from France; whereby the import surplus from France more than doubled from 4.1 billion kWh in 2017 to approximately 8.4 billion kWh in 2018. In contrast, the exchange with other countries was at a comparably low level.

At the moment, it is not yet possible to precisely ascertain the overall development of greenhouse gas emissions for the year 2018. However, a rough estimate of energy-related $CO_2$ emissions can be made on the basis of the changes in primary energy consumption according to the respective $CO_2$ content of the individual energy sources. Since the structure of energy consumption has shifted only slightly further towards emission-free (renewables and nuclear energy) and/or low-emission (natural gas) energy sources, energy-related $CO_2$ emissions are likely to have decreased somewhat stronger than primary energy consumption. As measured by the original values for primary energy consumption and according to a rough estimate, emissions are likely to have been reduced by around 4.8 %, which translates into about 34 million tons of $CO_2$; temperature-adjusted, the decline was slightly weaker with approximately 3.9 %, which translates into about 27 million tons of $CO_2$. Provided that there will neither be any material changes in process-related $CO_2$ emissions nor in any other greenhouse gases, Germany has not come much closer towards meeting its national objective of reducing greenhouse gas emissions by 40 % by 2020. In order to not miss the target for 2020, an annual reduction of about 55 million tons of $CO_2$ equivalents would be necessary for the current year 2019 and for 2020 respectively. From today's perspective, that is hardly possible.

**The Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat) – Working Group on Renewable Energies-Statistics participates in the creation of the Federal Republic of Germany's energy balances for renewables.**

Commencing with the balance year 2018, the Federal Ministry for Economic Affairs and Energy stipulated in conjunction with the renewed assignment of the Arbeitsgemeinschaft Energiebilanzen (AG Energiebilanzen) – Working Group on Energy Balances (Energy Balances Group) to prepare the energy balances for Germany that it incorporates the relevant data on renewables which are ascertained by the Working Group on Renewable Energies-Statistics (AGEE-Stat) under the auspices of the Federal Environment Agency (UBA) directly into the energy balances to be established by AGEB.

When it comes to renewables, AGEE-Stat had been an important data source for AGEB already in the past. The fact that original official statistics which could be adopted directly are generally not available for renewables prompts us to make individual estimates of the respective consumption values for whom it is often necessary to rely on specific in-house model calculations which have been specifically developed for this purpose. This applies to both AGEB and AGEE-Stat. It is therefore understandable that different approaches are taken by the model-based estimates of both institutions which do not necessarily lead to the same results.

Nevertheless, it seemed to be advisable to refer to a single data source in order to avoid any divergences which would be hard to explain to the public. When it comes to renewables, AGEE-Stat will, thus, be responsible for the respective data in the energy balance as well as in the requisite derivable evaluations starting with the balance year 2018. This already applies to the tabular information on renewable energy carriers included in this energy report.

# Total Primary Energy Consumption

In 2018, primary energy consumption in Germany amounted to a total of 12,963 PJ or 442.3 Mtce; compared to the previous year, this equaled a decrease of 3.5 % which translates into 477 PJ/16.3 Mtce (please see Table 1).

Table 1

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**Primary Energy Consumption in Germany in 2017 and 2018** [1)]

| Energy Carrier | 2017 | 2018 | 2017 | 2018 | Changes in 2018 compared to 2017 | | | Proportions in % | |
|---|---|---|---|---|---|---|---|---|---|
| | Petajoules (PJ) | | Million Tons of Coal Equivalents (Mtce) | | PJ | Mtce | % | 2017 | 2018 |
| Mineral Oil | 4,675 | 4,443 | 159.5 | 151.6 | -232 | -7.9 | -5.0 | 34.8 | 34.3 |
| Natural Gas | 3,121 | 3,071 | 106.5 | 104.8 | -50 | -1.7 | -1.6 | 23.2 | 23.7 |
| Hard Coal | 1,465 | 1,301 | 50.0 | 44.4 | -164 | -5.6 | -11.2 | 10.9 | 10.0 |
| Lignite | 1,508 | 1,465 | 51.5 | 50.0 | -43 | -1.5 | -2.9 | 11.2 | 11.3 |
| Nuclear Energy | 833 | 829 | 28.4 | 28.3 | -3 | -0.1 | -0.4 | 6.2 | 6.4 |
| Renewable Energy | 1,790 | 1,809 | 61.1 | 61.7 | 19 | 0.7 | 1.1 | 13.3 | 14.0 |
| Electricity Exchange Balance | -198 | -184 | -6.8 | -6.3 | 14 | 0.5 | - | -1.5 | -1.4 |
| Other | 246 | 229 | 8.4 | 7.8 | -17 | -0.6 | -6.9 | 1.8 | 1.8 |
| **Total** | **13,440** | **12,963** | **458.6** | **442.3** | **-477** | **-16.3** | **-3.5** | **100.0** | **100.0** |

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

*Source: Working Group on Energy Balances (AGEB), AGEEStat (for renewables)*

The decrease was primarily due to the mild weather as well as to improvements in energy efficiency. As measured by the degree day figures (averaged over 16 measurement stations), 2018 was about 7.5 % warmer than the previous year and 12.3 % warmer than the long-term average (please see Figure 1). In light of the weakening economic development and the moderate growth in population, the usual consumption-enhancing effect of the factors economic climate and growth in population was actually not that relevant in 2018.

If one merely considers the impact of the milder temperatures on the changes in primary energy consumption and if one were to assume temperatures similar to the long-term average, then the primary energy consumption, with all other parameters remaining unchanged, would not have decreased by 3.5 %, but "only" by 2.4 %. Thus, the temperature effect had a different impact on the individual energy sources (please see Figure 2).

As a general rule, the temperature-adjusted changes when compared to the changes in the original values depend on the respective temperature-related shares of energy consumption in the respective energy carrier. Temperature-adjusted declines in energy consumption in comparably warmer years are generally weaker than changes in the original values; accordingly, in colder years the increases in temperature-adjusted values are lower than those in the original values. This becomes also apparent from the different spreads of the energy carriers depicted in Figure 2.

Adjustment methods are important for any proper valuation of changes in the observable characteristics. With regard to the changes in energy consumption, it is without a doubt of utmost significance to take the influence of the weather into account. Since data from the energy balance sheet are primarily designed to ascertain the energy **consumption** related to a

Figure 1

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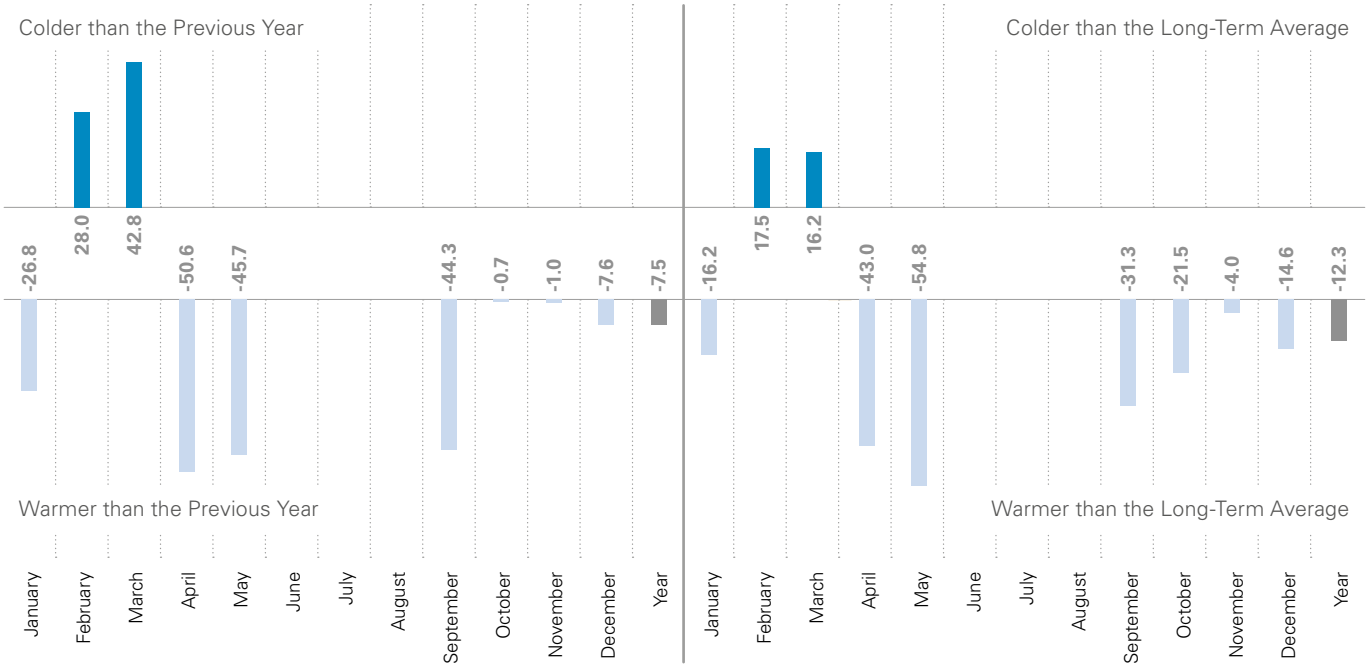
## Monthly Degree Day Figures in Germany in 2018 (16 Measurement Stations)

Changes in 2018 compared to the previous year and to the long-term average (1980-2017) in %.
Due to their limited informative value, the months of July and August are not included.




*Source: Germany's National Meteorological Service (DWD)*

Figure 2

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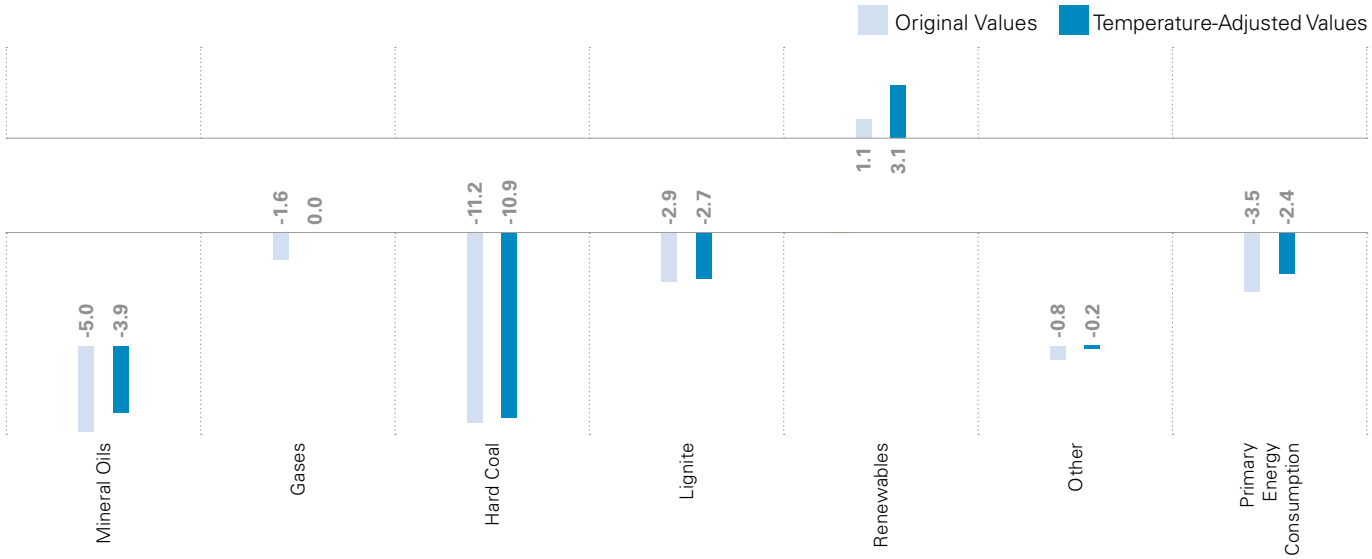
## Primary Energy Consumption in Germany According to Energy Sources

Changes between 2018 and 2017 in %




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

specific period of time, changes in the stockpiling[2] of the individual energy carriers should not be neglected as well. This applies particularly to storable fuels (coals and mineral oil products). Especially when it comes to providing information about mineral oil consumption, it needs to be kept in mind that the original values only include sales figures. Hence, the actual consumption may deviate from these sales figures by the respective changes in stockpiling. Yet these inventory changes are statistically recorded only for the energy sector and the manufacturing industry where they can be incorporated into the requisite consumption calculation. This is not the case for private households as well as the trade, commerce, and service sector. This applies, above all, to light fuel oil. In the past, the actual energy consumption in these two sectors could only be estimated – albeit in a general manner – on the basis of surveys conducted on the individual fueling behavior and the resultant changes in the refueling rate. However, these surveys are no longer available. That is why this report must currently forego an estimate of changes in stockpiling. Consequently, the following analyses will only refer to temperature-adjusted values. It should be pointed out in this context that some uncertainties will, thus, remain.

The economic development has also a substantial impact on the changes in energy consumption. In 2018, however, the consumption-enhancing effect was quite limited. For example, the price-adjusted gross domestic product increased by 1.5 % in 2018 which is quite low when compared to the previous year; while the manufacturing industry with +1.2 % and the producing industry with +0.9 % exhibited an even weaker production growth (please see Figure 3).

Figure 3 provides an overview of the annual rates of change in the production indices for 12 key economic branches of the manufacturing industry between 2015 and 2018:

Figure 2

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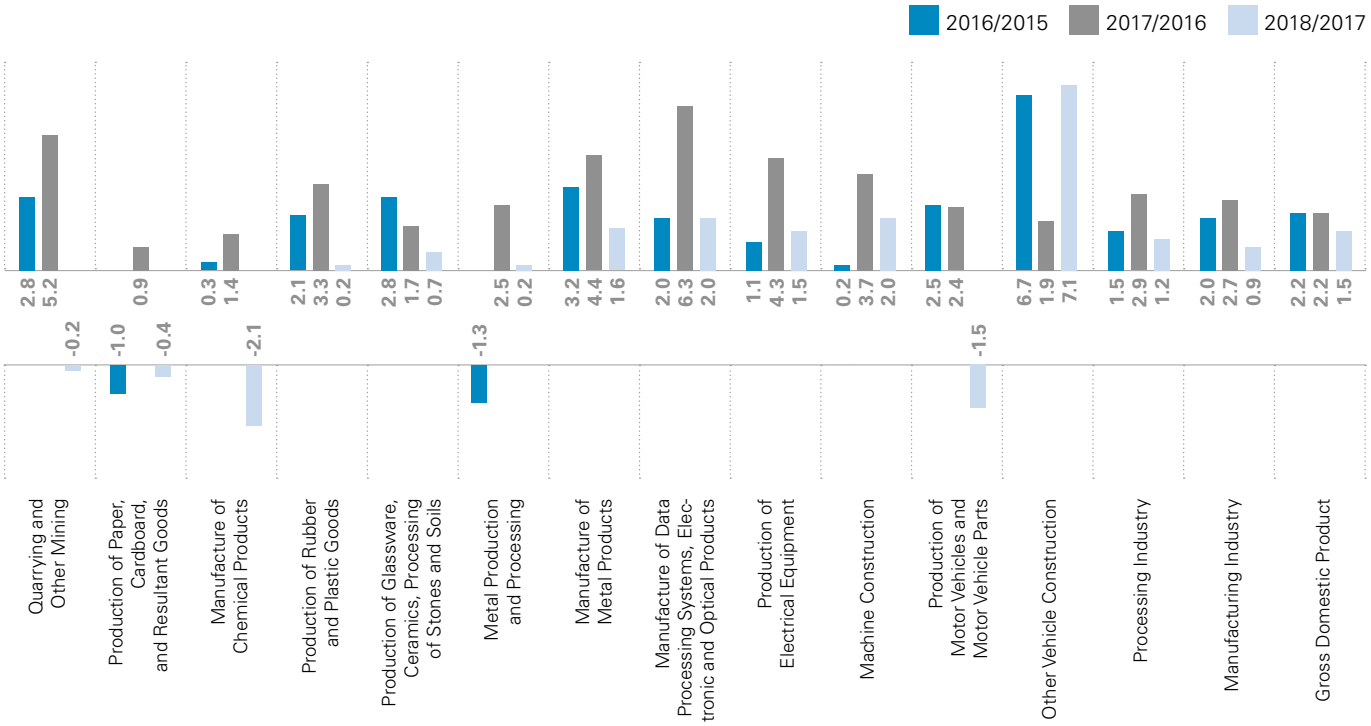
**Production Index in Germany's Manufacturing Industry between 2015 and 2018**

Changes Compared to the Previous Year in %




*Source: Federal Statistical Office (Destatis)*

2 *It should, however, be noted in this context that the assignment to establish the energy balance sheets for the years 2018 to 2020 also includes the development of an individual model that is designed to properly assess the changes in stockpiling in those areas which are not recorded officially. The respective methods were already developed within the scope of the Federal Ministry for Economic Affairs and Energy (BMWi)'s survey "Implementing a Procedure for the Periodic and Current Ascertainment of the Energy Consumption in Areas Not Recorded by Official Statistics;" and they are to be used within the scope of the energy balance activities in the future.*

- In 2018, 4 of these economic branches exhibited a decline in production. These branches included the production of motor vehicles (-1.5 %), the production of paper and cardboard (-0.4 %), and quarrying (-0.2 %) as well as, above all, the energy-intensive manufacture of chemical products with a minus of 2.1 %.

- A production growth of only 0.2 % each, which all told was significantly below the average, was recorded for the energy-intensive metal manufacture and metal machining and for the production of rubber and plastic goods as well as for the manufacture of glass, glassware, ceramics, and the processing of stones and soils (+0.7 %).

- An above average expansion in production was recorded for the less energy-intensive economic branches other vehicle construction with a plus of 7.1 %, machine construction (+2.0 %) as well as the manufacture of data processing systems, electronic and optical products (+2.0 %). The manufacture of metal products increased its production volume by 1.6 % and the production of electrical equipment by 1.5 %.

Against this backdrop of declining production growth and under the assumption that there will be further progress in energy efficiency, one cannot expect to see any further consumption-enhancing impulses.

The Federal Government's energy policy decisions on the continued support of renewable energy are also reflected in the changing structure of primary energy consumption. In 2018 as well, the most important energy carrier continued to be mineral oil with a share of 34.3 % even though its contribution decreased. It was followed by natural gas with a share that increased slightly to 23.7 % (2017: 23.2 %). Renewables were able to expand their third position to a share of 14.0 %. Despite slight declines in the primary energy consumption of lignite and nuclear energy, the share of these two energy carriers in the overall consumption still increased moderately to 11.3 % and 6.4 % respectively. Decreasing shares were recorded for hard coal (from 10.9 % to 10.0 %). The large surplus obtained from the physical flows of electric power to foreign countries caused primary energy consumption to decrease (by 1.4 percentage points).

Table 2

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**Macroeconomic Energy Productivity in Germany between 1990 and 2018**

| | Unit | 1990 [1] | 2000 | 2010 | 2015 | 2016 | 2017 [2] | 2018 [2] | Average Annual Change in % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 2017 to 2018 | 1990 to 2004 | 2004 to 2018 | 1990 to 2018 |
| Gross Domestic Product (price-adjusted; 2010 = 100) | Concatenated Volume Figures in Billion Euros | 1,959.1 | 2,358.7 | 2,580.1 | 2,807.6 | 2,870.6 | 2,932.5 | 2,975.6 | 1.5 | 1.5 | 1.5 | 1.5 |
| Population [3] | 1,000 | 79.5 | 81.5 | 80.3 | 81.7 | 82.3 | 82.7 | 82.9 | 0.3 | 0.2 | 0.1 | 0.2 |
| Primary Energy Consumption (unadjusted) | Petajoules | 14,905 | 14,401 | 14,217 | 13,262 | 13,491 | 13,440 | 12,963 | -3.5 | -0.2 | -0.8 | -0.5 |
| Primary Energy Consumption (temperature-adjusted) | Petajoules | 15,037 | 14,660 | 13,822 | 13,401 | 13,594 | 13,575 | 13,246 | -2.4 | -0.3 | -0.6 | -0.5 |
| Gross Electricity Consumption | Billion kWh | 550.7 | 579.6 | 615.9 | 596.3 | 597.0 | 598.8 | 594.9 | -0.7 | 0.7 | -0.2 | 0.3 |
| Energy Productivity (temperature-adjusted) | Euros/GJ | 131.4 | 163.8 | 181.5 | 211.7 | 212.8 | 218.2 | 229.5 | 5.2 | 1.6 | 2.4 | 2.0 |
| Energy Productivity (temperature and inventory adjusted) | Euros/GJ | 130.3 | 160.9 | 186.7 | 209.5 | 211.2 | 216.0 | 224.6 | 4.0 | 1.8 | 2.2 | 2.0 |
| Electricity Productivity | Euros/kWh | 3.6 | 4.1 | 4.2 | 4.7 | 4.8 | 4.9 | 5.0 | 2.1 | 0.7 | 1.7 | 1.2 |

*1) Some figures are estimates*
*2) Preliminary data*
*3) Average population based on the 2011 census (result as per the closing date May 9, 2011: 80,219,695 inhabitants)*

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

As measured by the original values and considering the 1.5 % increase in the macroeconomic performance in light of the significant decrease in primary energy consumption, the energy productivity of the German economy has improved considerably; namely, by 5.2 %. Even though its temperature-adjusted value was noticeably lower with a plus of 4.0 %, it still significantly exceeded the long-term trend (between 1990 and 2017: About 2 %). All told, this means that the decoupling of the macroeconomic trend and energy consumption continued to develop even stronger than before (please see Table 2 and Figure 4).

However, when assessing the development of energy productivity, it is essential to not only consider the temperature influence, but also a statistical effect which results from the fact that international conventions require the application of the so-called efficiency method for balancing the energy sources without considering the requisite calorific value. Since nuclear energy does not have any natural calorific value, the facilities' degree of efficiency is set at 33 % with the help of this method. Following the same logic, a degree of efficiency of 100 % is presumed for the renewable energies water, wind, and photovoltaics as well as for the electricity trade balance with foreign countries. Compared to the previously used so-called substitution method, this results in higher primary energy consumption for nuclear energy whereas the calculated primary energy consumption is lower for the aforementioned renewables and for the exchange of electricity. The greatest savings effect, thus, occurs if and when the electricity produced by nuclear power plants is replaced completely by renewable energy and/or electricity imports. Yet this effect was not very distinctive in 2018 because even though electricity production from wind, water, and solar radiation as well as the electricity trade balance increased by about 6 billion kWh, electricity production in nuclear power plants decreased only slightly when compared to the previous year.

Figure 4

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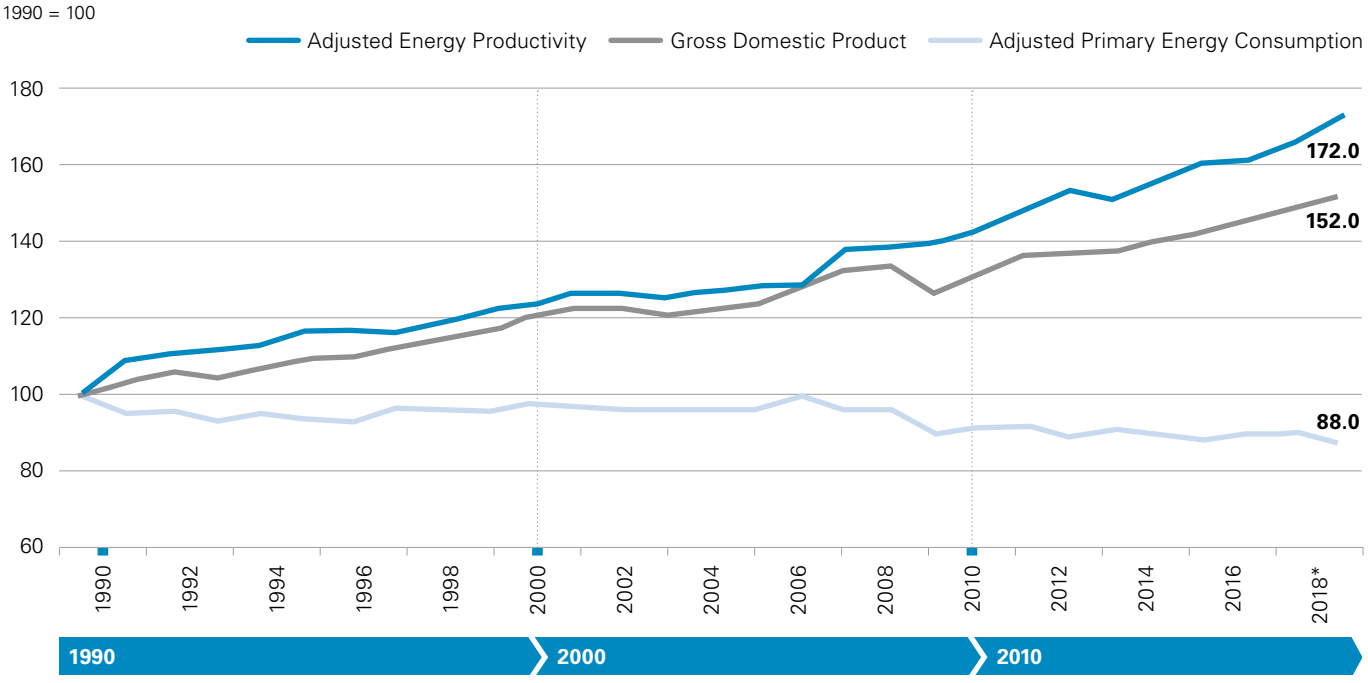
**Gross Domestic Product, Primary Energy Consumption, and Energy Productivity in Germany between 1990 and 2018**




*) Preliminary data

Sources: Federal Statistical Office (Destatis); BMWi/BMF, Working Group on Energy Balances (AGEB)

With component decomposition, it is possible to identify the key factors which influence the changes in the (adjusted) primary energy consumption (please see Figure 5). A comparison of the long-term changes between 1990 and 2018 aptly demonstrates the enormous influence of the decreased energy intensity (that is, the improvement in energy efficiency) on the reduction of the (temperature-adjusted) primary energy consumption (-7,934 PJ). This way, it was possible to significantly overcompensate the consumption-enhancing effect of the macroeconomic growth (+5,527 PJ) and the increase in population (+616 PJ). In a similar way, this applies to the short-term consideration of the changes between 2017 and 2018: But unlike a long-term comparison, it was above all the economic growth (+160 PJ) which now had only a relatively minor consumption-enhancing effect. While from a long-term perspective, the relationship between the reducing effect due to efficiency improvements and the consumption-enhancing effect of the economic growth was 1.4, the respective factor as seen from a short-term perspective amounted to 3.3. Hence, it was possible (by the way, unlike the previous year) to broadly counterbalance the consumption-enhancing effects of both the income and the population components by efficiency improvements, which ultimately resulted in a reduction of the (adjusted) primary energy consumption by 329 PJ.

Figure 5

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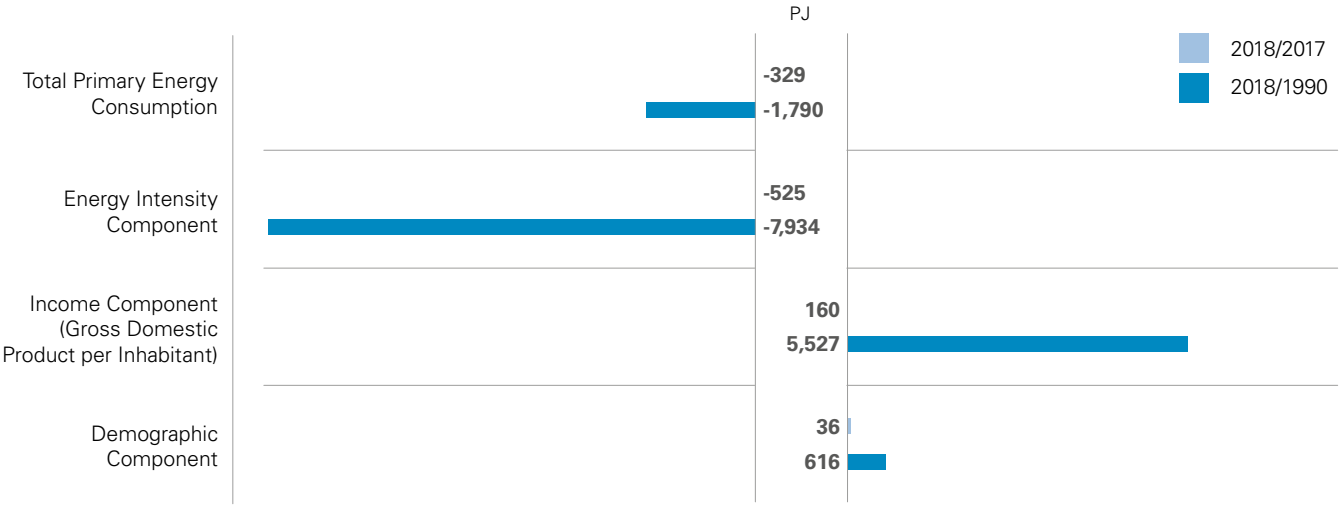
**Contributions of Diverse Influencing Factors to the Changes in the Adjusted Primary Energy Consumption in Germany**

Changes in 2018 Compared to 2017 and 1990 in Petajoules




*Sources: Federal Statistical Office (Destatis); Germany's National Meteorological Service (DWD)*

It must, however, be noted in the assessment of these results, that the changes in energy consumption may of course not only be influenced by the factors which are taken into account here (economic growth, population trend, and macroeconomic energy efficiency), but also, for example, by structural changes between individual energy consumption sectors that have a different energy intensity. Such structural effects are not included in the breakdown of the components which is assumed here for reasons of simplicity.

A glance at Germany's foreign trade balance for energy carriers is also of interest (please see Table 3). When it comes to all fossil fuels (which include the different coals, mineral oil, and natural gas), Germany is a considerable net importer. In 2018 as well, this did not change fundamentally. Significant changes, however, were recorded in the import prices of fossil fuels. As a result, these price increases caused the import calculation for coal, oil, and gas to increase substantially from 56.3 billion euros in 2017 by 11.6 billion euros, which equals an increase of about a fifth, to 67.9 billion euros in 2018. At the same time, oil imports went up by 21.3 % and natural gas imports by 28.0 %. In contrast, the import balance for coals decreased by 6.1 %. The export surplus for electrical energy remained virtually unchanged; while the (physical) export of electric power decreased noticeably at least over the entire year 2018 when compared to the previous year.

Table 3

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**Balance of Foreign Trade with Energy Carriers in Germany between 2010 and 2018**

| | 2010 | 2012 | 2015 | 2016 | 2017 | 2018 | 2017 ./. 2018 | |
|---|---|---|---|---|---|---|---|---|
| | Foreign Trade Balance (Imports ./. Exports) in Billion Euros | | | | | | | % |
| Coal, Coke, and Briquettes | 4.4 | 5.1 | 4.0 | 3.5 | 5.2 | 4.9 | -0.3 | -6.1 |
| Petroleum, Petroleum Products, and Related Goods | 49.4 | 68.0 | 38.0 | 29.0 | 36.1 | 43.7 | 7.7 | 21.3 |
| Gas [1)] | 20.7 | 27.1 | 20.5 | 16.1 | 15.0 | 19.2 | 4.2 | 28.0 |
| **Total Fossil Fuels** | **74.6** | **100.2** | **62.5** | **48.6** | **56.3** | **67.9** | **11.6** | **20.5** |
| Electric Power | -1.0 | -1.4 | -2.1 | -1.7 | -1.8 | -1.9 | 0.0 | 2.8 |
| **Total** | **73.5** | **98.8** | **60.4** | **46.9** | **54.5** | **66.0** | **11.5** | **21.1** |

*1) Including transit volumes*

*Source: Federal Statistical Office (Destatis), Special Series 7, Series 1 (values according to sections of the Standard International Trade Classification [SITC-Rev. 4])*

# Primary Energy Production in Germany

Except for renewables, domestic energy production decreased for all other energy carriers in 2018 which resulted in an overall decline of 2.8 % to 3,891 PJ or 132.8 Mtce (please see Table 4). The strongest decline was recorded for lignite with a quantitative minus of about 45 PJ (-2.9 %), for hard coal with -32 PJ (-29.7 %) as well as for natural gas with -29 PJ (-12.6 %). In contrast, domestic oil production decreased only slightly (-7 PJ; -7.1 %). Once again, renewable energy carriers managed to slightly expand their position as the most important indigenous energy source even ahead of lignite; their proportion of the total domestic production now amounts to about 46 %, followed by lignite with approximately 38 %. Both rank far ahead of natural gas, hard coals, and petroleum.

When taking into account the primary energy consumption in 2018, the proportion of domestic production increased slightly; namely, from 29.8 % in 2017 to now 30.0 % (please see Table 4).

Table 4

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**Primary Energy Production in Germany in 2017 and 2018**

| | Production | | | | Changes in 2018 Compared to 2017 | | Proportions | |
|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2017 | 2018 | | | 2017 | 2018 |
| | Petajoules (PJ) | | Million Tons of Coal Equivalents (Mtce) | | PJ | % | % | |
| Mineral Oil | 94 | 88 | 3.2 | 3.0 | -7 | -7.1 | 2.4 | 2.3 |
| Natural Gas, Petroleum Gas | 229 | 200 | 7.8 | 6.8 | -29 | -12.6 | 5.7 | 5.1 |
| Hard Coal | 108 | 76 | 3.7 | 2.6 | -32 | -29.7 | 2.7 | 2.0 |
| Lignite | 1,540 | 1,495 | 52.5 | 51.0 | -45 | -2.9 | 38.5 | 38.4 |
| Renewable Energy | 1,786 | 1,803 | 61.0 | 61.5 | 17 | 0.9 | 44.6 | 46.3 |
| Other Energy Carriers | 246 | 229 | 8.4 | 7.8 | -17 | -6.9 | 6.1 | 5.9 |
| **Total** | **4,004** | **3,891** | **136.6** | **132.8** | **-113** | **-2.8** | **100.0** | **100.0** |
| For information purposes: Proportion of Primary Energy Consumption | - | - | - | - | - | - | 29.8 | 30.0 |

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

*Sources: German Association of Energy and Water Industries (BDEW); The German Coal Industry's Statistical Office; German Hard Coal Association (GVSt); German Industrial Association of Oil and Gas Producers (WEG); Association of the German Petroleum Industry (MWV)*

## Mineral Oil

Compared to the previous year, the primary energy consumption of mineral oil in Germany was 5.0 % lower with 4,443 PJ (151.6 Mtce) in 2018. Except for aviation fuels, almost all products (domestic sales) recorded a minus. At the same time, consumption of the most important mineral oil products developed very differently from one another (please see Table 5). Probably as a reaction to the diesel scandal, for example, the consumption of diesel fuel dropped significantly (-3.1 %) after it had still been 2.1 % higher in 2017 than in 2016. Yet with 37.5 million tons, the consumption of diesel fuels continued to be twice as high as that of gasoline whose consumption decreased by 1.4 % in 2018. Even though the consumption of aviation fuels increased by 2.3 %, this increase was significantly weaker than in the previous year when it had actually gone up by 8.6 %. All told, the demand for fuels, which accounted for a share of almost 64 % in Germany's total oil consumption, was 1.8 % lower in 2018 than it had been in 2017.

With a substantial decrease of 16 %, the consumption of light fuel oil experienced a strong downward trend. Even though this was probably also due, to a great extent, to the warm weather, the higher efficiency of modern oil condensing heating systems, the conversion into heat pump systems or natural gas condensing systems probably played a role in this as well as did the sharp rise in prices.

At least, the prices for light fuel oil increased over the course of the year 2018 from € 62.27 per liter in January to € 84.51 per liter in November. It is unclear whether and to what extent these price increases led to a reduction in the fuel stocks rather than the purchase of fuel oil. If this had actually been the case, then the actual consumption would have been higher than the recorded sales volume. With a minus of 36.6 %, sales of heavy fuel oil experienced a particularly strong decline; here as well, one of the causes might have been the sharp increase in prices by almost 22 % when compared to the previous year. With a volume of only 2 million tons, however, the quantitative importance of heavy fuel oil is very limited[3].

With 5.6 %, refinery production decreased somewhat stronger than the entire oil consumption which exhibited a decline of 5.0 %. That is why refinery production from crude oil, which accounted for a share of almost 90 %, even decreased by 5.9 % whereas the processing of products decreased only by 3.8 %. In light of the declining production, the refining capacity of 103 million tons, which increased slightly in 2018, was actually only utilized at 85 % in 2018; in 2017, the degree of utilization had still amounted to 91 %. In part, this utilization below capacity is likely to be associated with the September 2018 refinery accident in the Bayernoil corporation's refinery in Vohburg (capacity: 10.3 million t/a).

*3 The drastic decline in the consumption of naphtha (-31.1 %) as shown in Table 5 needs to be seen against the backdrop of the fact that it is essentially a transfer required for methodological reasons in favor of the item "Miscellaneous Products" for which an increase of about 80 % has been entered.*

Table 5

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## Consumption and Volume of Mineral Oil in Germany in 2017 and 2018

| | | 2017 | 2018 [1] | Change |
|---|---|---|---|---|
| | | in Million Tons | in Million Tons | in % |
| **Total Consumption** | | **108.8** | **103.3** | **-5.0** |
| Self-Consumption and Losses [2] | | 6.1 | 5.7 | -6.6 |
| Domestic Consumption | | 102.7 | 97.6 | -5.5 |
| Proportion of: | Gasoline | 18.3 | 18.0 | -1.4 |
| | Diesel Fuel | 38.7 | 37.5 | -3.1 |
| | Aviation Fuels | 10.0 | 10.2 | 2.3 |
| | Fuel Oil, Light | 15.8 | 13.3 | -16.2 |
| | Fuel Oil, Heavy [3] | 3.1 | 2.0 | -36.6 |
| | Naphtha | 15.6 | 10.8 | -31.1 |
| | Liquid Gas | 4.3 | 3.6 | -17.2 |
| | Lubricants | 1.0 | 1.0 | -0.5 |
| | Other Products | 5.7 | 10.2 | 80.2 |
| | Recycling (to be deducted) | -6.5 | -5.5 | -16.2 |
| | Biofuels [4] (to be deducted) | -3.3 | -3.4 | 4.4 |
| **Total Volume** | | **102.7** | **97.6** | **-4.9** |
| Refinery Production | | 104.9 | 99.0 | -5.6 |
| Generated from: | Input of Crude Oil | 93.1 | 87.6 | -5.9 |
| | Input of Products | 11.8 | 11.3 | -3.8 |
| Foreign Trade Products (Balance) | | 17.6 | 16.8 | - |
| | Imports | 41.1 | 39.3 | -4.2 |
| | Exports | 23.5 | 22.6 | -4.1 |
| Compensation [Balance (Bunker, Differences)] | | -13.6 | -13.6 | - |
| Refining Capacity | | 102.2 | 103.0 | 0.8 |
| Utilization of Refining Capacity in % | | 91.1 | 85.1 | - |
| **Primary Energy Consumption of Mineral Oil (Mtce)** | | **4,675** | | |
| | in Tons of Oil Equivalents | 108.8 | 103.3 | -5.0 |
| | in Million Tons of Coal Equivalents | 159.5 | 151.6 | -5.0 |
| | in Petajoules | 4,675 | 4,443 | -5.0 |

*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*

*Source: Association of the German Petroleum Industry (MWV)*

Foreign trade in mineral oil products changed only slightly. On balance, imports predominated; with 39.3 million tons, they topped the exports of 22.6 million tons by almost 17 million tons in 2018. 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 about 6 % with 85.2 million tons in 2018. In 2018, the three most important countries supplying crude oil to German refineries continued to be Russia (with a share of 36.3 %), Norway (11.8 %), and the United Kingdom (7.8 %); altogether, these countries contributed almost 56 % to German crude oil imports. Important supplier countries continued to be Kazakhstan, Azerbaijan, Nigeria, Algeria, Iraq as well as Libya and Egypt (please see Table 6).

Divided into individual oil producing areas, the countries of the former Soviet Union (CIS states) were even able to expand their high share of German crude oil imports; namely, from almost 49 % in 2017 to nearly 53 % in 2018. In contrast, the OPEC states (2018: Almost 23 %) and the countries bordering the North Sea (2018: More than 21 %) recorded slight losses in their shares. Except for Libya, Nigeria, and Azerbaijan, supplies from other major oil exporting countries dropped noticeably.

Table 6

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**Germany's Crude Oil Imports in 2017 and 2018 According to Countries of Origin (Jan.-Nov.)**

| Important Supplier Countries/ Production Regions | 2017 | 2018 | 2017 | 2018 | Changes 2018/2017 |
|---|---|---|---|---|---|
| | in Million Tons | | Proportions in % | | in % |
| Russia | 33.5 | 31.0 | 36.9 | 36.3 | -7.6 |
| Norway | 10.3 | 10.0 | 11.4 | 11.8 | -2.5 |
| United Kingdom | 8.6 | 6.7 | 9.4 | 7.8 | -21.9 |
| Kazakhstan | 8.1 | 6.8 | 8.9 | 8.0 | -15.9 |
| Libya | 6.9 | 7.2 | 7.6 | 8.5 | 4.2 |
| Nigeria | 4.9 | 5.5 | 5.4 | 6.4 | 11.8 |
| Iraq | 4.7 | 3.0 | 5.2 | 3.6 | -35.2 |
| Azerbaijan | 2.5 | 3.1 | 2.7 | 3.6 | 25.0 |
| Algeria | 2.0 | 0.7 | 2.2 | 0.8 | -64.9 |
| Egypt | 1.7 | 1.1 | 1.9 | 1.3 | -37.1 |
| Other Countries | 7.6 | 10.1 | 8.4 | 11.9 | 33.0 |
| **Total** | **90.7** | **85.2** | **100.0** | **100.0** | **-6.1** |
| Production | | | | | |
| OPEC | 21.5 | 19.3 | 23.7 | 22.6 | -10.3 |
| North Sea [1] (excld. FRG) | 20.5 | 18.1 | 22.6 | 21.3 | -11.5 |
| Former CIS | 44.1 | 45.0 | 48.6 | 52.8 | 2.1 |
| Other | 4.7 | 2.8 | 5.2 | 3.3 | -40.1 |
| **Total** | **90.7** | **85.2** | **100.0** | **100.0** | **-6.1** |

*1) Preliminary data*

*Discrepancies in the totals are due to rounding off*

*Sources: Federal Office of Economics and Export Control (BAFA); Official Mineral Oil Statistics as well as RohölINFO [Information on Crude Oil], December 2018*

In 2018 as well, international oil prices and the Euro/US Dollar exchange rate exhibited an unstable development; in other words, they experienced considerable short-term fluctuations (please see Figure 6). While crude oil grade Brent UK, which is important for Europe, had peaked at an annual average of about 112 US dollars per barrel (US $/bbl; 1 barrel = 159 liters) in 2012 (the monthly peak to date had been about US $ 132/bbl in June 2008), the average price in 2013 and 2014 dropped to US $ 109/bbl and US $ 99/bbl respectively. The development in 2015 also showed a clear downward trend: Particularly since May, when the crude oil price reached its annual peak of about US $ 64/bbl, prices dropped and only reached about US $ 38/bbl in December 2015. This development initially continued in early 2016, but then gave way to an upward trend which was interrupted by fluctuations before it finally reached a price of about US $ 53/bbl in December. Until mid 2017, prices decreased once again to US $ 46.37/bbl in June, followed by an increase that continued over a longer period of time to about US $ 81/bbl in October 2018. By the end of 2018, the import prices amounted to approximately US $ 65/bbl.

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 mid-2014, the Euro exchange rate had deteriorated considerably. Compared to December 2014, the exchange rate had dropped by 12 % from US $ 1.2331/€ to US $ 1.0877/€ by December 2015. After a slight recovery in 2016, however, the downward trend continued at the end of the year; the exchange rate of US $ 1.0543 in late 2016 even fell noticeably below last year's low level. Starting in May 2017, the exchange rate increased once again to a comparably high level; ultimately reaching about US $ 1.2348 in February 2018. By the end of the year 2018, the exchange rates once again deteriorated until they ultimately reached US $ 1.1348. Hence, German crude oil import prices actually decreased slower (-7.6 %) than the global market prices for crude oil (-10.9 %) between December 2017 and December 2018.

Figure 6

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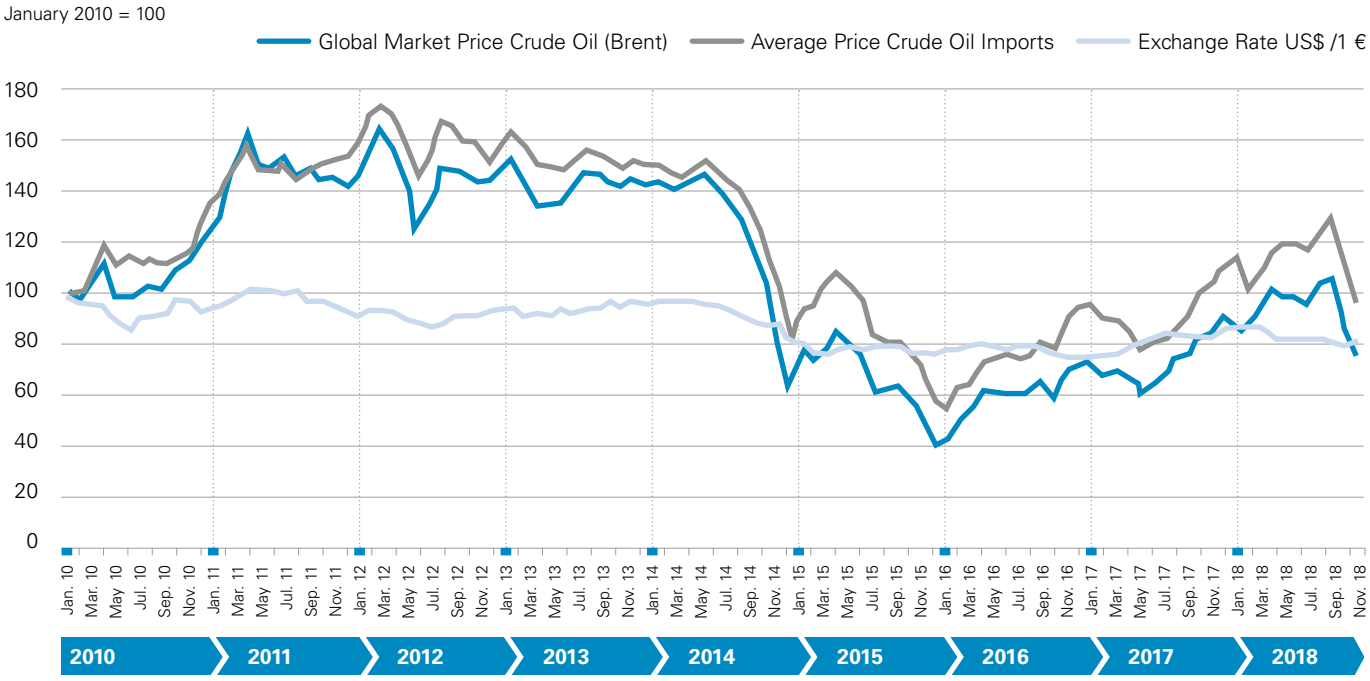
**Global Market Prices for Crude Oil (Brent) [1], Border-Crossing Prices for German Crude Oil Imports [2], and Exchange Rates between January 2010 and December 2018**




*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); Association of the German Petroleum Industry (MWV)*

This resulted in a 36 % reduction of the German crude oil import prices from an annual average of 555 euros per ton (€/t) in 2014 to € 356/t in 2015. Thereafter, they even hit rock bottom at € 214/t in February 2016. With the prices subsequently beginning to rise again to almost € 356/t in December 2016, an annual average of about € 286/t had to be paid. In 2017, the import prices dropped initially to about € 315/t in June; however, during the second half of the year, the price trend reversed and increased to almost € 414/t in December. This increase initially continued only until February 2018; after a short-term decline, there was an upward trend again that started in May and culminated in a new record high of € 513/t in October 2018. By the end of 2018, however, the crude oil import prices decreased once again to a level of € 382/t (7.6 % less than in December 2017). Yet on an annual average in 2018, a ton of crude oil cost 26.3 % more than in 2017. While the import volumes for crude oil were more than 6 % lower, the expenditures for crude oil imports increased by 18.6 % from 32.5 billion euros to 38.5 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 7). While the prices for premium gasoline, diesel fuel, and light fuel oil had decreased significantly already in 2015, they experienced another decline in 2016: On average, the annual prices for premium gasoline decreased by 7.0 %, for diesel fuel by 8.4 %, and for light fuel oil due to the lower tax proportion even by 16.9 %. However, an increasing trend became once again apparent over the course of the year 2016 so that the prices were noticeably higher in December than in the comparable month of the previous year. An upward trend also occurred in 2017; however, it stayed within a narrow margin. In December 2017, for example, the prices for premium gasoline were not even 1 % higher than in December 2016; for diesel fuel, it was a plus of 2.2 % and for light fuel oil a plus of 4 %. Over the course of the year 2018, all three products experienced a substantial increase in prices at least until November; namely, by 40.7 % for light fuel oil, by 22.4 % for diesel fuel, and by 13.2 % for premium gasoline between November 2017 and November 2018. Calculated over the course of the year, the prices in 2018 for light fuel oil were 21.7 %, for diesel fuel 11.5 %, and for premium gasoline 6.7 % higher than in 2017. As measured by the producer price index, the prices for mineral oil products in Germany were on an annual average and in total 11.2 % higher in 2018 than in 2017.

Figure 7

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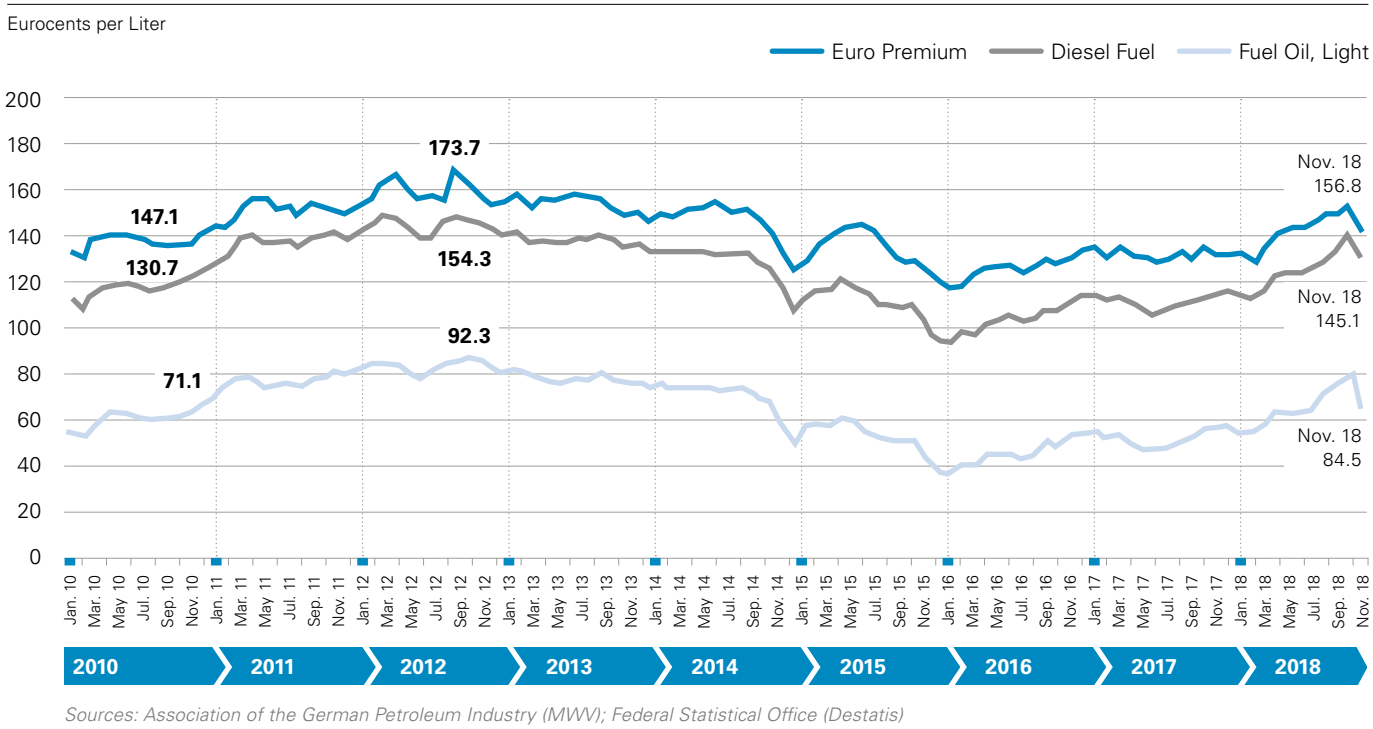
**Prices for Fuels and Light Fuel Oil in Germany between 2010 and 2018**




*Sources: Association of the German Petroleum Industry (MWV); Federal Statistical Office (Destatis)*

## Natural Gas

In 2018, natural gas consumption in Germany decreased by an estimated rate of 1.6 % to 945 billion kWh, which equals 3,071 PJ. This decline is primarily due to the reduced use of natural gas for heating purposes. Because of the warm temperatures starting in March, significantly lower volumes of natural gas were used both in private households and in the plants of the district heating suppliers than in the previous year. The production decline in the chemical industry (chemical raw materials and products) towards the end of the year provided another impulse for this development.

The proportion of electricity generated from natural gas in relation to gross electricity production decreased slightly by 0.4 percentage points to 12.9 %. Significantly lower volumes of natural gas were used for the generation of heat in heating and thermal power stations as well as in combined heat and power plants in 2018. According to preliminary figures, the volume of natural gas used by industry for the combined production of heat and electricity in its own power plants increased slightly by more than 1 %.

After the comparably cooler temperatures during the months of February and March had initially resulted in a higher consumption of natural gas for heating purposes, the temperatures from April up to and including December, which were to some extent significantly above the long-term average, caused the demand for heat to decrease substantially. The sustained drought reinforced the temperature effect in most parts of Germany.

An aspect which causes natural gas consumption to rise and which needs to be mentioned here is the continuous construction of new dwellings which are either directly or indirectly (district heating) heated with natural gas. According to preliminary figures, construction approvals for approximately 305,000 new homes (in new residential buildings) were granted in 2018. 39.0 % of them will get their heat from a gas-powered heating system; 24.9 % of them will be connected to the district heating grid. New homes in existing buildings as well as existing dwellings which are converted from other heating systems into natural gas powered and district heating systems must be added to this figure.

When it comes to the use of natural gas in the individual consumption sectors, the following trends have been identified for 2018 so far (please see Table 7):

- The number of natural gas heating systems continued to increase. By the end of 2018, a total of more than 20.7 million homes or 49.4 % of the existing homes were equipped with a gas heating system. The mostly warm and dry weather, however, caused a noticeable decline in sales in the space heating market. The natural gas consumed by private households decreased by 3.2 % and that of commercial and service enterprises by an estimated 0.6 %.

- Starting in the 3rd quarter, an economic downturn caused the industry's demand for natural gas to decrease slightly. The slight plus in the use of natural gas as a fuel in industrial power plants was overcompensated by its reduced use as a raw material in the chemical raw materials industry and as a supplier of process heat. All told and according to preliminary estimates, the consumption of natural gas in industry decreased by 0.1 %.

Tabelle 7

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## Volume and Use of Natural Gas in Germany in 2017 and 2018

| | Unit | 2017 | 2018 [1] | Change in % |
|---|---|---|---|---|
| Domestic Production | Billion kWh | 70.5 | 61.6 | -12.6 |
| Imports [2] | Billion kWh | 1,237.2 | 1,773.2 | 43.3 |
| Total Volume of Natural Gas | Billion kWh | 1,307.7 | 1,834.9 | 40.3 |
| Storage Balance [3] | Billion kWh | 0.7 | -27.8 | - |
| Exports [2] | Billion kWh | 347.6 | 861.7 | 147.9 |
| Self-Consumption and Statistical Differences | Billion kWh | 17.8 | 18.0 | 1.5 |
| Domestic Sales of Natural Gas | Billion kWh | 943.0 | 927.3 | -1.7 |
| **Primary Energy Consumption of Natural Gas** | **Billion kWh** | **960.8** | **945.3** | **-1.6** |
| | **Petajoules ($H_u$)** | **3,121.3** | **3,071.0** | **-1.6** |
| | **Mtce ($H_u$)** | **106.5** | **104.8** | **-1.6** |
| Share of Domestic Production in Germany's Natural Gas Consumption | % | 7.3 | 6.5 | |
| **Structure of Natural Gas Consumption According to Consumer Groups** | | | | |
| Industry (Including Industrial Power Plants) | Billion kWh | 370 | 369 | -0.1 |
| Power Supply (Including CHP Plants) | Billion kWh | 113 | 110 | -2.4 |
| Provision of District Heating and Cooling (Including CHP Plants) | Billion kWh | 70 | 67 | -4.9 |
| Private Households | Billion kWh | 274 | 265 | -3.2 |
| Trade. Commerce. Services | Billion kWh | 115 | 114 | -0.6 |
| Transportation | Billion kWh | 2 | 2 | 5.6 |
| **Total Sales of Natural Gas** | **Billion kWh** | **943** | **927** | **-1.7** |
| Self-Consumption and Statistical Differences | Billion kWh | 18 | 18 | - |
| **Natural Gas Consumption** | **Billion kWh** | **961** | **945** | **-1.6** |

*1) Preliminary data; some figures are estimates*
*2) Import and export volumes including all transit volumes*
*3) Minus = storage; plus = withdrawal*
*Discrepancies in the totals are due to rounding off*

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

- The use of natural gas in power plants and heating stations supplying the general public had increased significantly since the beginning of the second half of 2016. This was not only due to the price spreads to other energy carriers, which improved in favor of natural gas, but also due to the fact that the preservation of existing plants, which had been introduced by virtue of the Act on the Preservation, Modernization, and Expansion of Combined Heat and Power Plants (KWKG) in 2016, made it possible for combined heat and power plants based on natural gas to once again achieve more hours of full utilization. Starting in the second half of 2017, though, a decline was once again recorded which continued in 2018. Despite an increasing number of district heating connections, the warm weather, which was already referred to in this report, resulted in a considerably decreased use primarily in heating stations. All told, the use of natural gas in the supply and provision of electric power and heat (including combined heat and power plants) recorded a decline of 3.3 %.

Due to the below average reduction of natural gas consumption when compared to the total primary energy consumption, the former's share in consumption increased from 23.2 % in 2017 to 23.7 % in 2018.

Since the beginning of 2018, Germany's natural gas volume can no longer be compared to previous years due to a change in the recording of the requisite data. The import volumes as well as the export volumes contain all transit volumes which traverse Germany. In addition, natural gas imports and exports can hardly be distinguished according to their countries of origin and countries of destination anymore.

In 2018, the declining domestic production amounted to almost 62 billion kWh. This accounted for 6.5 % of the natural gas consumption in Germany. 93.5 % of the natural gas used in Germany were imported.

On balance, almost 28 billion kWh of natural gas were stored in 2018. In the previous year, nearly 1 billion kWh had still been taken from storage facilities.

The number of companies active in the gas industry continued to increase. At the end of 2017, there were 1,247 enterprises; at the end of 2018, there were 1,262. A closer look reveals that eight of these enterprises were active as natural gas producers, 28 as storage operators, 68 as mere wholesalers, 16 as long-distance gas grid operators, 713 as gas distribution grid operators, and 975 as distribution companies in the end customer business. The number of employees in the gas industry increased by 1.1 % in 2018 and amounted to about 37,000 persons at the end of the year.

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 which can be clearly seen in Figure 8. The price trend for oil no longer plays any role in the development of procurement costs for gas today.

In 2018, the import prices for crude oil as well as natural gas have increased significantly. On an annual average and when compared to 2017, however, the price increase for imported crude oil, which recorded a plus of 26.3 %, was significantly higher than that for natural gas, which recorded a plus of 12.7 %. Yet with 1.92 ct/kWh, the prices in 2018 were still significantly below the level of 2012 (minus almost 1 ct/kWh or 34 %).

Figure 8

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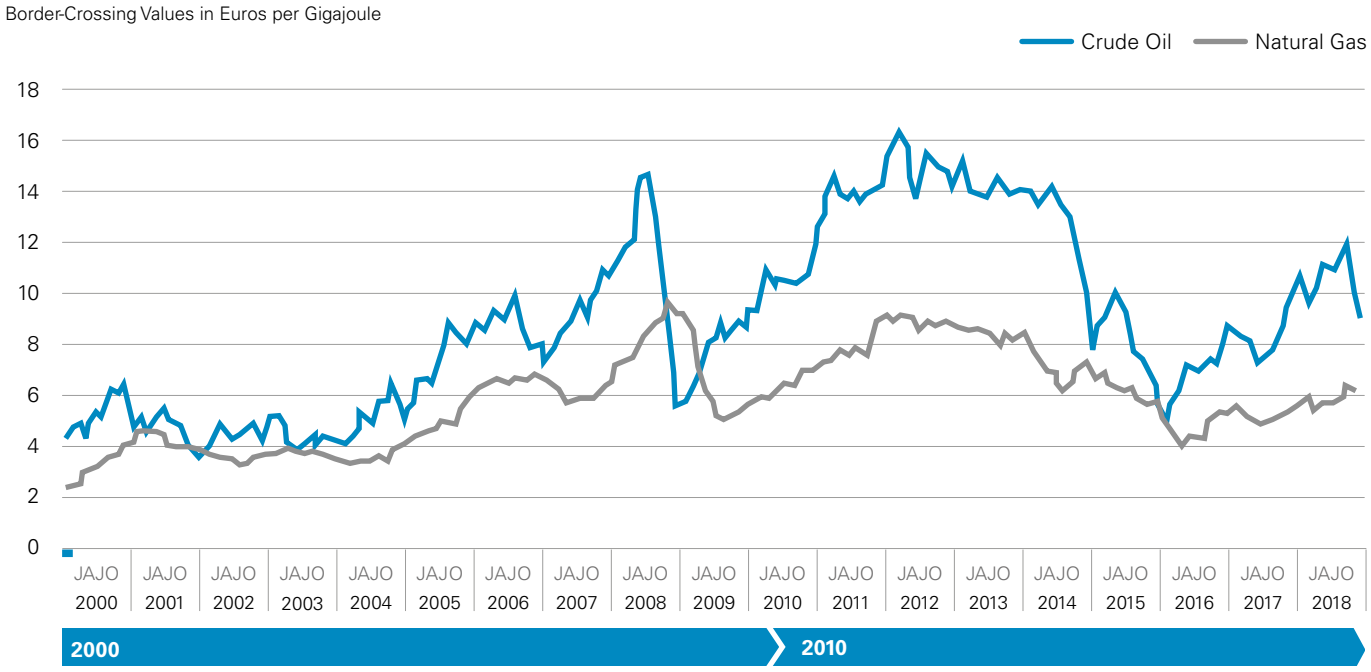
**Monthly Border-Crossing Values for Crude Oil and Natural Gas between 2000 and 2018**




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

The development of import prices has different effects on domestic sales prices (please see Figures 9a and 9b). 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.

Figure 9a

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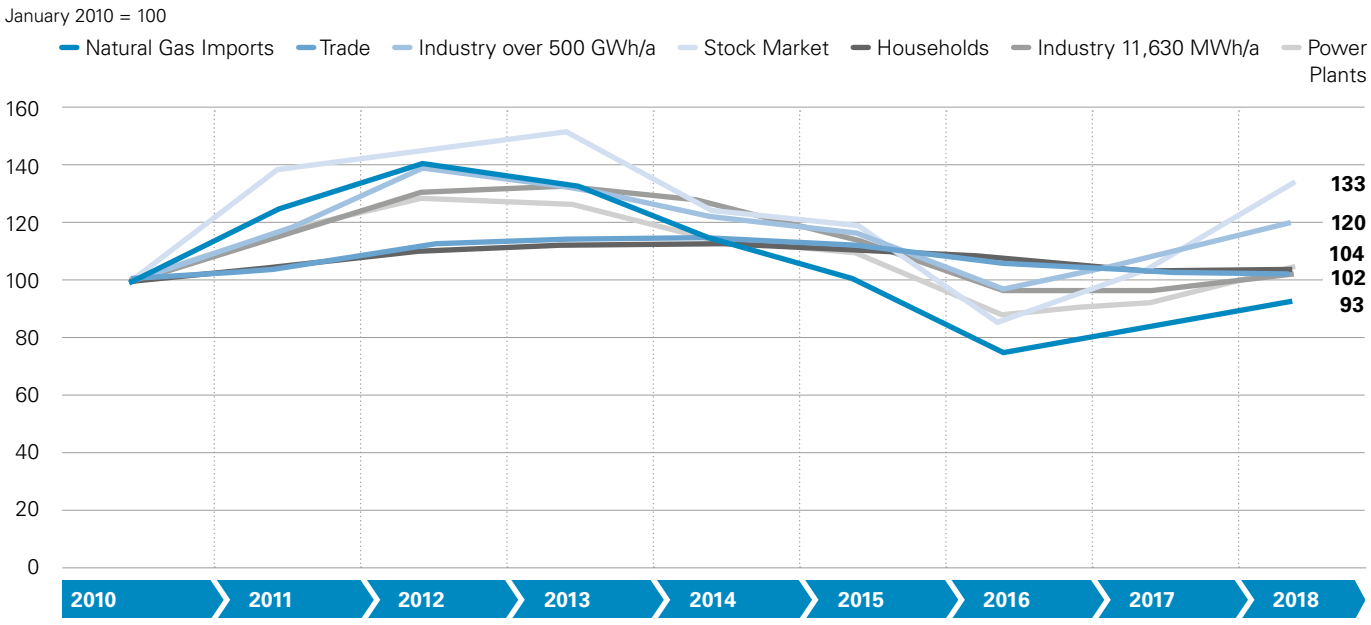
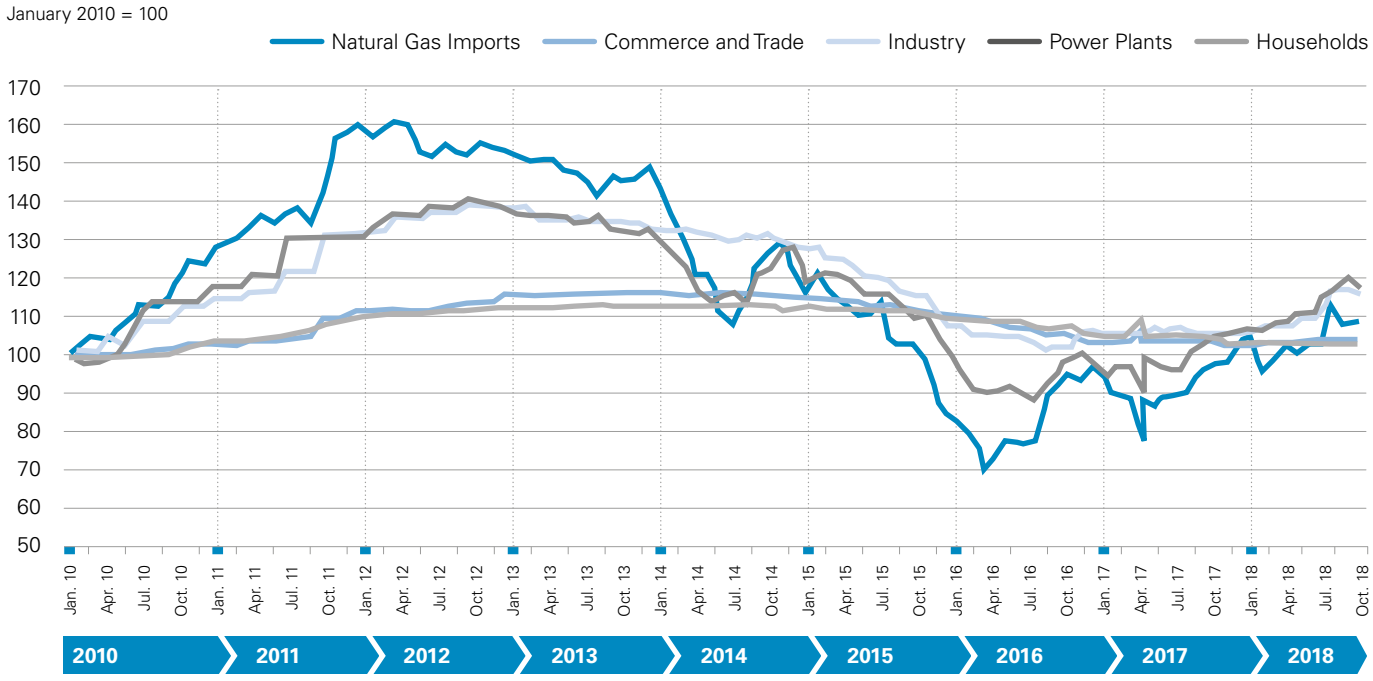
**Annual Prices for Natural Gas Imports and Natural Gas Sales in Germany between 2010 and 2018**




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

Figure 9b

**Prices for Natural Gas Imports and Natural Gas Sales in Germany between 2010 and 2018**




*Sources: Federal Office of Economics and Export Control (BAFA); Federal Ministry for Economic Affairs and Energy (BMWi); Federal Statistical Office (Destatis)*

As measured by the producer price indices and parallel to the import prices for natural gas, the price level for natural gas at the energy exchange increased by 29 % while the sales prices to power plants went up by 13 %. For large industrial clients (annual supply of more than 500 GWh), the purchase prices increased by 12 % compared to the previous year because natural gas had to be procured at shorter notice; small industrial gas consumers (supply of 11.63 GWh/a) had to pay 6 % more. Due to early procurement, the gas prices for the trade, commerce, and service sector remained virtually unchanged and those for private households decreased by almost 2 %. Over the past few years, the prices for both sectors actually exhibited a virtually uniform trend.

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

Procurement costs on the wholesale market actually reflect only a part of the end customer price. It 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.

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-sized enterprises. 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 hard coal consumption decreased significantly once again in 2018 (please see Table 8); it dropped by more than 11 %, which was the same rate as last year, to 44.4 Mtce (1,301 PJ). Thus, the hard coal consumption that had been reached in the previous year, which accounted for the lowest annual consumption of hard coal in post-war Germany so far, was undercut once again. The downward trend on the German hard coal market, which had persisted since 2013, still continued. This was essentially due to structural developments such as, above all, the expansion of renewables in the electricity sector; and here, specifically photovoltaics and wind energy. These factors increasingly displaced hard coal from the medium load in electricity production.

In contrast to the previous year, the use of hard coal in the steel industry in the form of coking coal and coke has decreased this year as well by almost 2 % to 17.3 Mtce. This is essentially due to the decline in the production of crude iron (as a primary product of crude steel production) by about 2 % to an estimated 27.3 million tons. When it comes to the volume, the heating market for hard coal (foundries, district heating plants, small businesses, and private households) continued to be relatively insignificant; it kept on shrinking and decreased to approximately 1 Mtce. With a share of almost 59 %, the most important consumption sector by far of hard coal continues to be the generation of heat and electricity in power plants and thermal power stations. Here, consumption fell sharply by more than 16 % to 26.1 Mtce when compared to the previous year. Directly and indirectly, this was the consequence of the expansion of renewable energy sources in electricity production and of a decline in the available power plant capacities based on hard coal. According to the German Association of Energy and Water Industries (BDEW) and the Federal Network Agency (BNetzA), many hard coal fired power plant units were shut down permanently last year. This affected, for example, power plant sites in Ensdorf (Saar River), Duisburg, Kiel, and Werdohl. In addition, Units 6 and 7 of the STEAG corporation's hard coal fired power plant Lünen were also disconnected from the grid by December 31, 2018.

And for 2019 as well, several shutdown notices have already been submitted. In the meantime, the commissioning of the new UNIPER power plant Datteln IV, which was scheduled for 2018 after a delay of several years, has been delayed even further.

A number of decisive price trends also played a major role in the decline in hard coal consumption. These price trends are well reflected by the so-called clean dark spreads which relate the electricity price, the power plant coal price, and the price for EU $CO_2$ emission rights to one another and, thus, permit statements on the gross margin of a coal fired power plant. Last year, all three parameters increased significantly, and the margins were small or even negative. The weekly quotation for power plant coals free at Northwest European ports (the so-called ARA ports = Antwerp, Rotterdam, and Amsterdam) increased since the beginning of the year 2018 from € 93.18/tce cif ARA to almost € 104/tce cif ARA in early October, which translates into about 11 %. Since then, however, the weekly quotation has once again taken a downturn; currently (mid-January 2019), it amounts to almost € 84/tce cif ARA. The electricity price also increased relatively sharply in 2018. For example, the base index of the Association of the Energy and Power Industry (VIK) increased from almost 150 points in January to about 188 points in December. This equals an increase of more than a quarter. The spot price for $CO_2$ emission rights on the secondary market of the energy exchange EEX in Leipzig even tripled over the same period of time (from € 7.54/t $CO_2$ in January to € 22.36/t $CO_2$ in December 2018).

Together with other factors, and last but not least, the increasingly disadvantageous general climate and energy policy conditions for coal, these price trends contributed essentially to the shutdown decisions mentioned above.

When it comes to the volume side, industrial hard coal mining in Germany was permanently discontinued in 2018 after more than 150 years of eventful industrial history. The last two mines Prosper-Haniel in Bottrop and Ibbenbüren (near Osnabrück) terminated their mining operations by the end of the year.

Table 8

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## Volume and Use of Hard Coal in Germany in 2017 and 2018

| | 2017 | | 2018 [1] | | Change |
|---|---|---|---|---|---|
| | PJ | Mtce | PJ | Mtce | in % |
| **Primary Energy Consumption** | **1,465** | **50.0** | **1,301** | **44.4** | **-11.2** |
| Power Plants and Thermal Power Stations | 914 | 31.2 | 765 | 26.1 | -16.3 |
| Steel Industry | 516 | 17.6 | 507 | 17.3 | -1.7 |
| Heating Market | 35 | 1.2 | 29 | 1.0 | -16.7 |
| Import of Hard Coal and Coke [2] | 1,413 | 48.2 | 1,266 | 43.2 | -10.4 |
| **Hard Coal Production** | **108** | **3.7** | **76** | **2.6** | **-29.7** |

*1) Preliminary data; some figures are estimates*
*2) Coke converted into coal*

*Discrepancies in the totals are due to rounding off*

*Source: German Hard Coal Association (GVSt), The German Coal Industry's Statistical Office, German Coal Importers Association*

Table 9

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## German Hard Coal Imports [1] According to Supplier Countries in 2018 and 2019 (January to November)

| | 2017 | 2018 [2] | 2017 | 2018 [2] | Change |
|---|---|---|---|---|---|
| | in Million Tons | | Proportions in % | | in % [3] |
| Russia | 16.2 | 15.9 | 36.8 | 40.2 | -1.7 |
| USA | 8.0 | 8.3 | 18.2 | 20.9 | 3.2 |
| Australia | 5.8 | 4.9 | 13.1 | 12.3 | -15.5 |
| Columbia | 5.0 | 3.0 | 11.3 | 7.5 | -40.2 |
| Poland | 2.4 | 1.5 | 5.5 | 3.9 | -35.4 |
| Canada | 1.5 | 1.4 | 3.4 | 3.6 | -5.5 |
| South Africa | 1.2 | 0.7 | 2.8 | 1.8 | -43.5 |
| Czech Republic | 0.4 | 0.3 | 0.9 | 0.7 | -36.0 |
| Other Third Countries | 1.0 | 1.1 | 2.2 | 2.8 | 16.9 |
| Other EU Countries [4] | 2.6 | 2.5 | 5.8 | 6.3 | -3.3 |
| **Total Imports** | **44.1** | **39.6** | **100.0** | **100.0** | **-10.1** |
| **Total Year (Expansion)** [5] | **48.2** | **43.2** | **100.0** | **100.0** | **-10.4** |

*1) Including coke imports; coke converted into coal*
*2) Estimate based on the Federal Statistical Office's foreign trade statistics for the first eleven months*
*3) Rates of change calculated on the basis of six digits after the decimal point*
*4) Including transit volumes from third countries via Belgian and Dutch ports*
*5) As-is values for 2017; projected values for 2018 based on imports accrued during the specific period of time*

*Discrepancies in the totals are due to rounding off*

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

With 2.6 Mtce, the expiring overall production of both mines was almost 30 % below the previous year's level (3.7 Mtce). At the same time, the existing stocks amounting to about 2 million tvF (tons of saleable hard coal produced) were sold completely. Thus, Germany will be fully dependent on the import of hard coals in order to cover its hard coal consumption as of 2019 (for an overview of the volume and use of hard coals, please see Table 8).

According to preliminary data derived from foreign trade statistics of the Federal Statistical Office for the first eleven months of the year 2018 and compared to the same period of the previous year, Germany's hard coal imports decreased by 10.1 % to approximately 39.6 Mtce (please see Table 9). Of this figure, 25.4 Mtce accounted for power plant coals, 11.4 Mtce for coking coals, 0.7 Mtce for anthracite coals and briquettes, and 2.1 Mtce for coke. To convert the requisite figures into hard coal equivalents, calorific values derived from the data ascertained in accordance with the Energy Statistics Act were additionally taken into account. If projected over the entire year 2018, this is likely to result in hard coal imports amounting to 43.2 Mtce (-10.4 % when compared to the as-is value of the previous year).

Even though Russia delivered slightly less coal than in the previous year, it was able to expand its share in German hard coal imports to 40 % and, thus, continued to dominate the field far ahead of the other supplier countries. With a share of 21 %, the United States continued to be the secondmost important country of origin for Germany. Temporarily, the US American coal exporters benefited from the particularly high coal price level in Northwest Europe which is why they supplied about 3 % more than in the previous year.

In contrast, imports from other major supplier countries consistently exhibited a downturn; the strongest declines were reported for imports from South Africa (-44 %), Columbia (-40 %), and Australia (-16 %). These three supplier countries taken together attained a proportion of 22 % of the entire German import volume; in the previous year, this figure had been 27 %. In a sectoral breakdown, Russia headed the field of power plant coal imports with a share of 56 % while Australia dominated the sector of coking coal imports with a share of 43 %. When it comes to coke imports, the major portion of 85 % came from EU countries; above all, from Poland which alone accounted for a share of 65 %.

According to estimates of the German Coal Importers Association, 7.1 billion tons of hard coal were produced on the entire globe in 2018. Compared to the previous year, this would equal a growth of 1.7 %. The highest increases could, thus, be allocated to India with 54 million tons, to Indonesia with 24 million tons, to Russia with 21 million tons, and to Australia with 16 million tons. A decline in the production trend, however, was recorded for Columbia (-9 million tons) and the United States (-8 million tons). In the EU as well, hard coal production continued to decline; during this time, by a total of 9.4 million tons. While the Polish hard coal production mostly stayed at the high previous year's level, the remaining production in the United Kingdom (-15 % to 2.6 million tons) and the Czech Republic (-18 % to 4.5 million tons) once again decreased significantly.

About one sixth of the global production went into international trade, the remainder was used directly in the producer countries. A small portion accounted for domestic trade (transport via inland vessels and rail) while the major portion became part of the seaward global hard coal trade. This trade grew by 3.7 % to about 1.2 billion tons and was primarily backed by exports from Australia (383 million tons), Indonesia (335 million tons), Russia (193 million tons), and Columbia (80 million tons). The highest export increases in maritime trade were recorded for Indonesia (+17 million tons), the USA (+16 million tons), Russia (+12 million tons), and Australia (+10 million tons). In contrast, export losses were exhibited by South Africa (-5 million tons) and Columbia (-3 million tons). The increase in the global trade of hard coal is primarily due to the growing demand in Southeast Asia. In 2018 as well, the world's two largest producer countries China and India were at the same time consumers of imported coal and, thus, also an important pillar of the global hard coal trade.

Figure 10 conveys an indication of the long-term price trend for power plant coals also in comparison to the changes experienced by crude oil. Figure 11 provides a comparison of the import prices for crude oil, natural gas, and hard coals. This comparison reveals that after a high-price phase in 2010/2011, followed by considerable price reductions stretching into the year 2016, the trend pointed upwards until the end of 2018 despite all fluctuations – yet without reaching the level that had been attained in the beginning of the decade.

Figure 10

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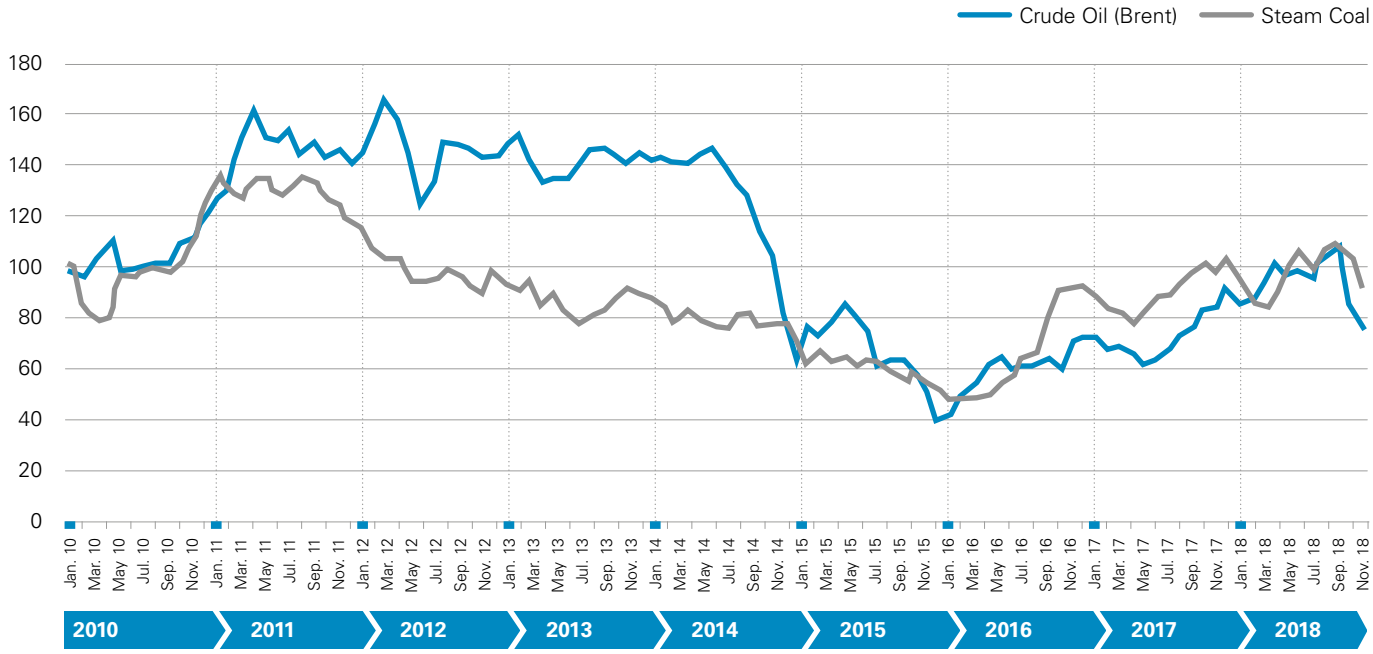
## Global Market Prices for Crude Oil (Brent) and Steam Coal between 2010 and 2018

January 2010 = 100




*Sources: German Coal Importers Association (Mc Closkey's Coal Report); Association of the German Coal Industry (MWV)*

Figure 11

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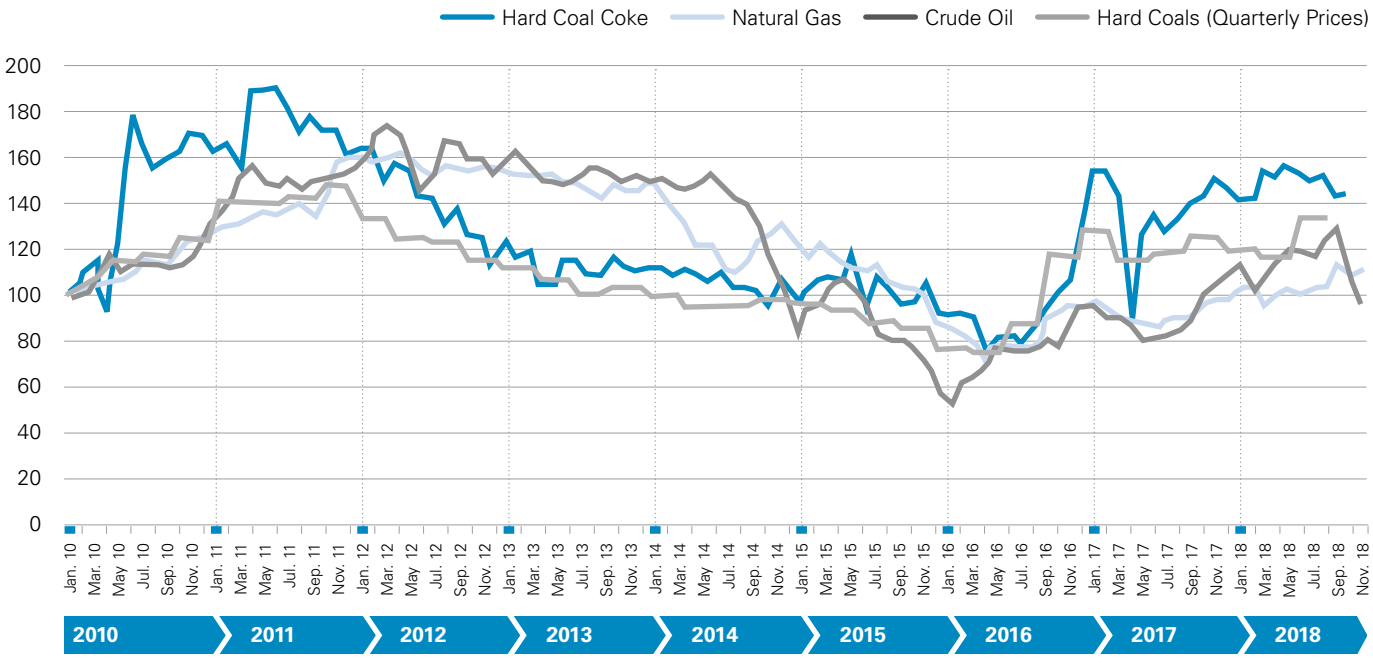
## Development of Energy Import Prices between 2010 and 2018

January 2010 = 100




*Sources: German Coal Importers Association; McCloskey's Coal Report; BAFA*

# Lignite

With about 166 million tons, lignite production in 2018 remained below the previous year's result for the sixth year in a row (-2.9 %). However, the development in the individual mining districts varied: In Central Germany (+2 %), the extracted coal volume was higher due to the improved availability of power plants. In Lusatia (-1 %) and the Rhineland area (-5 %), though, it fell below the previous year's result.

Table 10

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**Volume and Use of Lignite in Germany in 2017 and 2018**

| | Unit | 2017 | 2018 [1] | Change in % |
|---|---|---|---|---|
| **1. Domestic Raw Lignite** | | | | |
| **Total Lignite Production** | **Million Tons** | **171.3** | **166.3** | **-2.9** |
| | **Mtce** | **52.5** | **51.0** | **-2.9** |
| | **PJ** | **1,540** | **1,495** | **-2.9** |
| **Total Sales** | **Million Tons** | **154.0** | **149.0** | **-3.2** |
| to Power Plants Supplying the General Public | Million Tons | 153.2 | 148.2 | -3.3 |
| to Other Customers | Million Tons | 0.8 | 0.8 | 8.1 |
| Use for Refinement | Million Tons | 14.7 | 14.6 | -0.4 |
| Use in Lignite Mining Power Plants | Million Tons | 2.5 | 2.5 | 0.4 |
| Change in Stocks | Million Tons | 0.0 | -0.1 | - |
| **2. Foreign Trade** | | | | |
| Total Imports | 1,000 tce | 22 | 24 | 11.1 |
| Total Exports | 1,000 tce | 1,096 | 1,091 | -0.4 |
| Foreign Trade Balance | 1,000 tce | -1,074 | -1,068 | - |
| **3. Primary Energy Consumption** | | | | |
| | Mtce | 51.5 | 50.0 | -2.9 |
| | PJ | 1,508 | 1,465 | -2.9 |
| **4. Electricity Production from Lignite** [1] | | | | |
| Power Plants Supplying the General Public | Billion kWh | 145.0 | 142.1 | -2.0 |
| Industrial Power Plants | Billion kWh | 3.4 | 3.4 | - |
| Total | Billion kWh | 148.4 | 145.5 | -1.9 |

*1) Preliminary data; some figures are estimates*

*Discrepancies in the totals are due to rounding off*

*Sources: The German Coal Industry's Statistical Office; Deutscher Braunkohlen-Industrie-Verein e.V. (DEBRIV)*

These changes generally correspond to the respective development of deliveries to power plants supplying the general public (148.2 million tons; -3.3 %) which receive around 90 % of the production. In addition to the power plants Buschhaus and Frimmersdorf – more than 900 megawatts (MW/net), which have been in the standby mode for backup purposes already since 2016 and 2017 respectively, two units of the power plant Niederaußem in the Rhineland area (almost 600 MW) as well as one unit of the power plant Jänschwalde in Lusatia (465 MW) were taken off the grid as of October 1, 2018. With the transfer of a total net capacity of 2,730 MW into a standby mode for backup purposes, the volume of lignite used for electricity production in Germany will decline by a total of about 13 % by 2020. $CO_2$ emissions from electricity production in Germany's lignite fired power plants will, thus, be approximately 19 million tons less by 2020 than in 2015.

With about 51 Mtce (1,495 PJ), the energy content of the extracted lignite fell about 3 % short of the previous year's result. The contribution of lignite to domestic energy production once again amounted to about 38 %. Lignite, thus, continues to be an important domestic energy carrier.

With 145.5 billion kWh, power generation from lignite was once again lower than in the previous year (-1.9 %). Lignite's share in power generation decreased to 22.5 % (previous year: 22.7 %). Thus, more than every fifth kilowatt hour of the electricity used in Germany is sourced from lignite (please see Table 10).

The manufacture of refined products based on lignite decreased in total by 0.9 % to about 6.6 million tons. Increases were reported for fluidized bed coal (+18 %) and coke production (+2 %). The production of briquettes (-6 %) and pulverized coals (-1 %), however, remained below the previous year's result.

With 50.0 Mtce (1,465 PJ), lignite-based primary energy consumption was 2.9 % lower than in the previous year. Lignite, thus, met more than 11 % of the entire domestic demand for energy.

With a total consumption of about 3.0 Mtce (-1.4 %) in 2018, the final energy sectors used in total less lignite and lignite products than in the previous year (please see Table 11). When it comes to industry, the use of lignite decreased by about 1 % while sales to private households also reported a decrease (-2 %).

At the end of 2018, the number of employees working in the German lignite industry amounted to about 20,851 people. This figure includes nearly 1,300 apprentices and almost 5,000 employees who work in the lignite companies' power plants supplying the general public. Employment statistics listed 9,986 employees in the Rhineland area, 8,375 in Lusatia, and 2,379 in Central Germany. After the end of coal mining, only 111 employees still worked on behalf of the lignite industry in the Helmstedt District. If one takes the results of the study *Folgenabschätzung Klimaschutzplan und Strukturwandel in den Braunkohleregionen [Assessment of the Impact of the Climate Protection Plan and Structural Change in the Lignite Mining Regions],* which was conducted by the Cologne Institute for Economic Research (IW Consult), as a basis, a total of more than 70,000 jobs in Germany can be secured either directly or indirectly by lignite mining and power generation from lignite.

Table 11

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## Lignite Balance for Germany in 2017 and 2018

in 1,000 tce

| | | 2017 | 2018 [1] | Change |
|---|---|---|---|---|
| | | | | in % |
| Domestic Production | | 52,539 | 51,038 | -2.9 |
| + | Imports | 22 | 24 | 11.1 |
| **=** | **Volume** | **52,561** | **51,062** | **18.2** |
| +/– | Change in Stocks (Reduction: +, Replenishment: -) | -2 | 69 | - |
| – | Exports | 1,096 | 1,091 | -0.4 |
| **=** | **Primary Energy Consumption** | **51,463** | **50,040** | **-2.9** |
| – | Use in Power Plants | 47,468 | 46,150 | -2.8 |
| – | Other Conversion Input | 4,532 | 4,500 | -0.7 |
| + | Conversion Output | 4,863 | 4,795 | -1.4 |
| – | Consumption during Production and Conversion as well as Non-Energetic Consumption | 1,247 | 1,150 | -7.8 |
| **=** | **Final Energy Consumption** | **3,079** | **3,035** | **-1.4** |
| | Industry | 2,588 | 2,555 | -1.3 |
| | Households, Trade, Commerce, Services, Concessionary Coal | 491 | 480 | -2.2 |

*1) Preliminary data; some figures are estimates*

*Source: The German Coal Industry's Statistical Office*

## The Electric Power Industry

In 2018, gross electricity production in Germany amounted to 646 billion kWh. The production of electric power, thus, decreased by about 1.2 % when compared to the previous year's figure. Power generation from the individual energy carriers developed differently. Renewable energy sources – except for hydropower – supplied, in part, significantly more electricity than in 2017. All fossil fuels recorded more or less considerable declines in production. The contribution of nuclear energy to power generation decreased slightly. According to the available figures, gross electricity consumption decreased by 0.7 % to almost 595 billion kWh (please see Table 12).

The electricity produced by lignite fired power plants amounted to 145.5 billion kWh in 2018. This equals a decline of 1.9 % when compared to the previous year's value. According to preliminary data, a net power plant capacity of about 21,000 MW was installed at the end of the year, of which 1,973 MW were already in the standby mode of lignite for backup purposes and, thus, no longer on the market. The contribution of lignite fired power plants to the gross electricity production amounted to 22.5 %. All told, lignite thus continued to be the most important energy carrier in the German electricity mix right after the group of renewables last year as well.

With 83.2 billion kWh in 2018, hard coal fired power plants once again delivered less electricity than in the previous year. This equals a decline of 10.4 % when compared to the previous year. Shutdowns in 2018 resulted in the fact that a capacity of 24,462 MW (net) was installed by the end of the year whereas the previous year's capacity had still amounted to 25,341 MW. This equals a decline of 879 MW, which translates into more than 3 % of the installed capacity in 2017. In 2018, hard coal's share in the mix of energy sources supplying Germany with electric power amounted to 12.9 %.

During the reporting year, nuclear power plants generated 76.0 billion kWh of electricity (-0.4 %); this equals a share of 11.8 % in Germany's gross electricity production. At the beginning of 2018, the installed capacity went down by 1,284 MW to currently 9,515 MW which was due to the decommissioning of the nuclear power plant Gundremmingen B as per December 31, 2017.

After the strong increase during the years 2016 and 2017, the use of natural gas as a fuel in power plants and thermal power stations designed to supply electricity experienced a downturn in 2018. An estimated total of 83.4 billion kWh of electric power was produced from natural gas; this equals a minus of 3.9 % when compared to 2017. After the production of electric power from natural gas had experienced a continuous decline between 2008 and late 2015, it increased considerably once again in 2016 which was due, for example, to the price spread that was actually more favorable for natural gas when compared to other energy carriers. Additional power plant capacities in 2016 also generated further growth in 2017 because these facilities were connected to the grid all year round for the first time ever in 2017. In 2018, electricity production in gas fired power plants took a downturn which was due, for example, to the increase in electricity production based on renewables. Compared to the previous year, the installed capacity (net) of 29,767 MW remained virtually unchanged. According to initial calculations, natural gas accounted for a 12.9 % share in Germany's gross electricity production in 2018.

With 92.2 billion kWh, onshore wind turbines generated 4.8 % more electric power than in 2017. With 19.3 billion kWh, offshore wind turbines also supplied more electricity than in the previous year (+ 9.4%) which was to some extent also due to the installation of additional capacities during the year under review. In 2018, the installed capacity of onshore wind turbines increased by almost 2,200 MW to currently 52,444 MW while nearly 1,000 MW were newly connected to the grid off shore. Thus, the offshore wind capacity installed in Germany now amounts to almost 6,400 MW. All told, wind energy accounted for a share of 17.3 % in the German electricity production mix in 2018.

In the reporting year, 45.1 billion kWh of electricity were produced from solid, liquid, and gaseous biomass (including landfill gas, sewage gas as well as sewage sludge). This equaled an increase of 0.3 % when compared to the previous year. Power plants generating electricity from biomass accounted for a share of 7.0 % in electricity production. In addition to the proportional power generation in waste fueled power plants (from biogenic waste), 51.3 billion kWh

Table 12

## Gross Electricity Production, Electricity Exchange, and Gross Electricity Consumption in Germany between 1990 and 2018 According to Energy Carriers

| | 1990 | 2000 | 2010 | 2015 | 2016 | 2017 | 2018 [1] | 2017 to 2018 | 1990 to 2004 | 2004 to 2018 | 1990 to 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | in Billion kWh | | | | | | | Average Annual Change in % | | | |
| Lignite | 170.9 | 148.3 | 145.9 | 154.5 | 149.5 | 148.4 | 145.5 | -1.9 | -0.6 | -0.6 | -0.6 |
| Nuclear Energy | 152.5 | 169.6 | 140.6 | 91.8 | 84.6 | 76.3 | 76.0 | -0.4 | 0.7 | -5.5 | -2.5 |
| Hard Coal | 140.8 | 143.1 | 117.0 | 117.7 | 112.2 | 92.9 | 83.2 | -10.4 | 0.0 | -3.7 | -1.9 |
| Natural Gas | 35.9 | 49.2 | 89.3 | 62.0 | 81.3 | 86.7 | 83.4 | -3.9 | 4.1 | 2.0 | 3.1 |
| Mineral Oil | 10.8 | 5.9 | 8.7 | 6.2 | 5.8 | 5.6 | 5.2 | -5.8 | 0.0 | -5.0 | -2.6 |
| Renewables | 19.7 | 37.9 | 105.5 | 188.6 | 189.9 | 216.3 | 225.7 | 4.3 | 7.9 | 10.3 | 9.1 |
| Other | 19.3 | 22.6 | 26.6 | 27.3 | 27.3 | 27.5 | 27.0 | -1.9 | 0.6 | 1.8 | 1.2 |
| **Gross Electricity Production** | **549.9** | **576.6** | **633.6** | **648.1** | **650.7** | **653.7** | **646.1** | **-1.2** | **0.8** | **0.3** | **0.6** |
| Electricity Flows from Foreign Countries | 31.9 | 45.1 | 42.2 | 33.6 | 27.0 | 28.4 | 31.5 | 11.0 | 2.4 | -2.4 | 0.0 |
| Electricity Flows into Foreign Countries | 31.1 | 42.1 | 59.9 | 85.4 | 80.7 | 83.4 | 82.7 | -0.8 | 3.7 | 3.4 | 3.6 |
| Foreign Electricity Exchange Balance | 0.8 | 3.1 | -17.7 | -51.8 | -53.7 | -55.0 | -51.2 | - | - | - | - |
| **Gross Electricity Consumption** | **550.7** | **579.6** | **615.9** | **596.3** | **597.0** | **598.8** | **594.9** | **-0.7** | **0.7** | **-0.2** | **0.3** |
| Change versus Previous Year in % | - | 4.0 | 5.8 | 0.7 | 0.1 | 0.3 | -0.7 | | | | |
| | Structure of Gross Electricity Production in % | | | | | | | | | | |
| Lignite | 31.1 | 25.7 | 23.0 | 23.8 | 23.0 | 22.7 | 22.5 | | | | |
| Nuclear Energy | 27.7 | 29.4 | 22.2 | 14.2 | 13.0 | 11.7 | 11.8 | | | | |
| Hard Coal | 25.6 | 24.8 | 18.5 | 18.2 | 17.2 | 14.2 | 12.9 | | | | |
| Natural Gas | 6.5 | 8.5 | 14.1 | 9.6 | 12.5 | 13.3 | 12.9 | | | | |
| Mineral Oil | 2.0 | 1.0 | 1.4 | 1.0 | 0.9 | 0.9 | 0.8 | | | | |
| Renewables | 3.6 | 6.6 | 16.7 | 29.1 | 29.2 | 33.1 | 34.9 | | | | |
| Other | 3.5 | 3.9 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | | | | |
| **Gross Electricity Production** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | | | | |

*1) Preliminary data; some figures are estimates*
*Discrepancies in the totals are due to rounding off*

*Sources: German Association of Energy and Water Industries (BDEW); The German Coal Industry's Statistical Office; Working Group on Energy Balances (AGEB)*

of electricity were produced from biogenic energy sources in Germany in 2018. Their total contribution to the German electricity producers' mix of energy sources, thus, amounted to almost 8.0 %.

According to preliminary figures, photovoltaic systems also supplied more electricity than had been the case in 2017 (39.4 billion kWh); namely, 46.2 billion kWh. Compared to the previous year, this equaled a plus of 17.2 %. 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. In addition to the construction of new photovoltaic systems, the strong growth in electricity production was also due to the very high number of sunshine hours in most parts of Germany. According to preliminary estimates, an additional photovoltaic capacity of more than 2,600 MWp had been installed in 2018; thus, a total capacity of approximately 45,900 MWp had been installed at the end of the year. The contribution of solar energy to the German electricity mix in the reporting year amounted to 7.1 %.

That what had promoted the power generation of photovoltaic systems had the converse effect on hydropower: Due to extremely low precipitation in large parts of the Federal Republic of Germany, the very sunny year 2018 caused a significant decline in electricity production from hydropower. With 16.6 billion kWh, for example, the electricity produced in run-of-the-river and hydroelectric storage plants recorded a minus of 18.1 % when compared to the previous year. The contribution of hydropower to the electricity mix amounted to 2.6 %.

In total, 225.7 billion kWh of electricity were generated from renewable energy in the reporting year; this equals an increase of 4.3 %. According to initial figures, renewable energy's contribution to meeting the gross domestic electricity consumption, thus, increased to almost 38.0 % in 2018 (2017: 36.1 %).

In 2018, storage facilities collected approximately 8.4 billion kWh of electric power and fed 6.3 billion kWh back into the grid again. So far, pumped storage plants assumed the largest proportion in this development. While the pumping capacity was 8.3 billion kWh, the backflow into the grid amounted to 6.2 billion kWh.

Figure 12

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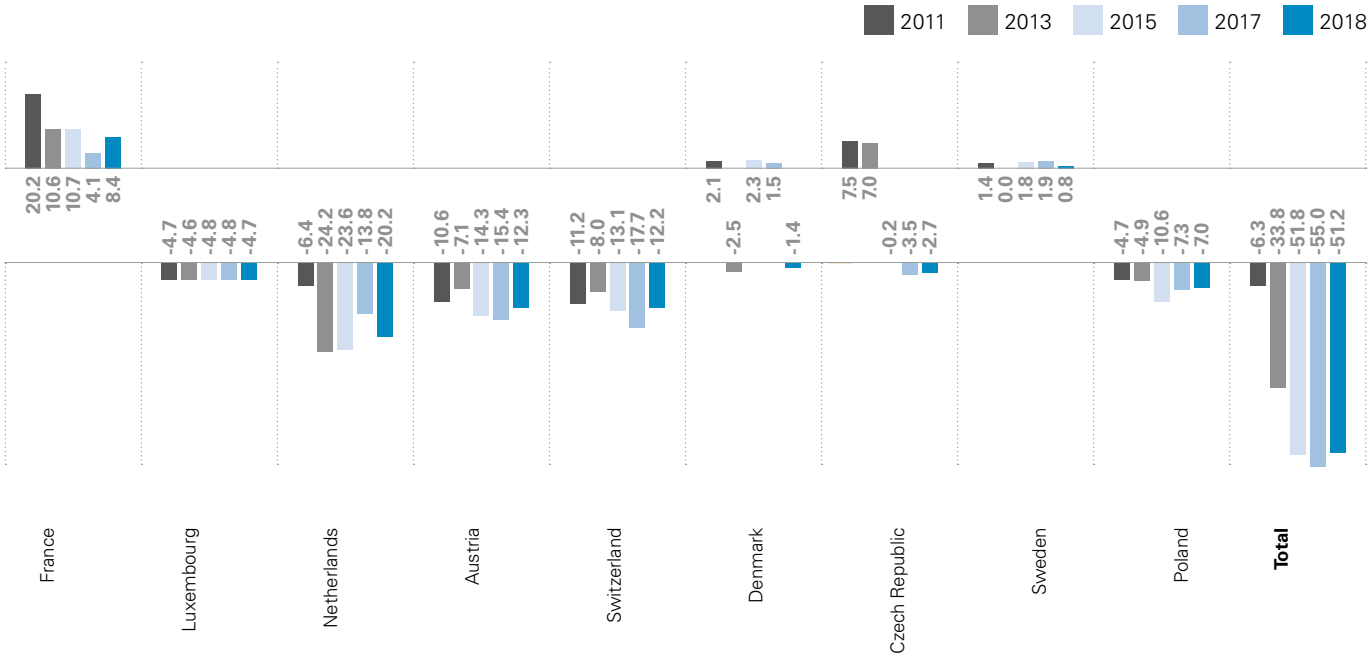
**Germany's Electricity Exchange Balance with Neighboring Countries between 2011 and 2018**

Electricity Flows in Billion kWh




*Source: BDEW*

After Germany's negative balance in the electricity exchange with its neighboring countries had initially decreased in 2011, and then increased again in part considerably during the subsequent years, it reached its highest level so far in the reporting year 2017. In 2018, a reduction of the high export balance was recorded for the first time ever (please see Figure 12). The highest electricity export balances exhibited the Netherlands, followed by Austria and Switzerland (Netherlands: 20.2 billion kWh, Austria: 12.3 billion kWh, Switzerland: 12.2 billion kWh). A major portion of such physical flows of electric power from Germany to the Netherlands, however, actually moves farther in the direction of Belgium and the United Kingdom. The largest amounts of electric power continued to come from France with an import balance of 8.4 billion kWh.

All told, 82.7 billion kWh of electricity flowed from German power grids to foreign countries (2017: 83.4 billion kWh) while Germany sourced 31.5 billion kWh from abroad (2017: 28.4 billion kWh). With an export surplus of 51.2 billion kWh, the balance for 2018 fell for the first time in six years below the previous year's level (2017: 55.0 billion kWh). It should be noted in this context that most of the cross-border electricity flows are not any contractually agreed deliveries, but rather transit volumes and loop flows.

According to preliminary figures, gross electricity consumption decreased by 0.7 % to almost 595 billion kWh. According to first estimates and due to the economic situation, industrial power consumption went down by 0.5 % from 248.7 billion kWh in 2017 to 247.5 billion kWh in 2018. Particularly when it comes to electricity-intensive industries, production declines were recorded to some extent already during the 3rd quarter so that a reduction was to be anticipated for the entire year 2018 as well. According to initial figures, the power consumption of private households also decreased by 0.8 % to 127.2 kWh as

Table 13

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**Electricity Balance of Germany's Power Supply between 2000 and 2018**

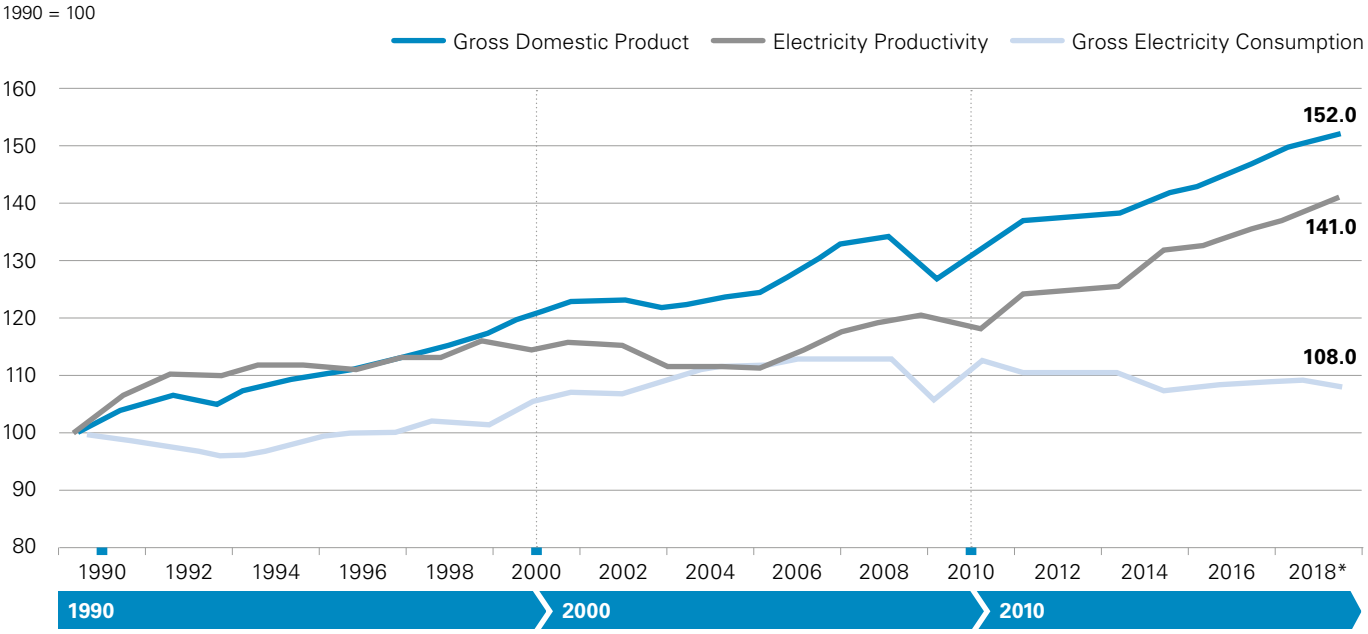
| | 2000 | 2008 | 2010 | 2015 | 2016 | 2017 [1] | 2018 [1] | Changes 2017/ 2018 | Changes 2008 to 2018 |
|---|---|---|---|---|---|---|---|---|---|
| | Billion kWh | | | | | | | Change in % | |
| **Gross Electricity Production** | **576.6** | **641.5** | **633.5** | **648.1** | **650.7** | **653.7** | **646.1** | **-1.2** | **0.7** |
| Self-Consumption in Power Plants | -38.1 | -40.4 | -39.0 | -37.7 | -36.4 | -34.6 | -33.5 | -3.2 | -17.3 |
| **Net Electricity Production** | **538.5** | **601.1** | **594.5** | **610.4** | **614.3** | **619.1** | **612.6** | **-1.0** | **2.0** |
| Electricity Flows from Foreign Countries | 45.1 | 40.2 | 42.2 | 33.6 | 27.0 | 28.4 | 31.5 | 11.0 | -21.6 |
| Electricity Flows into Foreign Countries | 42.1 | 62.7 | 59.9 | 85.4 | 80.7 | 83.4 | 82.7 | -0.8 | 32.0 |
| **Net Domestic Electricity Volume** | **541.5** | **578.6** | **576.8** | **558.6** | **560.6** | **564.2** | **561.4** | **-0.4** | **-2.9** |
| Pump Current Consumption | 6.0 | 7.9 | 8.6 | 8.1 | 7.5 | 8.3 | 8.3 | 0.9 | 4.8 |
| Grid Losses and Unrecorded Factors | 34.1 | 32.3 | 27.6 | 26.0 | 26.0 | 27.1 | 27.0 | -0.1 | -16.2 |
| **Net Electricity Consumption** | **501.4** | **538.4** | **540.6** | **524.6** | **527.1** | **528.8** | **526.0** | **-0.5** | **-2.2** |
| Proportion of: | | | | | | | | | |
| Mining and Manufacturing Industries | 239.1 | 252.4 | 249.7 | 245.8 | 247.2 | 248.7 | 247.5 | -0.5 | -1.9 |
| Households | 130.5 | 139.5 | 141.7 | 128.7 | 128.2 | 128.2 | 127.2 | -0.8 | -8.8 |
| Commerce and Trade, Public Institutions | 118.6 | 135.4 | 135.4 | 135.4 | 140.0 | 140.0 | 140.0 | 0.0 | 3.4 |
| Transportation | 13.1 | 11.1 | 12.1 | 11.1 | 11.7 | 11.2 | 11.3 | 1.1 | 1.8 |
| **Gross Domestic Electricity Consumption** | **579.6** | **619.1** | **615.8** | **596.3** | **597.0** | **598.7** | **594.9** | **-0.6** | **-3.9** |

*1) Some figures are preliminary and estimates*

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

Figure 13

**Gross Domestic Product [1], Gross Electricity Consumption, and Macroeconomic Electricity Productivity [2] in Germany between 1990 and 2018**




1) Price-adjusted
2) Gross domestic product per unit of gross electricity consumption
*) Preliminary data

Sources: Federal Statistical Office (Destatis); BMWi/BMF; German Association of Energy and Water Industries (BDEW)

a result of the warm weather starting in March and the abundance of sunshine hours during the year.

In contrast, power consumption in the trade, commerce, and service sector increased by an anticipated 0.2 % to 78.5 billion kWh. This was mainly caused by the demand for additional power for cooling and air conditioning purposes. Something similar applies – albeit to a lesser extent – to the power consumption of public institutions: It went up by 0.1 % to 52.8 billion kWh. Consumption in the transportation sector also exceeded the previous year's figure. In total, net electricity consumption in Germany with a minus of 0.4 % exhibited a downward trend. It amounted to 526.9 billion kWh (please see Table 13).

Due to the weakened economic growth which was accompanied by a decline in electricity consumption, the macroeconomic productivity of electric power, when expressed as the ratio of the price-adjusted gross domestic product to gross electricity consumption, increased by 1.9 % in 2018 when compared to the previous year. When considering the period between 1991 and 2018, the average annual increase in productivity was significantly lower with a rate of 1.2 % (please see Table 2 as well as Figures 13 and 14).

The influence of the different components on the changes in power consumption from 1990 to 2017 and/or 2018 are shown in Figure 15. This indicates that the 2018 decline of 3.7 billion kWh in gross electricity consumption when compared to 2017 was primarily caused by higher electricity productivity (electricity intensity component) (-12.4 billion kWh). The associated reductions in the consumption were correspondingly higher than the consumption-enhancing effects of economic growth (+7.1 billion kWh) and increasing population (+1.6 billion kWh). Over the entire period between 1990 and 2018, however, the long-term increase in electricity productivity did not result in any absolute reduction of power consumption. After all, the electricity productivity contributed essentially to the fact that the increase in gross electricity consumption between 1990 and 2018, despite the strong increase in consumption by the growing economy, could be limited by 219 billion kWh to about 44 billion kWh and/or a plus of about 8 %.

Figure 14

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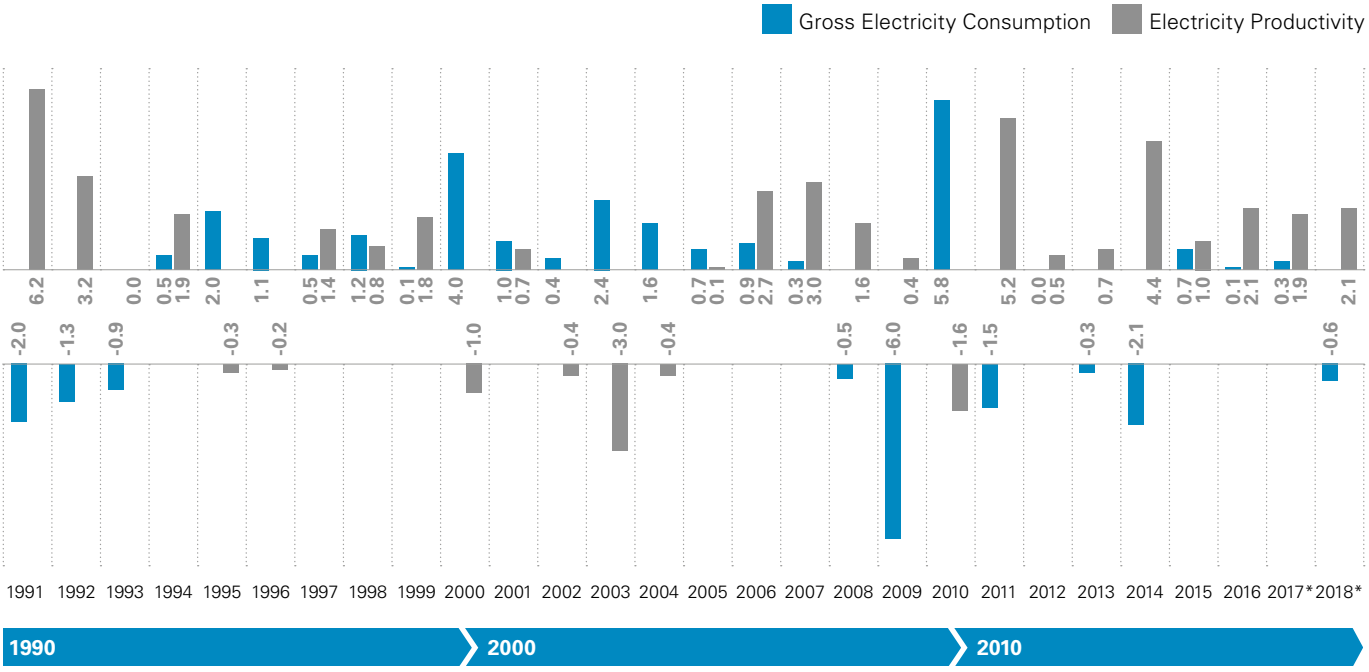
## Changes in Gross Electricity Consumption and Electricity Productivity between 1991 and 2018

Changes Compared to the Previous Year in %




**) Preliminary data*

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

Figure 15

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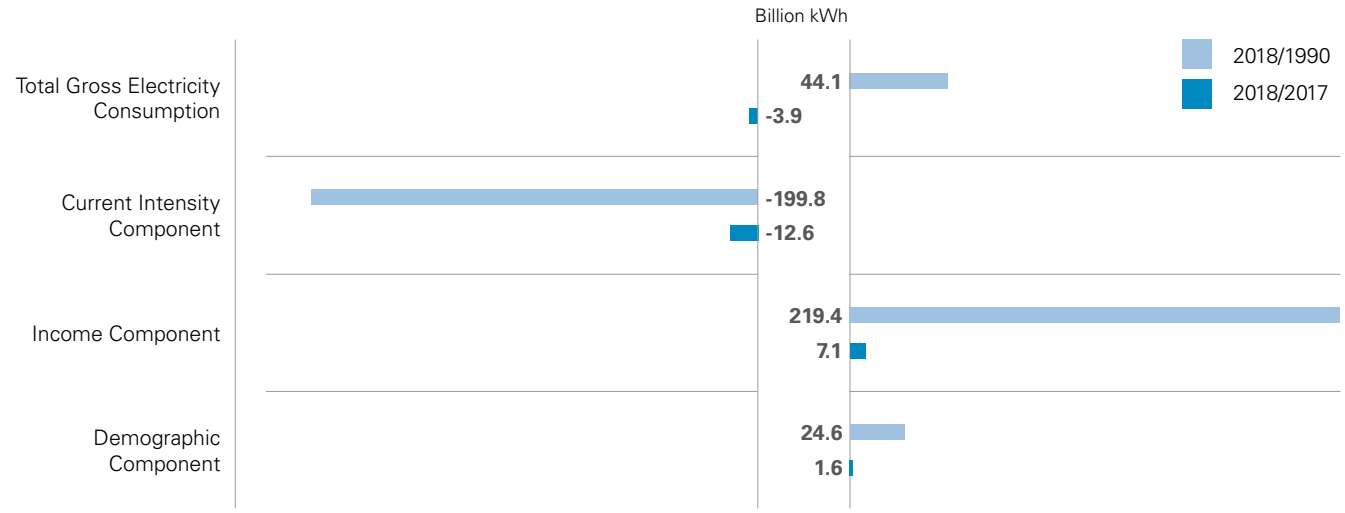
## Contributions of Diverse Influencing Factors to the Changes in Gross Electricity Consumption in Germany

Changes in 2018 Compared to 2017 and 1990 in Billion kWh




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

The number of companies which are active in the electric power industry has been growing continuously since the start of the liberalization process in 1998. At the end of 2017, there were 1,821 companies; by the end of 2018, the number had increased to 1,899. At closer examination, it is revealed that 95 of these companies were active as electricity producers with a power plant park larger than 100 MW, 908 of which worked as power distribution grid operators, four as transmission grid operators, 103 as operators of power storage facilities, 56 as electricity wholesalers, and 1,302 as distributors in the ultimate consumer business. (It is not possible to add up the indicated figures 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 working in the electric power industry increased once again in 2018. According to preliminary figures, there were 136,000 employees at the end of 2018 which was an increase of about 3.0 % when compared to the end of 2017.

Electricity prices for industrial clients went up by 5 %, which was primarily due to the increase in procurement costs. That is why the proportion of governmental charges included in the electricity price for industrial clients, which had still amounted to 48 % in 2017, decreased to 45 % in 2018 (excluding the electricity tax). Electricity prices for households increased only marginally by 0.6 % in 2018. This was caused by increased procurement costs on the wholesale market, whereas the network charges as well as taxes, duties, and levies decreased slightly. Once again, the proportion of taxes, duties, and levies included in the electricity price decreased slightly to 54 % in 2018 compared to 55 % in the previous year; however, it was still the largest item on the customer bill. In 2019 as well, the overall governmental charges remained virtually unchanged despite the decreased apportionment pursuant to the Renewable Energy Act (EEG).

As measured by the producer price index, electricity prices developed differently in 2018 for each respective customer group: While they remained virtually unchanged with a plus of 0.1 % for households, they even dropped slightly by 0.5 % for commercial customers. The prices for special-contract customers at the low voltage level went up by 1.4 %. In contrast, a substantially stronger increase of 9.6 % was recorded for special-contract customers at the high voltage level (please see Figure 16). Particularly hefty was the price

Figure 16

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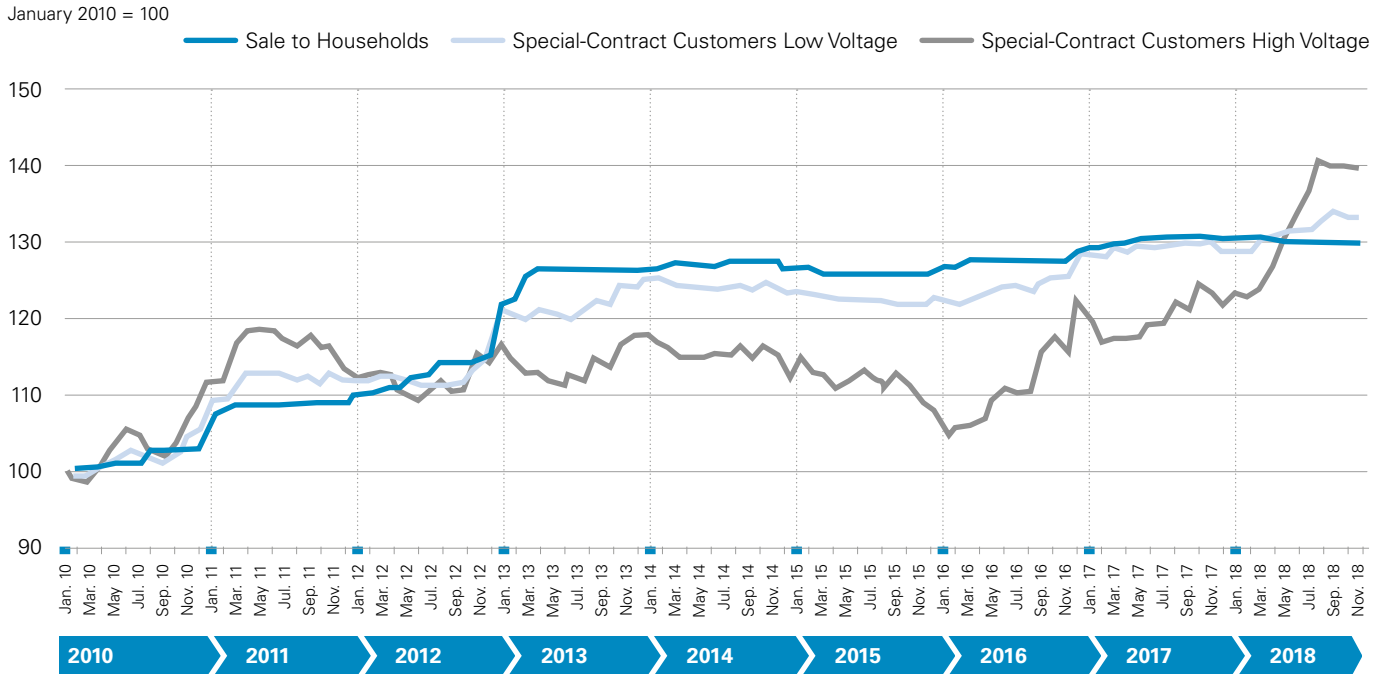
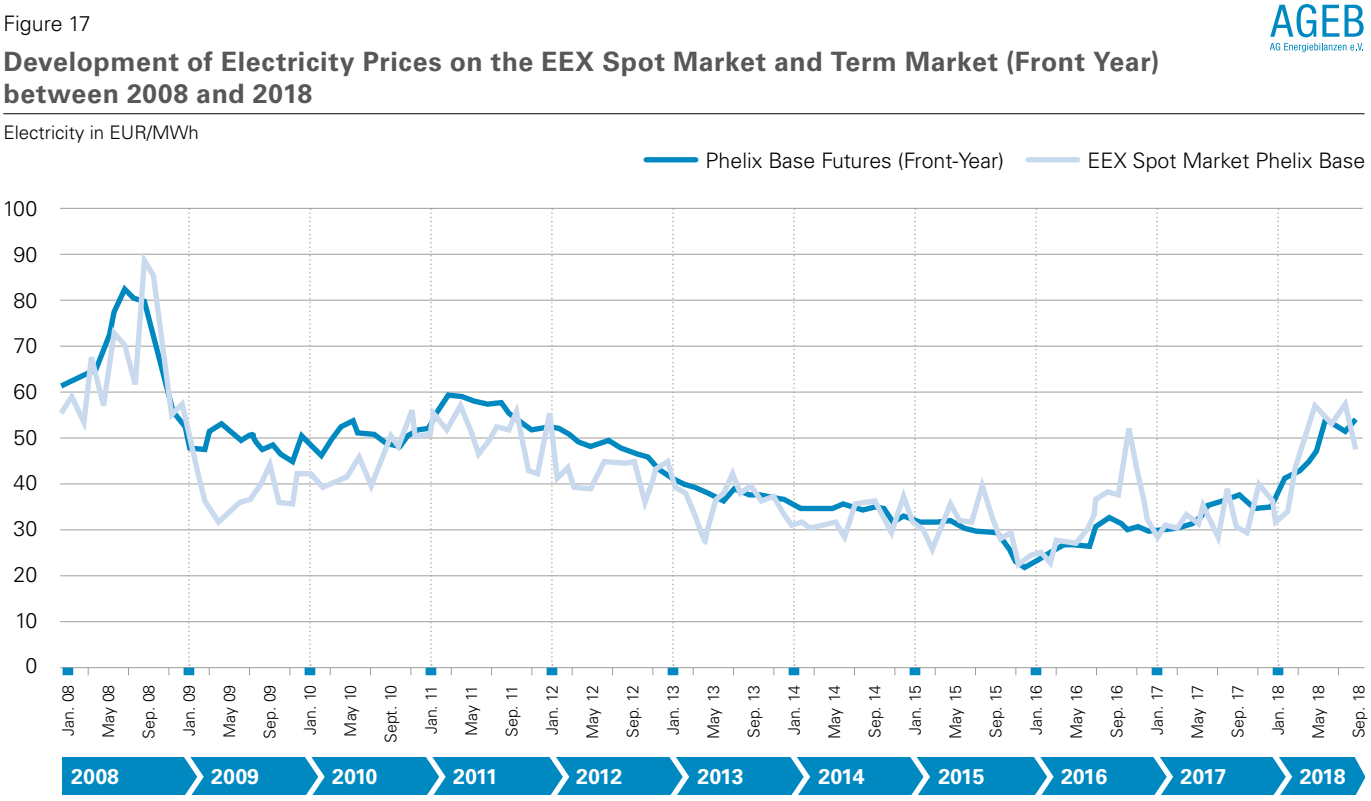
**Electricity Producer Price Index for Special-Contract Customers and Sale to Households in Germany between 2010 and 2018**




*Source: Federal Statistical Office (Destatis)*

Figure 17

**Development of Electricity Prices on the EEX Spot Market and Term Market (Front Year) between 2008 and 2018**




*Source: BMWi*

increase on the exchange: Here, the prices for electricity on the exchange were 28.6 % higher in 2018 than had been the case in the previous year. Compared to the highest level to date which had been reached in 2008, the quoted price for electricity on the exchange was 39.3 % lower.

If one observes the monthly development of the prices for electricity on the exchange since 2008, then one will initially see, after a high in 2008, a strong decline which, after a temporary rise, was followed by a clear development towards price reductions both on the spot market and the futures market commencing during the first half of 2011 and ceasing in mid-2016 (please see Figure 17). However, the subsequent price upswing remained mostly below the limit of € 40 /MWh until the end of 2016. Nonetheless after the turn of 2016/2017, there were considerable price fluctuations of up to more than € 100 /MWh. Since mid-2018, the exchange price mostly exceeded the limit of € 50/MWh.

According to initial calculations made by the German Association of Energy and Water Industries (BDEW), power generation plants supplying the general public (which neither include the power generation plants of mining facilities nor those of the manufacturing industry) emitted 234.1 million tons of $CO_2$ in 2018 (2017: 246.6 million tons of $CO_2$). This equals a decline of more than 5 % when compared to the previous year. The specific $CO_2$ emissions amounted to 0.42 kg $CO_2$/kWh net, which represented a decrease of about 4 % when compared to the previous year. The downward trend of the specific emissions is primarily due to the further increasing power generation from renewables and due to the simultaneous decline in electricity production in coal fired power plants. Just concerning the mix of fossil energy carriers in the power plants of electricity suppliers, the specific $CO_2$ emissions in the reporting year amounted to more than 0.88 kg $CO_2$/kWh net, which was 1 percent more than the previous year's figure.

For the electric power industry, after all the largest group of emitters in Germany, the development of certificate prices for $CO_2$, which are determined within the scope of European emissions trading, continues to be increasingly relevant. A closed time series of $CO_2$ certificate prices is available for the second trading period between 2008 and 2012 and is now also on hand for the first six years of the third trading period between 2013 and 2020. After prices of more than € 20 /t $CO_2$ had initially been recorded, the onset of the global economic crisis in 2008 marked a dramatic decline in

prices which first decreased to values of less than € 15 /t $CO_2$ by early 2009. This was then followed by a longer phase during which the prices remained relatively stable within a range of approximately € 13 /t $CO_2$ to € 17 /t $CO_2$ until May 2011. However, it became all the more apparent that due to the crisis, companies participating in emissions trading had a considerable surplus of additional certificates which was augmented even further by certificates acquired within the scope of CDM projects. This overallocation, which became increasingly more evident, finally resulted in prices which have continuously been below € 5 /t $CO_2$ since early 2013. Only over the course of the year 2014 was there a slight upward trend in the direction of € 7 /t $CO_2$ to € 9 /t $CO_2$ which lasted until late 2015 but came to a new standstill in 2016: During this year, the prices ranged again between € 4 /t $CO_2$ and € 6 /t $CO_2$ (please see Figure 18). After the EU had responded to the high surplus quantities with the implementation of diverse volume-regulating measures and an effective structural reform of emissions trading had been agreed upon for the fourth trading period between 2021 and 2030, the certificate prices increased significantly to more than € 22/t $CO_2$ at the end of 2018. Between January and early March 2019, the prices amounted to € 22.20/t $CO_2$.

Figure 18

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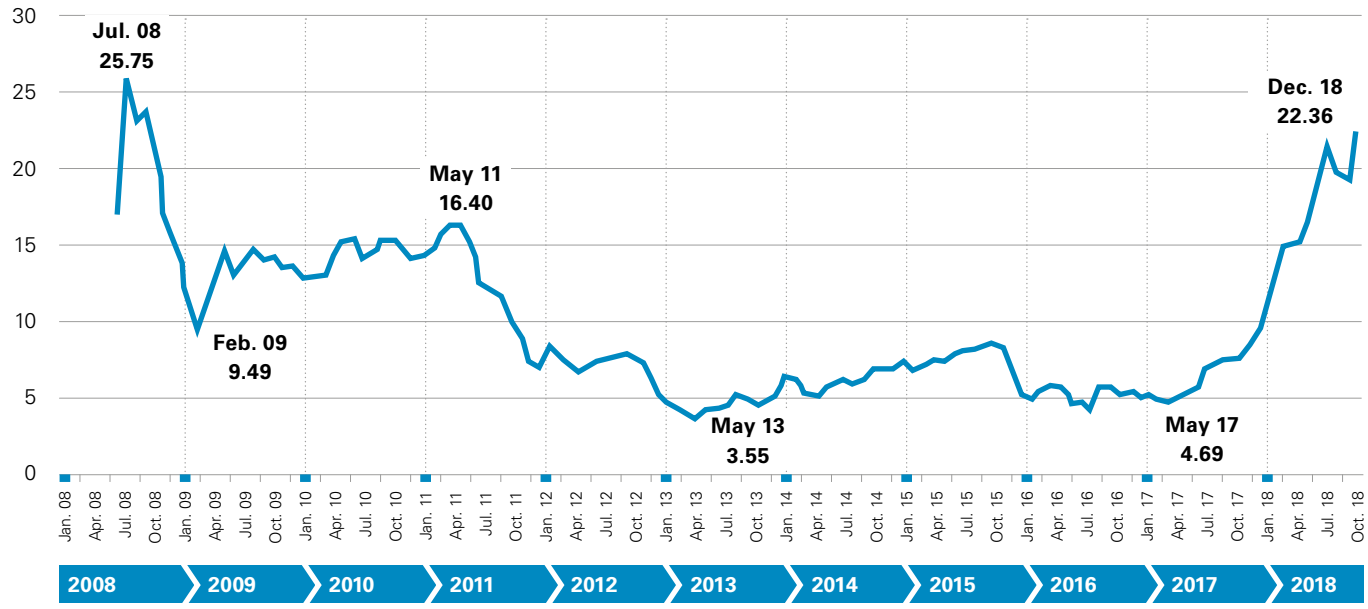
**European Emission Allowances on the EEX Spot Market between 2008 and 2018**

Certificate Prices in /t $Co_2$




*Source: BMWi*

## Provision of District Heating and Cooling

According to first estimates, district heating and district cooling suppliers produced 127 billion kWh of net heat[4] in 2018; an additional 8 billion kWh came from other producers of heat. A total of 135 billion kWh was fed into the heating/cooling grid. Compared to 2017, production decreased by 2.4 %. In 2018, more than 83 % of the net heat production came from cogeneration plants.

According to initial calculations and after deducting the operating consumption, grid losses as well as statistical differences, the net heat consumption sourced from the energy suppliers' grids amounted to 116 billion kWh (2017: 121 billion kWh). The decline in consumption, which was ascertained when compared to the previous year and despite the further expansion of district heat production, is due to the warm weather that started in April. Due to the reduced production of heat, the use of fuel in heating and thermal power stations supplying the general public also went down by a total of about 4 % from 148 billion kWh in 2017 to 142 billion kWh in 2018. The decline affected all energy carriers. Renewables accounted for almost 20 % of the fuel used in Germany's heating and thermal power stations.

According to initial estimates, the heat consumed by private households and the heat supplied to residential buildings went down by 6.5 % to 48.5 billion kWh. The construction of new dwellings which are supplied with district heat only managed to dampen the weather-related decline slightly. A connection to district heating is scheduled for 24.9 % of the 305,000 new residential units for which a construction permit was granted in the reporting year. Primarily in correlation to the economic trend, industrial consumers purchased 45.5 billion kWh of thermal energy which was approximately 2.0 % less than in 2017. The consumption of heat by other customers in 2018 decreased by 5.4 % to approximately 22 billion kWh.

Table 14

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### Balance of Heating and Cooling Companies 2015 to 2018

| | 2015 | 2016 | 2017 | 2018 [1] | Changes 2017/2018 |
|---|---|---|---|---|---|
| | Billion kWh | | | | in % |
| **Net Production** | **134.0** | **138.7** | **138.3** | **134.9** | **-2.4** |
| Mains Losses and Operating Consumption; Statistical Differences | 18.0 | 17.1 | 17.0 | 19.0 | ... |
| **Net Consumption District Heating/ Cooling** | **116.0** | **121.5** | **121.3** | **115.9** | **-4.5** |
| Industry | 47.1 | 47.7 | 46.4 | 45.5 | -1.8 |
| Households Including Housing Companies | 47.6 | 51.7 | 51.9 | 48.5 | -6.5 |
| Other | 21.3 | 22.0 | 23.1 | 21.8 | -5.4 |

*1) Some figures are preliminary and estimates*

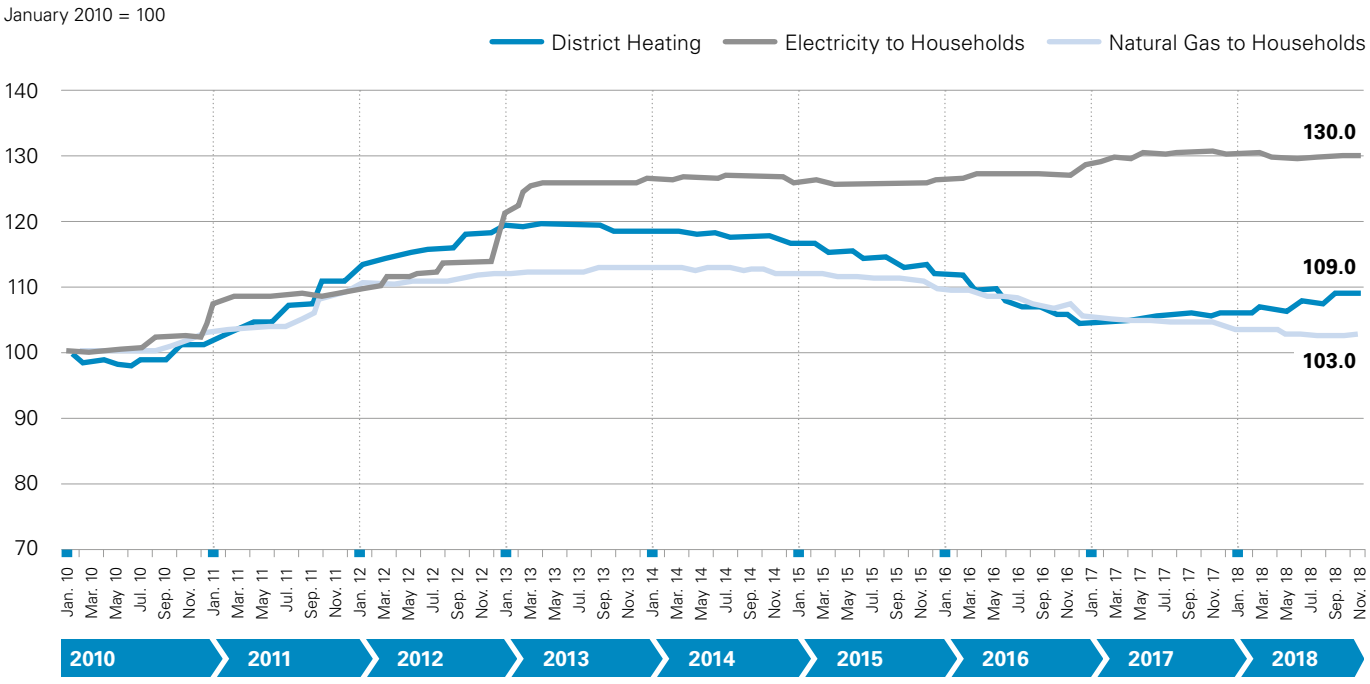
*Sources: Federal Statistical Office (Destatis); BDEW*

*4 Here, reference is always made to district heating and district cooling.*

It is interesting to compare the development of the producer prices for supplying electricity, natural gas, and district heat to households (please see Figure 19). Here, the trends for natural gas and district heat initially exhibit more or less similar curves; since about mid-2017, however, this trend has been replaced by a slight spread with once again increasing prices for district heat, on the one hand, and by a development towards slightly decreasing prices for natural gas, on the other hand. The producer price index for electricity does not follow the downward trend of these two energy carriers. After a significant increase until mid-2013, the curves exhibit a persistent development towards a slight increase until mid-2017 and thereafter a period of stabilization until the end of 2018.

Figure 19

**Producer Price Indices for District Heating, Electricity, and Natural Gas Charges to Households in Germany between January 2010 and December 2018**




*Source: Federal Statistical Office (Destatis)*

## Renewable Energy[5]

In 2018, the consumption of renewable energy sources amounted to a total of 1,809 PJ (61.7 Mtce) (please see Table 15). When compared to the previous year 2017 (1,790 PJ or 61.1 Mtce), this equals a total increase of 1.1 % which translates into an absolute increase of 19 PJ. This development was decisively driven by the progressive expansion of capacities specifically in the sectors photovoltaics and, to a lesser extent, also wind energy as well as, above all, by the partially extreme weather conditions. When considering the entire year, the number of sunshine hours during the period under review had reached a similar level for the last time in 2003; and it exceeded the level of 2017 by more than 26 %. This was complemented by excellent wind conditions on and off the shore in individual months – particularly the months of January and December fell only marginally short of December 2017, which has been the record high feed-in month so far. The positive trend was only dampened by the substantial decline in energy production from hydropower, which was due to extremely low precipitation during the reporting year.

A glance at the individual consumption sectors reveals that renewables are used primarily in facilities and power plants for the production of electricity (including district heating); amounting to a share of 61.6 % as measured by the total primary energy consumption of renewables (2017: 61.4 %). The increased decentralized use of renewables entails that 37.2 % of the energy used is attributable to end consumers (2017: 37.0 %). With a share of 65.8 % in the total final energy consumption of renewables, this segment is essentially dominated by individual hearths such as stoves and fireplaces, solar thermal systems, or heat pumps in private households (2017: 66.3 %). In addition, combined heat and power plants and micro cogeneration plants in the commercial and industrial sector (2018: 17.3 %) designed to generate thermal energy as well as additives to gasoline and diesel fuels in the transportation sector (2018: 17.0 %) also contribute their share to the supply of renewable energy.

*5 It should be noted in this context that all data related to the consumption of renewables stated in Table 15 are based on the data provided by AGEE-Stat. The text was created by AG Energiebilanzen on the basis of the information available therein.*

Table 15

## Renewable Energy in Germany in 2017 and 2018 According to Its Use and Energy Sources

| | Hydropower | | | Wind Energy (Onshore and Offshore) | | | Solar Energy | | | Geothermal Energy | | | Biomass | | | Waste | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | Changes | 2017 | 2018 | Changes | 2017 | 2018 | Changes | 2017 | 2018 | Changes | 2017 | 2018 | Changes | 2017 | 2018 | Changes | 2017 | 2018 | Changes |
| | Petajoules | | % | Petajoules | | % | Petajoules | | % | Petajoules | | % | Petajoules | | % | Petajoules | | % | Petajoules | | % |
| Domestic Production | 72.5 | 59.4 | -18.1 | 380.5 | 401.7 | 5.6 | 170.1 | 198.2 | 16.5 | 55.5 | 59.7 | 7.6 | 973.1 | 964.1 | -0.9 | 134.7 | 120.1 | -10.8 | 1,786.4 | 1,803.2 | 0.9 |
| Foreign Trade Balance | - | - | - | - | - | - | - | - | - | - | - | - | 3.2 | 5.5 | 71.9 | | | | 3.2 | 5.5 | 71.9 |
| **Primary Energy Consumption** | **72.5** | **59.4** | **-18.1** | **380.5** | **401.7** | **5.6** | **170.1** | **198.2** | **16.5** | **55.5** | **59.7** | **7.6** | **976.3** | **969.6** | **-0.7** | **134.7** | **120.1** | **-10.8** | **1,789.6** | **1,808.7** | **1.1** |
| Use in Power Plants (Electricity+Heat) | 72.5 | 59.4 | -18.1 | 380.5 | 401.7 | 5.6 | 141.8 | 166.2 | 17.2 | 7.1 | 7.5 | 5.6 | 380.0 | 376.4 | -0.9 | 117.4 | 102.8 | -12.4 | 1,099.4 | 1,114.0 | 1.3 |
| **Consumption during Conversion. Losses** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **25.3** | **24.0** | **-5.1** | | | | **25.3** | **24.0** | **-5.1** |
| **Final Energy Consumption** | **-** | **-** | **-** | **-** | **-** | **-** | **28.3** | **32.0** | **13.2** | **48.4** | **52.2** | **7.8** | **571.0** | **568.3** | **-0.5** | **17.3** | **17.3** | **0.0** | **665.0** | **669.8** | **0.7** |
| Industry | - | - | - | - | - | - | - | - | - | - | - | - | 98.4 | 98.4 | 0.0 | 17.3 | 17.3 | 0.0 | 115.7 | 115.7 | 0.0 |
| Transportation | - | - | - | - | - | - | - | - | - | - | - | - | 108.7 | 113.6 | 4.5 | | | | 108.7 | 113.6 | 4.5 |
| Households. Trade. Commerce. Services | - | - | - | - | - | - | 28.3 | 32.0 | 13.2 | 48.4 | 52.2 | 7.8 | 363.9 | 356.3 | -2.1 | | | | 440.6 | 440.5 | 0.0 |

*All values for 2018 are preliminary.*

*Source: AGEEStat.*

The analysis of the individual technologies for the use of renewables aptly demonstrates that the energy carrier specific consumption exhibited quite different tendencies (please see Figure 20). Hydropower, which had still contributed a share of 4.1 % to the primary energy consumption of renewables in 2017, dropped to 3.3 % in 2018. The downward trend was caused by one of the driest periods during the past 15 years not only in Germany, but also in some of our neighboring countries. One example that needs to be mentioned here are the months of February to November which experienced on average 30 % less rainfall when compared to the long-term average. As a result, the water levels of a number of rivers dropped in such a way that not only inland shipping, but also the operation of run-of-the-river power plants had to be temporarily discontinued. While a total of 72.5 PJ had been consumed in run-of-the-river and hydroelectric storage plants as well as in pumped storage plants with a natural influx into the upper reservoir and then used for electricity production in 2017, this figure amounted to only 59.4 PJ in 2018. In contrast, the (theoretically) available installed capacity of electric power continued to stagnate at currently about 5.7 GW.

The entire wind year can be seen as thoroughly positive. With a total of 401.7 PJ, the primary energy consumption of onshore and offshore wind energy attained another record result thanks to superb wind conditions; with a share of 22.2 % in the primary energy consumption of renewables, it expanded its second position behind biomass. Compared to 2017 (380.5 PJ), this equals an increase of 5.6 %. In an internal comparison, due to their significantly higher number of plants, wind turbines on land (332.1 PJ, +4.8 %) ranked of course far ahead of wind turbines at sea (69.6 PJ, +9.4 %). Unlike in the preceding years, only a limited number of new onshore wind turbines were put into operation. This has several reasons: Planned wind turbines which had been approved by the end of 2016 had to be built within a transitional period of two years in order to still obtain the legally determined fixed remuneration per fed-in kilowatt hour within the scope of the turbine's entire service life. At the same time, this fixed remuneration had been subject to a strong, quarterly effective degression since early 2017. Both resulted in the fact that due to the pressure of completing the construction, most of the approved wind turbines were built and connected to the grid in the course of 2017. This explains the record high construction of an additional 5.3 GW in 2017.

Figure 20

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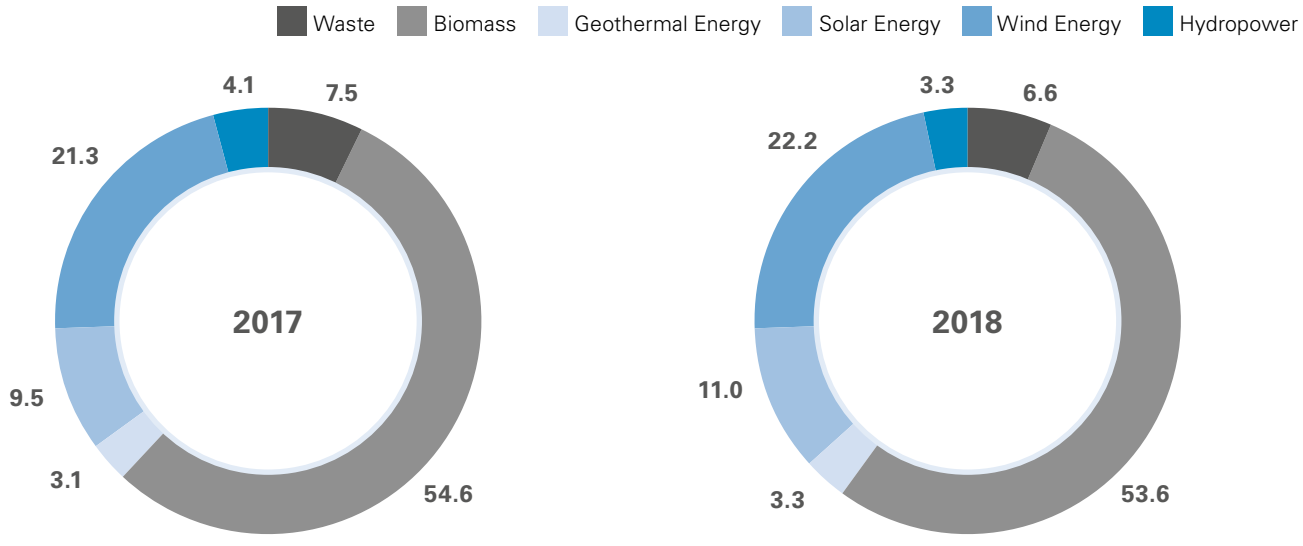
**Structure of Renewable Energy Sources in Germany between 2017 and 2018**

Shares in Total Renewable Energy in %




*Source: AGEEStat.*

Furthermore, it needs to be added in this context that about 1.3 GW of the systems which had been approved by 2016 were still not built by the end of 2018. It may be assumed that lawsuits are currently pending for these systems, or that the potential operators of these systems have decided in favor of participating in the bidding procedure designed to determine the financial support of onshore wind turbines. That is why in a direct comparison, the newly commissioned capacity of about 2.4 GW in 2018 was quite low. The résumé for offshore wind energy turns out to be similar. Even though numerous foundations were built and the construction of wind turbines was actively pursued, not a single newly built turbine at sea was able to feed electricity into the grid during the first six months of 2018. Currently, the installation of new capacities which had actually been built just in the second half of 2018 alone amounts to 1.0 GW after it had been nearly 1.3 GW in the previous year.

In 2018, solar energy's primary energy consumption went up from an initial 170.1 PJ to currently 198.2 PJ and, thus, attained a 11.0 % share in the primary energy consumption of renewables. The strong increase of 16.5 % is primarily due to an extremely productive summer – only during the exceptionally hot summer of 2003 had similar values been measured for sunshine hours and radiation intensity. Thus, 166.2 PJ or 83.8 % accounted for the use of solar energy for electricity production with photovoltaic cells, of which about 89 % were fed into public power grids and approximately 11 % were produced and consumed directly on site. After the installation of additional capacities had been on a continuous decline since 2011 and merely amounted to around one gigawatt in 2015, an upward trend was recorded for the installation of additional capacities since 2016 which culminated in a significant peak in 2018: After 1.5 GW had been installed in 2016 and 1.7 GW in 2017, a total of 2.9 GW of new rooftop and open space systems were installed in 2018. The number of existing systems by the end of 2018 was, thus, well above 45 GW. Unlike photovoltaics, solar thermal collectors supply thermal energy which is primarily used for space heating and drinking water heating. The contribution to the primary energy consumption of renewables in 2018 amounted to about 32 PJ; compared to the previous year, this equals an increase of 13.2 %.

Geothermal energy continued to remain at a low level; even though a new deep geothermal energy facility with an installed electrical capacity of 4.0 MW was put into operation in Bavaria in April 2018. In contrast, heat pumps for heating systems and domestic hot water, whose total number increased to now more than 1 million systems that are mostly installed in private households, augmented their share to 52.2 PJ. This equals an increase of 7.8 % when compared to the previous year. All told, the contribution of geothermal energy was 59.7 PJ (2017: 55.5 PJ); this equals a low share of 3.3 % in the primary energy consumption of renewables.

Biomass, which accounted for a current share of 53.6 % in the primary energy consumption of renewables, consists of diverse solid, liquid, and gaseous fuels; while wood in the form of wood logs, wood chips, pellets, or briquettes continued to be the most important source with more than half of the biomass. Liquid fuels such as palm kernel oil or rapeseed oil as well as biofuels such as biodiesel and bioethanol assume only a secondary role. Usually, biogas is either used on site in biogas plants with an attached combined heat and power plant or freed from impurities in specific processing plants and fed into the natural gas grid as biomethane. In contrast, landfill and sewage gases are – similar to biogas – above all energetically recycled on site. Thus, gaseous biomass contributed well above one third to the primary energy consumption of biomass. Considering the overall situation, the primary energy consumption of biomass went down slightly to 969.6 PJ when compared to the previous year's level (976.3 PJ). Due to the warm weather, the consumption of biomass particularly in households recorded a decline of 2 % whereas the sale and/or use of biofuels as additives to gasoline and diesel increased considerably (+4.5 %). Yet when it comes to biogas plants, the additional net capacity of almost 400 MW which was installed over the course of the year was almost exclusively designed to provide more flexibility for plants and systems (of which just above 25 MW accounted for new plants) and is, thus, only partially relevant for consumption.

And finally, biogenic waste contributed 120.1 PJ, which equals 6.6 %, to the primary energy consumption of renewables.

## $CO_2$ Emissions

As mentioned above and according to preliminary calculations made by the German Association of Energy and Water Industries (BDEW), power generation plants supplying the general public emitted 234.1 million tons of $CO_2$ in 2018. This was 12.5 million tons of $CO_2$ or 5 % less than in 2017 when the $CO_2$ emissions had amounted to 246.6 million tons in this segment. Since the level and structure of power generation in the plants of mining facilities and the manufacturing industry changed only a little towards becoming emission-free between 2017 and 2018, the values indicated by the BDEW are to be expected to that extent for the entire electricity sector. If, for a first estimate of the total energy-related $CO_2$ emissions, the calculation were to be based on the reduction of the original values of primary energy consumption (2018/2017: -3.5 %), and when taking the decreased energy intensity of primary energy consumption into account, then an even stronger declining emissions level is to be anticipated. The rough calculations made in this regard come to the conclusion that the energy-related $CO_2$ emissions might have been decreased by approximately 34 million tons of $CO_2$.

If the calculation were to be based on the aforementioned emissions reduction for the electricity sector, then about 21 million tons of $CO_2$ less would have been emitted in the other sectors. A reduction of emissions is likely to have occurred in the transportation sector for the first time ever since 2009, if one takes the decline in the consumption of gasoline and diesel fuels into account. This could entail an overall emissions reduction of about 5 million tons of $CO_2$. Due to the significantly declining consumption of light fuel oil, additional emissions reductions ought to be recorded for the other final energy sectors; roughly calculated, about 8 million tons less $CO_2$ ought to be anticipated for these sectors. The decline in the consumption of other mineral oil products (for example, heavy fuel oil and liquid gas) ought to have resulted in an emissions reduction of another 6 million tons. And when it comes to the supply of thermal energy based on natural gas, in light of the estimated changes in the consumption of natural gas in 2018, the emissions ought to have decreased by almost 2 million tons of $CO_2$ when compared to 2017. All told, emissions reductions of 21 million tons of $CO_2$ seem to be plausible and presentable above and beyond the electricity sector.

Irrespective of the emissions trend for the individual sectors, it needs to be stated here that even though the overall emissions in Germany experienced a significant decline in 2018, they continued to stay far behind the objective of reducing 40 % of the greenhouse gas emissions by 2020. In order to still attain the objective for 2020, which is 753 million tons of $CO_2$ equivalents, emissions would have to be reduced by an annual 55 million tons of $CO_2$ equivalents both for the current year 2019 and for 2020. This – admittedly – simplified calculation aptly demonstrates the enormous challenges that continue to be imposed on the requisite reduction measures which are necessary to reach the objective by 2020. From today's perspective, it does not seem possible that this objective can be achieved. Hence, it will first and foremost be paramount to close the target gap for 2020 to the maximum possible extent and to turn all efforts towards achieving the objectives for 2030 in a safe and secure manner.

In this context, a continuing problem should once again be highlighted which, seen from the emissions' perspective, is associated with the fact that those emissions which originate from domestic electricity production and are accompanied by the high export surplus ought to be allocated to Germany according to the territorial principle. At the same time, emission-generating electricity production in the supplied countries is most likely to be displaced which, in turn, will lead to lower emissions in those countries. But it is questionable whether the emissions balance will be positive when viewed from an international perspective. This depends primarily on the specific emissions of the export flow in relation to the specific emissions of the electricity displaced in the individual recipient country.

## Conclusion

According to preliminary calculations made by the Arbeitsgemeinschaft Energiebilanzen (AG Energiebilanzen) – Working Group on Energy Balances (Energy Balances Group), energy consumption in Germany decreased by 3.5 % in 2018. Thus, Germany's energy consumption dropped to its lowest level since the early 1970s. Responsible for the lower energy consumption were, above all, increased prices for energy, the mild weather as well as improvements in energy efficiency. In light of the weakening economic development and the moderate growth in population, the usual consumption-enhancing effect of the factors economic climate and growth in population was actually not that relevant in 2018. Without the consumption-decreasing impact of the mild weather, consumption would have fallen 2.4 % below the previous year's level.

As measured by the original values, the macroeconomic energy productivity improved considerably in 2018. With a rate of 5.2 %, it more than doubled when compared to the previous year (+2.5 %). Even the temperature-adjusted rate of 4.0 % in 2018 was still significantly above the long-term average of 2.0 %.

Except for renewable energy (+1.1 %), consumption of all other energy carriers declined more or less significantly. For example, the consumption of hard coals went down by 11.2 %, of mineral oil by 5.0 %, and of lignite by 2.9 %, followed by natural gas with a minus of 1.6 %. Electricity production from nuclear energy decreased slightly by 0.4 %.

With a share of 34.3 % in primary energy consumption, mineral oil continued to be the most important energy carrier; followed by natural gas which managed to increase its share to 23.7 %. Renewable energy carriers ranked third with a current share of 14.0 % – ahead of lignite with 11.3 % and hard coal with 10.0 %. The share of nuclear energy increased slightly to 6.4 % in 2018.

Similar to primary energy consumption, gross electricity consumption also went down in 2018; albeit the decline of 0.7 % to almost 595 billion kWh was significantly weaker. Compared to the previous year, the macroeconomic electricity productivity improved by 2.1 % in 2018, which was a substantial 70 % higher than the annual average of 1.2 % between 1990 and 2017.

As measured by the producer price index, electricity prices developed differently in 2018 for each respective customer group: While they remained virtually unchanged with a plus of 0.1 % for households, they even dropped slightly by 0.5 % for commercial customers. The prices for special-contract customers at the low voltage level went up by 1.4 %. In contrast, a substantially stronger increase of 9.6 % was recorded for special-contract customers at the high voltage level. Particularly hefty was the price increase on the exchange: Here, the prices for electricity were 28.6 % higher in 2018 than had been the case in the previous year. Compared to the highest level to date which had been reached in 2008, the quoted price for electricity on the exchange was 39.3 % lower.

In 2018 as well, international oil prices, which determine the German price for crude oil imports, and the Euro/US Dollar exchange rate developed with substantial short-term fluctuations. An interim rock bottom price of US $ 46.37/bbl in mid-2017 was followed by an increase that continued over a longer period of time to about US $ 81/bbl in October 2018. By the end of 2018, the import prices declined once again to approximately US $ 65/bbl. The German import prices for crude oil changed mostly parallel to this; they were, however, also influenced by extreme fluctuations in the exchange rates.

As a result, the German import prices for crude oil increased at an annual average rate of 26.3 % from € 358 per ton in 2017 to € 452 per ton in 2018. At the end of 2018, though, they once again dropped to € 382 per ton – 7.6 % less than in December 2017. While the import volumes for crude oil were more than 6 % lower, the expenditures for crude oil imports increased by 18.6 % from 32.5 billion euros to 38.5 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. Over the course of the year 2018, gasoline, diesel fuel, and light fuel oil experienced a substantial increase in prices until at least November; namely, by 40.7 % for light fuel oil, by 22.4 % for diesel fuel, and by 13.2 % for premium gasoline between November 2017 and November 2018. Calculated over the course of the year, the prices in 2018 for light fuel oil were 21.7 %, for diesel fuel 11.5 %, and for premium gasoline 6.7 % higher than in 2017. As measured by the producer price index, the prices for mineral oil products in Germany were on an annual average and in total 11.2 % higher in 2018 than in 2017.

In 2018, the import prices for natural gas increased significantly. On an annual average, a price of 1.92 ct/kWh had to be paid; this equals an increase of 12.7 % when compared to 2017. As measured by the producer price indices and parallel to the import prices for natural gas, the price level for natural gas at the energy exchange increased by 29 % while the sales prices to power plants went up by 13 %. For large industrial clients, the purchase prices increased by 12 % when compared to the previous year because natural gas had to be procured at shorter notice; small industrial gas consumers had to pay 6 % more. The gas prices for the trade, commerce, and service sector remained virtually unchanged and those for private households decreased by almost 2 %.

For the electric power industry, but also for the plants and facilities for whom emissions trading is compulsory in other sectors, the development of certificate prices for $CO_2$, which are determined within the scope of European emissions trading, has just recently become increasingly relevant once again after a long phase of low certificate prices. While the certificate prices had ranged only between € 5.23/t $CO_2$ and € 7.54/t $CO_2$ in 2017, the prices in 2018 increased from € 8.34/t $CO_2$ in January to € 15.15/t $CO_2$ in June all the way to a final € 22.36/t $CO_2$ in December. The EU responded to this development with a number of volume-regulating measures and with the structural reform of emissions trading which was agreed upon for the fourth trading period between 2021 and 2030.

In light of the objectives pursued by the German Federal Government in conjunction with its energy concept, the first energy-related data for 2018 actually provide mixed results. For example, there are no more doubts – and the Federal Government has admitted this for quite some time now – that the objective of reducing primary energy consumption by 20 % in 2020 compared to 2008 will not be attained. That is why the requisite measures which have been launched by the Federal Government so far would not suffice in any case within the short time remaining.

Similar considerations apply to electricity consumption which is to be reduced by 10 % between 2008 and 2020. Here as well, it becomes apparent that additional efforts are necessary. In 2018, electricity consumption decreased by only 3.9 % or, on an annual average, by only 0.4 % when compared to 2008. In order to still reach the objective for 2020, the total electricity consumption would have to be reduced by another 6.4 % or by an annual average of 3.2 % when compared to 2018. However, when assessing the electricity objective, it should be borne in mind that specifically because of renewable energy's great relevance for the production of electricity, innovative electricity applications based on renewables are also penetrating the market and will, thus, stimulate electricity consumption. In this respect, a reinterpretation of the electricity objective in the direction of "conventional" electricity consumption might be useful.

Last but not least, in the aftermath of the commitments made at the UN Climate Change Conferences of Paris 2015 and Katowice 2018, and based on the findings gained from the latest IPCC Special Report, the objective pursued by Germany of reducing greenhouse gas emissions by 55 % by 2030 when compared to 1990 plays a key role in this. If one were to follow the considerations referred to above, then the greenhouse gas emissions in 2018, based on the original values, will probably be about 31 % lower than in 1990. In order to attain the 55 % reduction by 2030, the greenhouse gas emissions would have to be reduced until then by around 34 % or by 300 million tons of $CO_2$ equivalents in total or by 25 million tons of $CO_2$ equivalents per year during the remaining twelve years when compared to 2018. In comparison, an emissions reduction of only 128 million tons of $CO_2$ equivalents in total or by an average of 11 tons of $CO_2$ equivalents per year was achieved during the past twelve years between 2006 and 2018. This means that the average emissions during the upcoming twelve years would have to be reduced at a rate that is 2.4 times higher every year until 2030 than this has actually been the case during the past twelve years.

This will unavoidably result in a fundamental reorientation of the energy and climate protection policy. For the energy sector, the Commission for Growth, Structural Change, and Employment has published important recommendations which not only include the gradual decommissioning of coal fired power plants, but also the increased use of renewables for the generation of electric power as well as the Federal Government's compulsory share of 65 % for electricity consumption in 2030. For the electricity sector, this might suffice; however, substantial efforts are still necessary to improve the energy efficiency in individual sectors and to reduce the energy consumption particularly in the transportation and building sectors so that the overall objective can be attained. Here again, the requisite measures continue to be missing.

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