BACKGROUND // MARCH 2021

Renewable energies in Germany

Data on the development in 2020

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Content

Renewable energies in 2020

On behalf of the Federal Ministry for Economic Affairs and Energy, the Working Group on Renewable Energy Statistics (AGEE-Stat) takes stock of the use of renewable energies and annually prepares an official estimate of the development of renewable energies for the previous year. This background paper describes the initial findings for the electricity, heat and transport sectors, supplemented by figures on the economic effects and emissions avoidance through renewable energies. In addition, some selected indicators on weather conditions are presented in the annex to better understand current developments.

The data presented here are preliminary and will be updated in the course of the year as further official statistics become available.

Development of renewable energies in 2020—most important facts:

Share of renewables in gross electricity consumption rises to 45.4 percent
The share of renewable energies in gross electricity consumption has grown continuously in recent years. The amount of electricity generated from renewable sources also increased in 2020. Due to the Corona pandemic, the overall electricity demand fell at the same time, resulting in a strong increase in the share of renewable electricity from 42.0 percent to 45.4 percent in the year 2020.

Share of renewables for heating and cooling slightly higher than in 2019
Milder weather and the effects of the Corona pandemic lead to a lower total heat consumption in 2020 compared to 2019. Although the use of renewable energies in the heating sector fell slightly, the overall share of renewables in heat consumption rose slightly from 15.0 percent in the previous year to 15.2 percent in 2020.

Share of renewables in final energy consumption for transport rises to 7.3 percent
Sales of biofuels (especially biodiesel/HVO) grew significantly in 2020. The reason for the increase was the raising of the greenhouse gas reduction quota from four to six percent. Because the use of conventional fuels decreased due to restrictions during the Corona pandemic, the share of renewables rose significantly from 5.6 to 7.3 percent.

Share of renewables in total gross final energy consumption – EU target met
2020 was the target year of the EU's Renewable Energy Directive of 2009, in which Germany committed itself to increasing the share of renewable energies in total gross final energy consumption – across all sectors – to at least 18 percent. Taking into account currently available data, this target has been exceeded – largely due to corona effects – at 19.3 percent.

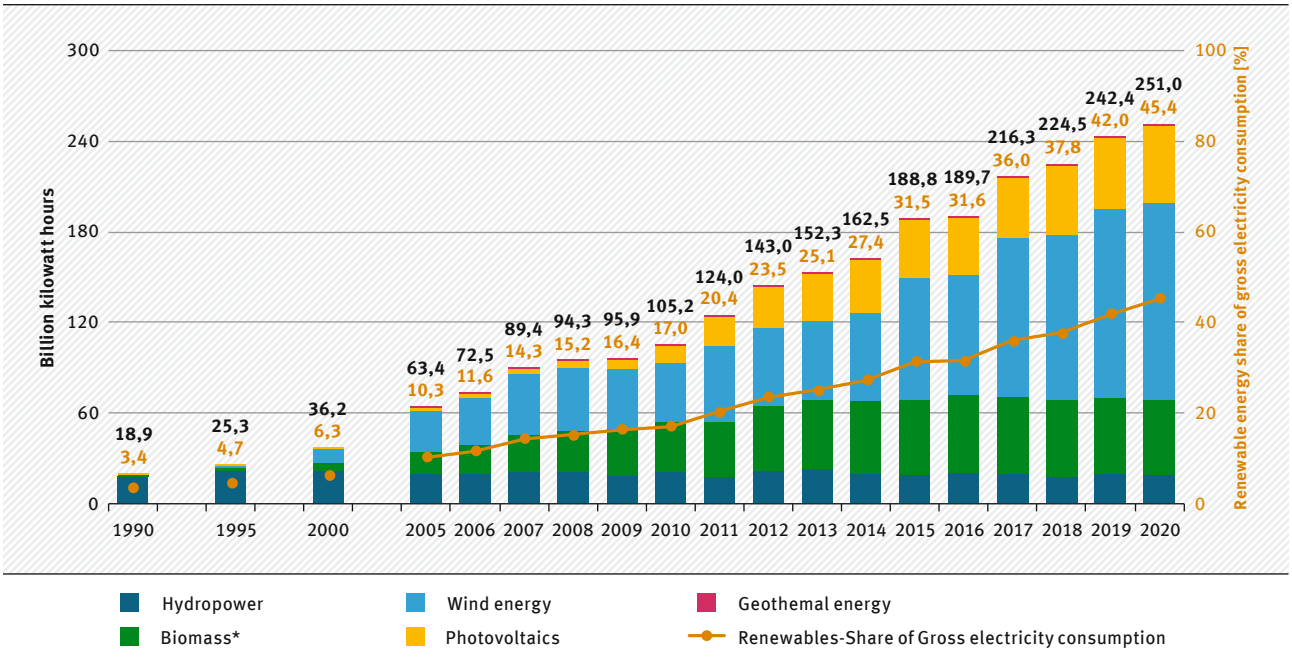
Renewables avoid 227 million tonnes of greenhouse gas emissions
The use of renewable energies reduces the use of fossil fuels and, at the same time also reduces the emission of greenhouse gases and air pollutants. The contribution of renewable energies to climate protection summed up to to around 227 million tonnes of avoided CO_2 equivalents in 2020.

Investments and economic effects
Overall, investments in renewable energy plants increased slightly and amounted to around 11.0 billion euros in 2020. The economic impulses from the operation of the plants also grew and amounted to 18.2 billion euros.

Electricity generation from renewable sources grows due to good weather conditions

Figure 1

Development of electricity generation from renewable energies



* including solid and liquid biomass, biogas, biomethan, landfill gas, sewage gas, sewage sludge and the biogenic fraction of waste

Source: Federal Ministry for Economic Affairs and Energy based on AGEE-Stat, Time series of the the development of renewable energies in Germany

After continuous growth in previous years, electricity generation from renewable energies also increased in 2020. For the first time ever, renewable energy sources generated more electricity than all fossil energy sources (coal, gas and oil) combined. Wind energy was also able to expand its position as the most important energy source in the German electricity mix.

Overall, the share of electricity generated from renewable energies in gross electricity consumption was 45.4 percent, 3.4 percentage points higher than the previous year's figure (42.0 percent). In addition to the increased amount of renewable electricity, a significant decrease in total electricity consumption (minus four percent) due to the Corona pandemic was particularly responsible for the increase.

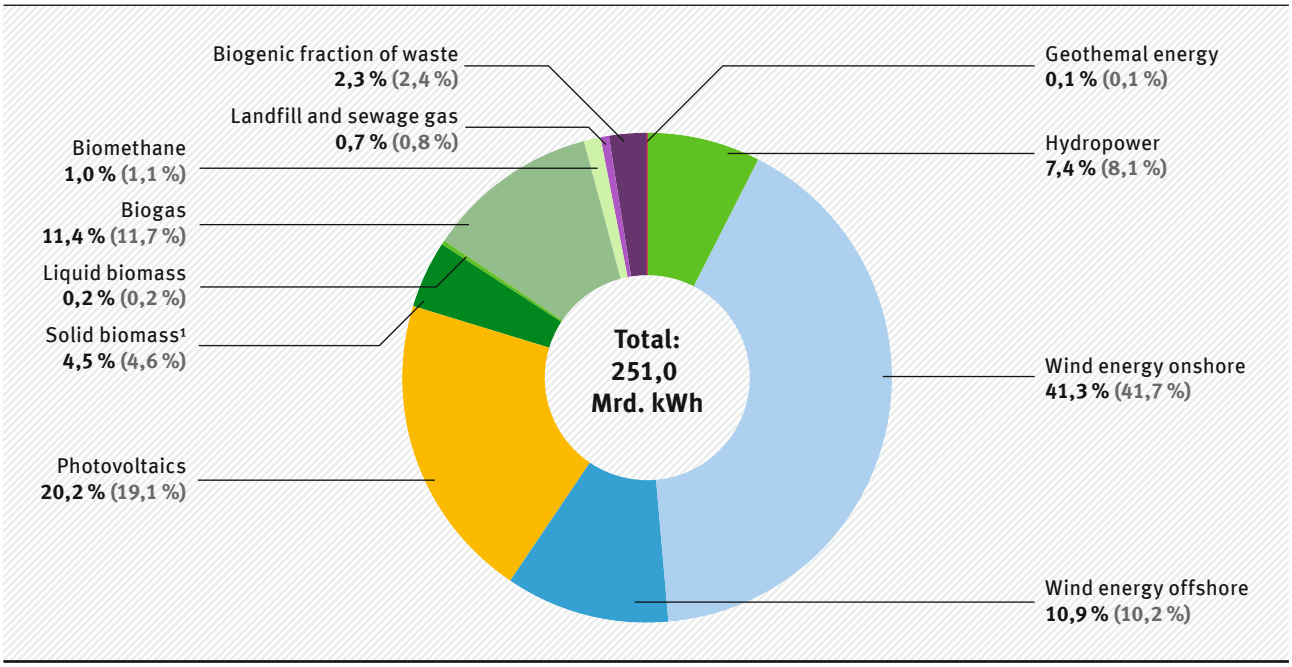
At 251.0 billion kilowatt hours (billion kWh), electricity generation from renewable sources was almost four percent above the level of the previous year (242.4 billion kWh). This positive development was driven in roughly equal parts by wind energy and photovoltaics (PV). These two energy sources also contributed the largest shares of renewable electricity generation: 52 percent came from wind power plants and 20 percent from PV plants. Wind turbines and PV plants benefited from sunny weather and very good wind conditions in 2020.

However, looking at the development during the year, it is noticeable that the entire annual growth of renewables was already achieved (due to favourable weather conditions) in the first half of the year. Renewable electricity generation in the second half of the year was slightly below the respective 2019 figure, reflecting not only less favourable weather but also the hampered development of new wind energy capacities in recent months.

Figure 2

Electricity generation from renewable energies in 2020

Share in percent [%], values for previous year in brackets



¹ incl. sewage sludge

Source: Federal Ministry for Economic Affairs and Energy based on AGEE-Stat, Time series of the the development of renewable energies in Germany

Photovoltaics (PV)

In 2020, electricity generation from PV systems rose by around nine percent year-on-year to 50.6 billion kWh (2019: 46.4 billion kWh). Especially very sunny wheather conditions in the first half of the year were responsible for this significant increase. Additionally, the significant addition of new PV plant capacities also made a strong contribution to the positive development.

In each of the previous three years, photovoltaics benefited from very good weather and high global radiation (see Appendix, Figure 14). 2018 was the year with the highest global radiation in the last 30 years. The year 2020 reached the third place in this ranking.

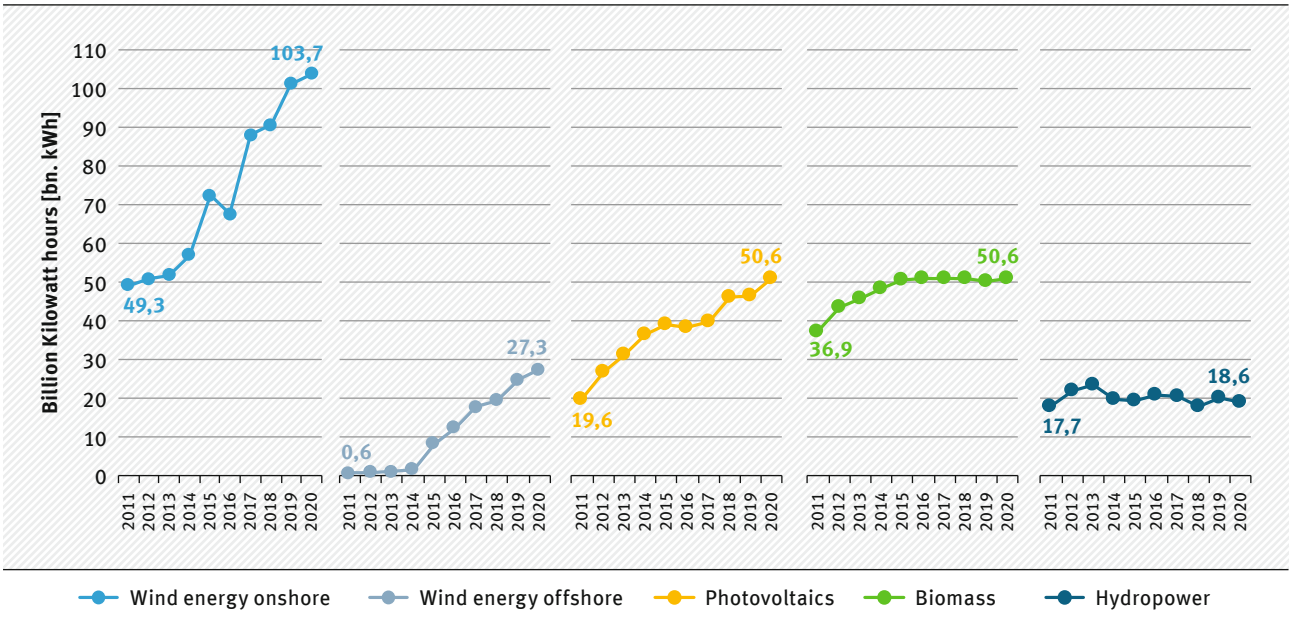
After the record expansion of PV systems in 2012 (8,161 megawatts), the number of newly installed systems declined sharply in the following years. Since 2015, however, the annual addition of PV capacity has been rising steadily.

This trend was also clearly evident in 2020: With 4,801 megawatts (MW), capacity addition increased again compared to the previous year (2019: 3,889 MW). Reasons were a further decrease in the cost of PV modules and corresponding storage systems. At the end of 2020, PV systems with a total capacity of 53,848 MW were installed in Germany. This means that total capacity grew by almost 10 percent compared to 2019 (49,047 MW).

An originally planned “PV cap” of 52,000 MW, which would have led to the elimination of the EEG feed-in tariff for new PV installations, was cancelled by the federal government in the course of the year.

Figure 3

Development of electricity generation from renewable energy sources in the last 10 years



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

Wind energy

Wind turbines on land and at sea generated 131.0 billion kWh of electricity in 2020 – an increase of four percent over the previous year (125.9 billion kWh). Wind energy thus contributed about half of renewable electricity and covers almost 24 percent of Germany's gross electricity consumption. It consolidated its position as the most important energy source in the German electricity mix. However, electricity generation from wind turbines benefited from a few exceptionally windy months at the beginning of the year. In contrast, wind power production in the second half of the year fell short of the production in the second half of 2019.

The amount of electricity generated from onshore wind energy plants rose only moderately. At 103.7 billion kWh, the previous year's value (101.1 billion kWh) was exceeded by slightly more than two percent. The electricity generation increasingly reflects the slow expansion of onshore wind power. Compared to the record addition in 2017 (4,891 MW), the net addition of new onshore wind turbines remained at a very low level in 2020 (1,227 MW). However, the historically low value from the previous year (865 MW) was exceeded. At the end of 2020, onshore wind turbines with a total capacity of 54,420 MW were installed in Germany. This means that the total capacity grew by two percent compared to the previous year (53,193 MW).

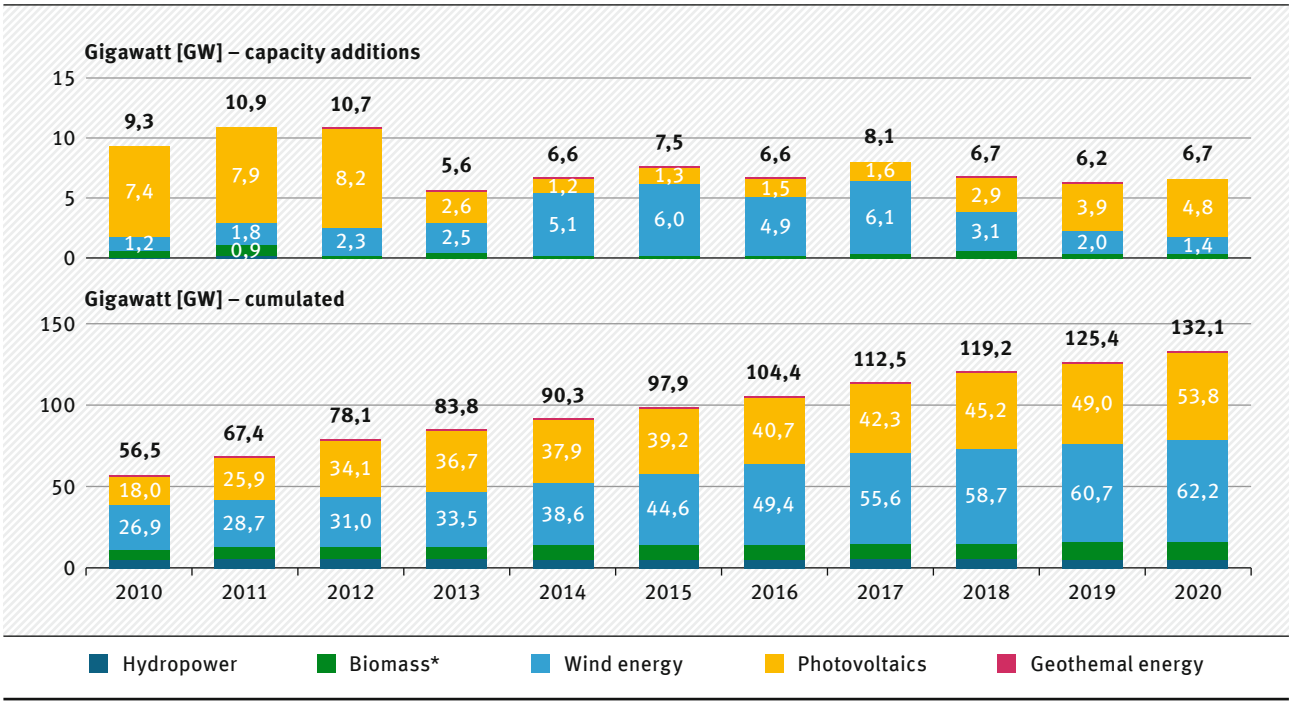
At sea (offshore), only a few wind turbines were added in 2020. In total, only 219 MW of new capacity was installed and connected to the grid. Overall, the installed capacity of offshore wind turbines increased by about three percent from 7,528 MW (2019) to 7,747 MW at the end of 2020. The significant additions in the second half of 2019 were still noticeable in electricity generation: With 27.3 billion kWh, about ten percent more electricity was generated than in the previous year (24.7 billion kWh).

Biomass

In 2020, more capacity was added for electricity generation from biomass (397 MW) than in 2019 (307 MW). As in previous years, a high proportion of the newly installed capacity was used to increase generator output of existing plants without increasing

Figure 4

Development of the expansion and installed capacity for electricity generation from renewable energies



* including solid and liquid biomass, biogas, biomethan, landfill gas, sewage gas and sewage sludge, as well as the biogenic fraction of waste

Source: Federal Ministry for Economic Affairs and Energy based on AGEE-Stat, Time series of the the development of renewable energies in Germany

feedstock capacity. This practice aims to promote flexible and demand-oriented electricity generation from biogas and biomethane. Thus, despite the increase in capacity, electricity generation from these two energy sources increased only marginally from 31.0 billion kWh (2019) to 31.3 billion kWh (2020). For plants using solid and liquid biomass, installed capacities and the related electricity generation changed only insignificantly.

Overall, electricity generation from biomass increased by about one percent compared to the previous year. Including sewage and landfill gas as well as the renewable share of municipal waste, around 50.6 billion kWh of electricity was generated (2019: 50.2 billion kWh). All types of biomass together provide about 20 percent of the total renewable electricity and thus cover about nine percent of the total gross electricity consumption.

Hydropower

Another dry year in 2020 caused electricity generation from hydropower to fall below the previous year's value (19.7 billion kWh) to 18.6 billion kWh. In the past ten years, only in two years (2011 and 2018) less electricity was generated from hydropower plants. The share of hydropower in total gross electricity consumption was just over three percent. In 2020 only 10 MW of new hydropower capacity was added.

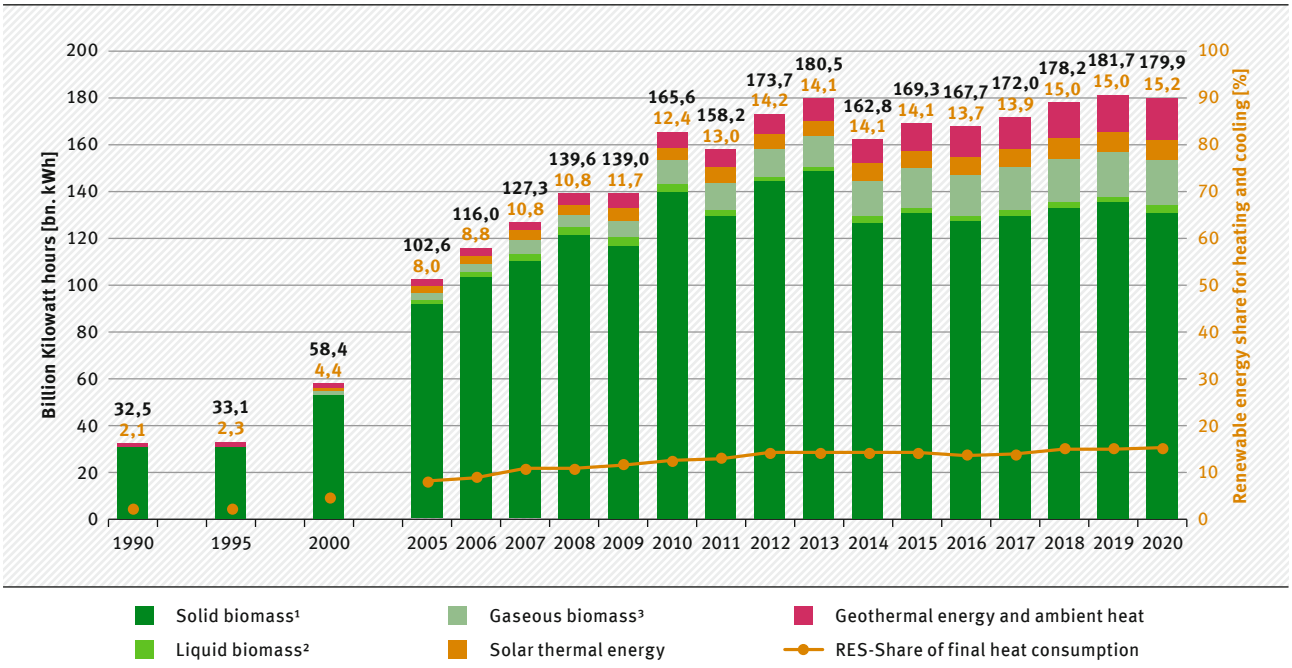
Geothermal energy

Although the amount of electricity generated from geothermal energy increased by about ten percent in 2020, its share of total gross electricity consumption in Germany was still less than 0.1 percent (about 0.2 billion kWh).

Share of renewables for heating and cooling slightly higher

Figure 5

Development of final energy consumption for heat from renewable energies



¹ incl. sewage sludge and the biogenic fraction of waste
² incl. biofuels used in agriculture, construction and military
³ biogas, biomethane, sewage- and landfill gas

Source: Federal Ministry for Economic Affairs and Energy based on AGEE-Stat, Time series of the the development of renewable energies in Germany

According to currently available data, the final energy consumption of renewable energies for heating and cooling was slightly below the level of the previous year at 179.9 billion kWh (2019: 181.7 billion kWh).

Due to the relatively warm weather and the effects of the Corona pandemic it is estimated that the total final energy consumption for heating and cooling fell slightly more than the renewable part. In total, this led to a slight increase in the share of renewable heat to 15.2 percent (plus 0.2 percentage points).

2020 showed different developments for the individual renewable heat technologies: Biomass and biogenic waste, for example, showed a decline in heat generation due to weather conditions (minus two percent). At the same time, developments in solar thermal energy and geothermal energy heat use pointed in a positive direction. Due to higher solar radiation compared to the previous year, heat utilisation from solar thermal systems increased by about three percent. With an increase of nine percent, the increase in heat use from geothermal and environmental heat pumps was even stronger.

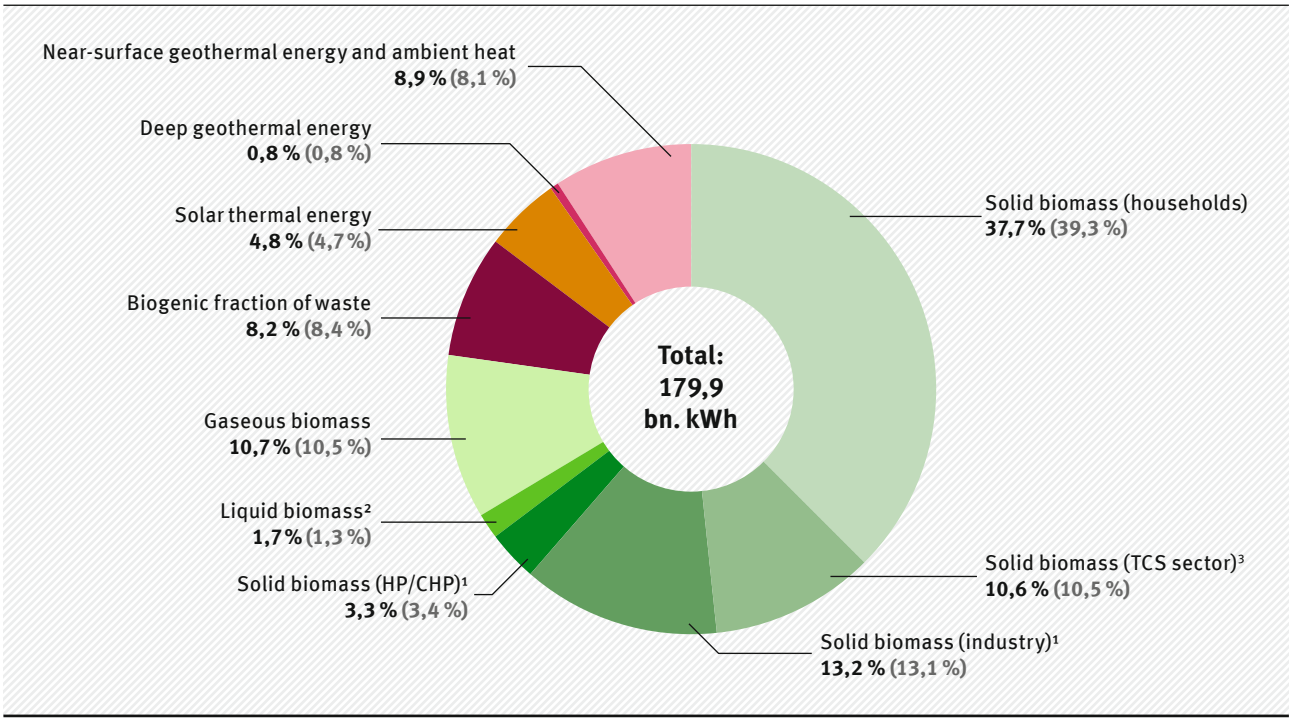
Biomass

With a share of 85 percent, biomass (including biogenic waste) remained by far the most important renewable heat source. The total amount of heat provided from biomass fell by two percent from 157.2 billion kWh in 2019 to 153.8 billion kWh in 2020. Currently, the figure is still based on estimates. In late summer, the results of empirical surveys on the use of wood by private households will be available, which might deviate from current data. Further statistical data on the use of solid biomass in the service sector and industry will also be available in the course of the year 2021.

Figure 6

Final energy consumption for heat from renewable energies in 2020

Share in percent [%], values for previous year in brackets



¹ incl. sewage sludge (HP/CHP = heating plants and combined heat and power plants)
² inkl. biofuels used in agriculture, construction and military
³ since 2015 data for the TCS (trade, commercial and service) sector available

Source: Federal Ministry for Economic Affairs and Energy based on AGEE-Stat, Time series of the the development of renewable energies in Germany

Geothermal energy and ambient heat

As in previous years, the heat pump market grew in 2020, according to the German Heat Pump Association (BWP). With around 120,000 heat pumps, 40 percent more systems were sold than in 2019. As a result of the continued increase in system sales, the total number of installed heat pumps increased by about 12 %. In total, about 1.3 million heat pumps contributed to the generation of renewable heat in 2020.

The increasing number of installations is also reflected in an increase in heat generation: Together with deep geothermal and balneological installations (thermals baths), a total of 17.5 billion kWh of heat was generated from geothermal and environmental heatpumps in 2020. This was nine percent more than in the previous year (16.0 billion kWh) and corresponded to almost 10 percent of total renewable heat production.

Solarthermal energy

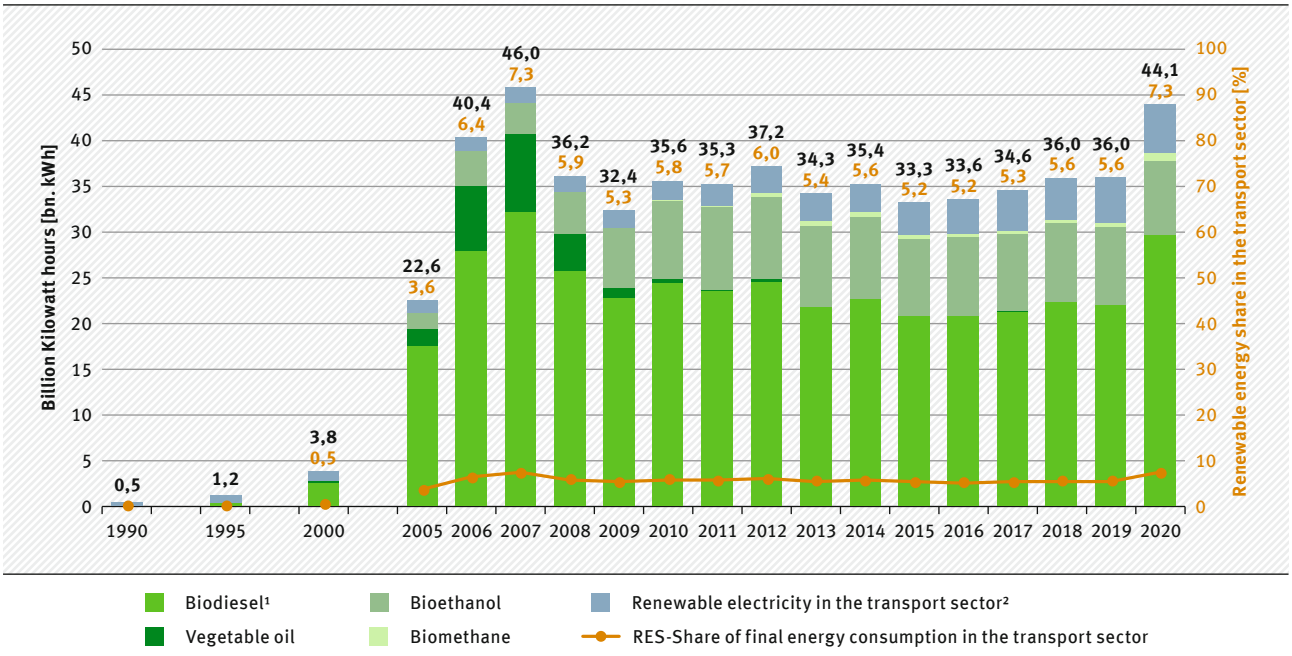
The installation of solar thermal collector systems had declined continuously since 2012. This trend was stopped in 2020. According to the German Solar Industry Association (BSW) the total new installed collector area in 2020 was around 643,500 square metres. This value was significantly higher than the previous year's figure (511,000 square metres). Taking into account the dismantling of old systems, it is estimated that a total solar thermal collector area of more than 19.3 million square metres was installed in Germany at the end of 2020.

Heat generation from solar thermal installations in 2020 was 8.7 billion kWh, and thus about three percent higher than in 2019 (8.5 billion kWh). However, the peak value from 2018 (8.9 billion kWh) was not reached.

Share of renewable energies in the transport sector increases significantly

Figure 7

Development of final energy consumption from renewable energies in the transport sector



¹ consumption of biodiesel (incl. HVO) in transport sector, without use in agriculture and forestry, building sector and military
² Calculation based on share of renewable electricity consumption of current year

Source: Federal Ministry for Economic Affairs and Energy based on AGEE-Stat, Time series of the the development of renewable energies in Germany

In 2020, the share of renewable energies in total final energy consumption in transport increased significantly from 5.6 percent to 7.3 percent. The reason was a strong increase in the use of renewable energy sources with a simultaneous decline in total fuel consumption.

Sales of biofuels, for example, rose by almost a quarter due to the legal requirements within the framework of the greenhouse gas reduction quota. Additionally, the use of renewable electricity in transport also grew by almost ten percent.

The growth of renewable energy sources contrasts with a significant decline in total energy consumption in the transport sector. According to preliminary estimates, final energy consumption in transport in 2020 was just under 604 billion kWh, and thus seven percent below the previous year's figure (647 billion kWh) and lower than in any year since 1990.

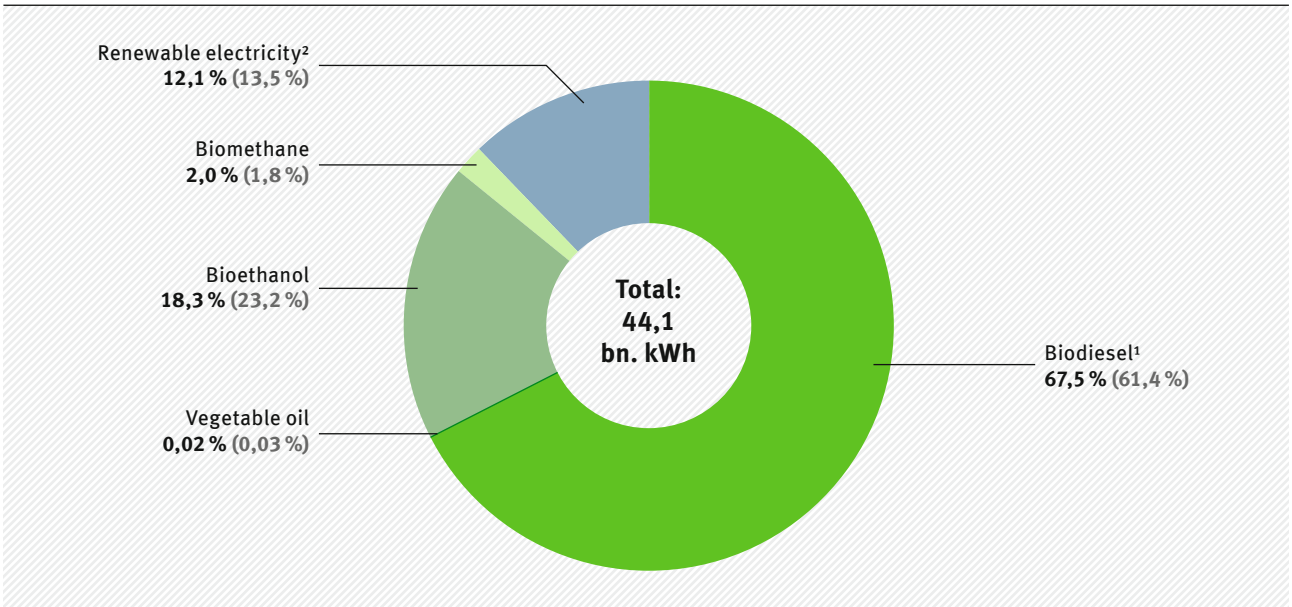
Biofuels

Based on an interpretation of preliminary data from the Federal Office of Economics and Export Control (BAFA), total sales of biofuels in 2020 increased by about 24 percent in terms of energy content. Sales of biodiesel/HVO increased particularly significantly (+35 percent) to 2.8 million tonnes. In contrast, sales of bioethanol fell by three percent to just under 1.1 million tonnes. At 884 million kWh, the use of biomethane as a fuel was about 34 percent higher than in 2019 (660 million kWh). Vegetable oil continued to be used only to a very small extent (about 1,000 tonnes, 10 million kWh).

Figure 8

Final energy consumption from renewable energies in the transport sector in 2020

Share in percent [%], values for proviuous year in brackets



¹ consumption of biodiesel (incl. HVO) in transport sector, without use in agriculture and forestry, building sector and military
² Calculation based on share of renewable electricity consumption of respective year

Source: Federal Ministry for Economic Affairs and Energy based on AGEE-Stat, Time series of the the development of renewable energies in Germany

Renewable electricity in the transport sector

In addition to biofuels, renewable electricity consumption contributes to the energy transition in the transport sector.

According to the Federal Motor Transport Authority (KBA), 394,940 new cars with electric drive systems (battery-electric, plug-in, fuel cell) were newly registered in 2020. This was 13.5 percent of all newly registered passenger cars in Germany. The number of purely battery-electric passenger cars amounted to 194,163, which is about three times higher than in 2019.

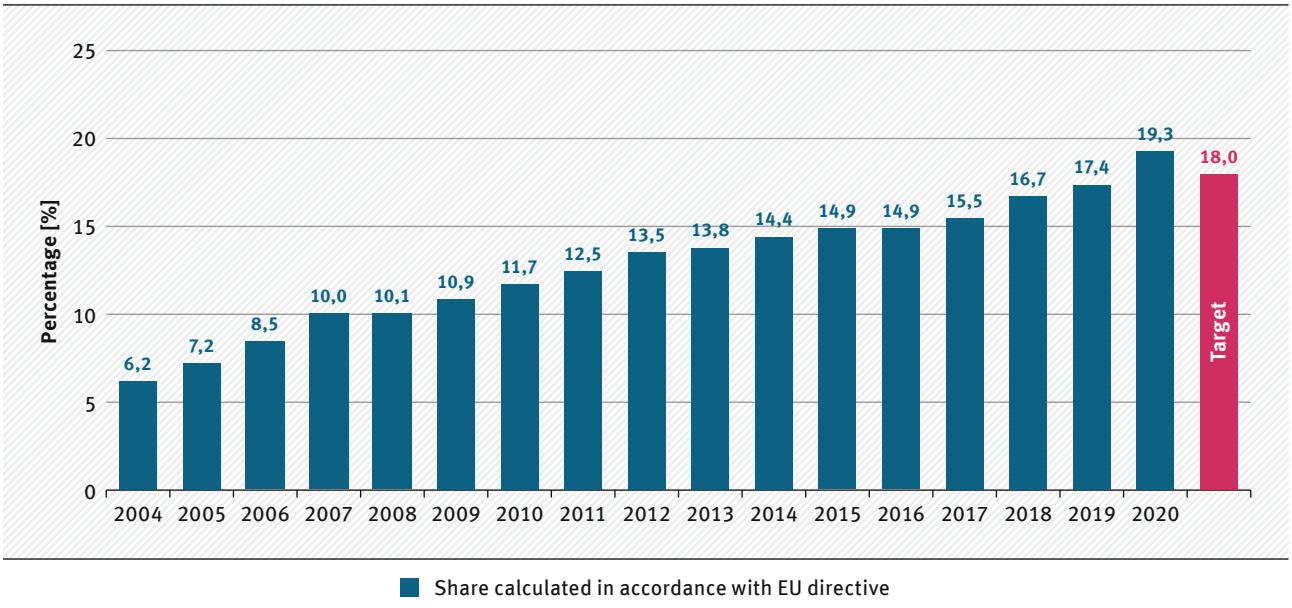
As a result, the total electricity consumption of the electric vehicle fleet again rose sharply compared to the previous year. However, at 0.6 billion kWh, it was still significantly lower than the consumption of electricity in rail transport (about 11 billion kWh). Road and rail transport together were responsible for just over two percent of Germany's gross electricity consumption.

The use of renewable electricity in the transport sector increased by almost ten percent in 2020 to just under 5.4 billion kWh (2019: 4.9 billion kWh). Overall, the consumption of electricity from renewable sources contributed about twelve percent to the total final energy consumption of renewable energies in the transport sector.

Share of renewable energy in gross final energy consumption above target

Figure 9

Share of renewable energies in gross final energy consumption according to EU directive



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

The European Renewable Energy Directive (2009/28/EC) sets binding targets for the entire EU: By 2020, 20 percent of gross final energy consumption across the EU should be provided by renewable energies, as well as a minimum share of 10 percent of renewable energies in the transport sector. In addition to the EU-wide aim, the directive provides binding national targets for all EU member states. Germany has committed to providing 18 percent of gross final energy consumption from renewable energies.

Based on the data available at the time of this publication, the share of renewable energies in total gross final energy consumption rose to 19.3 percent in 2020. The significant increase in the share of renewable energies was achieved with a further increase in renewable electricity generation, and the strong increase in sales of biofuels, but also greatly benefitted from the significant decrease in fuel and energy consumption due to the Corona pandemic.

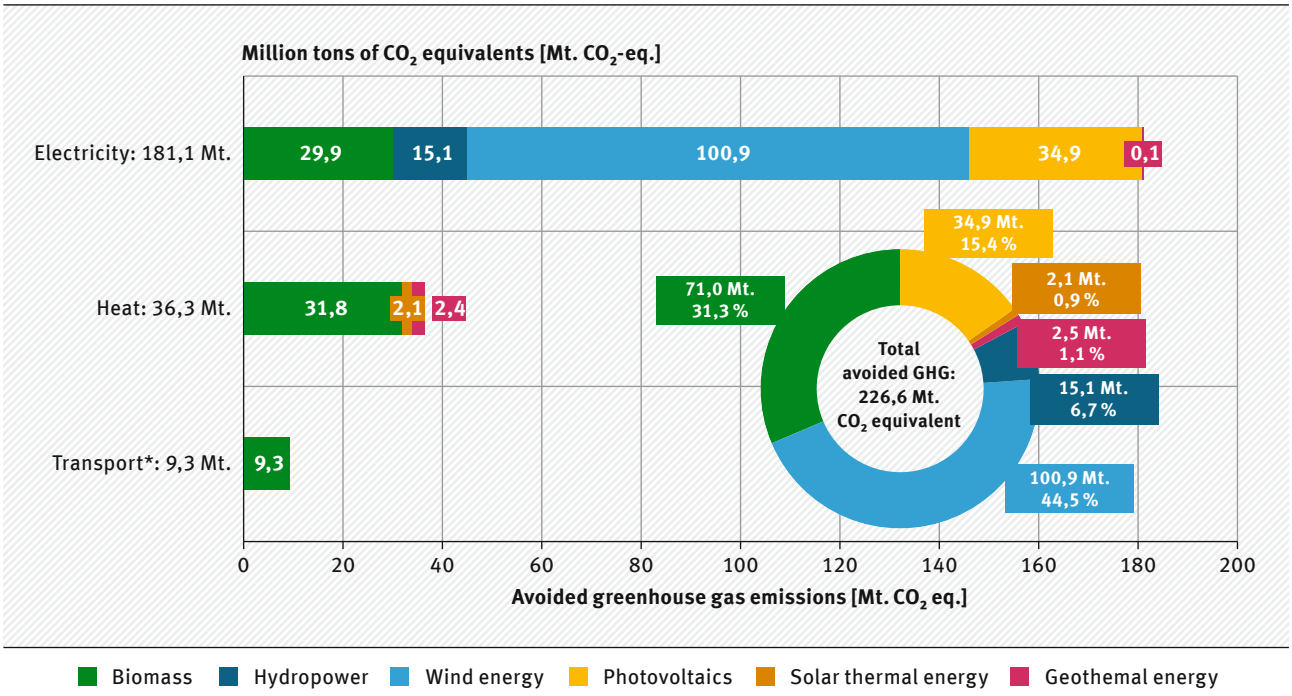
In the course of the year, the availability of new empirical and statistical data on energy consumption in all sectors may result in deviations from the currently estimated share. Nevertheless the target of 18 percent should in any case be met.

The target value of a minimum share of 10 percent of renewable energies in the transport sector, could be narrowly missed with a share of 9.8 percent according to a first conservative estimate.

Renewable energies avoid 227 million tonnes of greenhouse gases

Figure 10

Net balance of avoided greenhouse gas emissions through the use of renewable energies in Germany in 2020



* only biofuels in the transport sector (without agricultural sector, construction machinary and military) based on BLE

Source: German Environment Agency (UBA)

The expansion of renewable energies contributes significantly to achieving climate protection goals. By replacing fossil fuels with renewable energies, energy-related greenhouse gas emissions from coal, gas and oil are reduced. In total, around 227 million tonnes of CO_2 equivalents were avoided in 2020 through the use of renewable energies.

The largest share of this, 101 million tonnes of CO_2 equivalents, came from electricity generation from wind power. In total, the electricity sector accounted for the avoidance of around 181 million tonnes of CO_2 equivalents. In 2019 and 2020, an increasing displacement of electricity generation from hard coal and lignite was observed due to increased CO_2 certificate prices and lower fuel costs for natural gas.

In the heating sector, about 36 million t CO_2 equivalents were avoided and about 9.3 million t CO_2 equivalents were avoided by biofuels in transport.

In the underlying calculations, the emissions caused by the provision of energy from renewable sources are offset against those emissions avoided by the substitution of fossil energy sources. Upstream process chains for the extraction and provision of the energy sources as well as for the production and operation of the plants (without dismantling) are also considered.

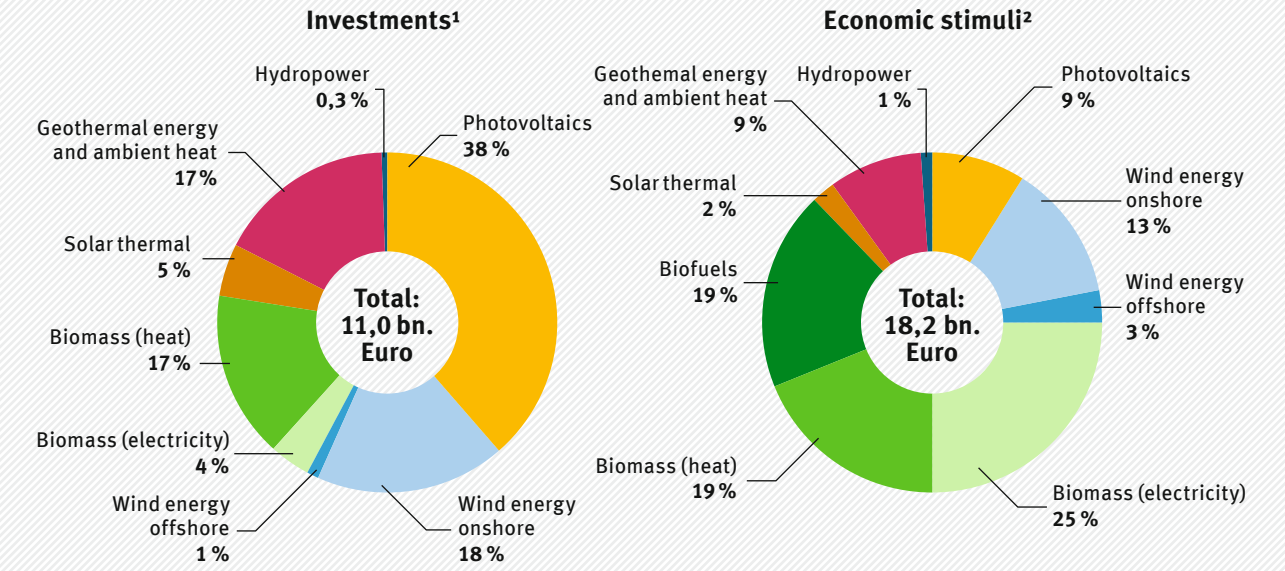
More detailed information on the methodology can be found in the Federal Environment Agency's publication "Emissionsbilanz Erneuerbarer Energieträger" (Emission balance of renewable energy sources, see Infobox).

The publication "Emissions balance of renewable energy sources" is available (in German language with English summary) on the website of the Federal Environment Agency at: www.umweltbundesamt.de/publikationen/emissionsbilanz-erneuerbarer-energietraeger

Economic Effects

Figure 11

Economic effects of renewable energies in 2020



¹ Mainly investments in new capacity and the expansion of existing installations. Investments from all relevant actors are included (utilities, industry, service and trade sector and private households).
² Economic stimuli include all relevant (economic) input in service and maintenance of renewable energy installations, als well related fuels (e. g. biomass or turnover from biofuels)

Source: Centre for Solar Energy-and Hydrogen Research (ZSW)

Renewable energies have been an important economic factor for Germany for years. After a downward trend in the two previous years, investments in the construction of renewable energy plants grew slightly again from around 10.7 billion euros (2019) to 11.0 billion euros (2020). This corresponds to an increase of 3.1 percent and is due to higher installation figures, especially for photovoltaic systems, onshore wind energy and in the renewable heating sector. These areas more than compensated for the slump in investments in offshore wind power plants.

The strongest absolute growth in a year by year comparison was in photovoltaics, followed by biomass plants (heat), heat pumps, onshore wind energy, solar thermal energy and biomass plants for electricity generation. Apart from offshore wind energy, only investments in hydropower plants declined compared to the previous year.

Overall, 38 percent of investments were in photovoltaics (up from 33 percent in 2019), 19 percent in wind energy (down from 34 percent in 2019) and 17 percent in geothermal and environmental heat (up from 13 percent in 2019).

The economic impulses from the operation of renewable energy plants (including biofuels) continued their upward trend and grew from 17.2 billion euros in 2019 to 18.2 billion euros in 2020. This was in particular due to a strong increase in turnover from the sale of biofuels. As in all years since 2015 the value of economic impulses of existing plants exceeded investments in new plants.

Sources

AGEB	Working Group on Energy Balances, Berlin
AGEE-Stat	Working Group on Renewable Energies Statistics
BAFA	Federal Office of Economics and Export Control, Eschborn
BDEW	German Association of Energy and Water Industries, Berlin
BLE	Federal Agency for Agriculture and Food, Bonn
BMWi	Federal Ministry for Economic Affairs and Energy, Berlin
BNetzA	Federal Network Agency, Bonn
BSW	German Solar Industry Association, Berlin
BWP	German Heat Pump Association, Berlin
DEPV	German Energy Wood and Pellet Association, Berlin
DWD	German Weather Service, Offenbach
FNR	Agency for Renewable Resources, Gülzow
GeotIS	Geothermal Information System for Germany, Hanover
GZB	International Geothermal Centre, Bochum
KBA	Federal Motor Transport Authority, Flensburg
StBA	Federal Statistical Office, Wiesbaden
TI	Thünen Institute, Hamburg
UBA	German Environment Agency, Dessau
ZSW	Centre for Solar Energy and Hydrogen Research Baden-Württemberg, Stuttgart

Annex

Graphics and tables on the development of renewable energies in Germany Status: February 2021

Table 1

Gross electricity production from renewable energy sources

	Renewable Energy 2019		Renewable Energy 2020	
	Gross electricity generation in GWh	Share of gross electricity consumption[4] in %	Gross electricity generation in GWh	Share of gross electricity consumption[4] in %
Hydropower[1]	19.731	3,4	18.633	3,4
Wind energy onshore	101.150	17,5	103.662	18,7
Wind energy offshore	24.744	4,3	27.303	4,9
Photovoltaics	46.392	8,0	50.600	9,2
Solid biomass[2]	11.106	1,9	11.321	2,0
Liquid biomass	397	0,1	384	0,1
Biogas	28.425	4,9	28.702	5,2
Biomethane	2.620	0,5	2.585	0,5
Sewage gas	1.581	0,3	1.593	0,3
Landfill gas	285	0,1	285	0,1
Biogenic fraction of waste[3]	5.806	1,0	5.729	1,0
Geothemal energy	197	0,03	217	0,04
Sum of renewable energy sources	**242.434**	**42,0**	**251.014**	**45,4**

[1] river and storage power plants including pumped storage plants with natural inflow
[2] including sewage sludge
[3] biogenic fraction of waste in waste incineration plants estimated at 50 %
[4] based on following gross electricity demand: 2019 = 576,7 TWh; 2020 = 552,9 TWh, fossil gross electricity production according to BDEW, electricity trade based on StBA, values preliminary

Table 2

Installed capacity

	Hydro-power	Windpower		Photo-voltaics	Geother-mal energy	solid biomass[1]	liquid biomass	gaseous biomass[2]	Total
		onshore	offshore						
	Megawatt (MW)								
2005	5.210	18.248	–	2.056	< 1	1.805	60	1.074	28.453
2006	5.193	20.474	–	2.899	< 1	2.048	177	1.422	32.213
2007	5.137	22.116	–	4.170	3	2.045	295	1.666	35.432
2008	5.164	22.794	–	6.120	3	2.141	341	1.889	38.452
2009	5.340	25.697	35	10.566	8	2.190	412	2.991	47.239
2010	5.407	26.823	80	18.006	8	2.264	410	3.548	56.546
2011	5.625	28.524	188	25.916	8	2.297	345	4.520	67.423
2012	5.607	30.711	268	34.077	19	2.272	277	4.918	78.149
2013	5.590	32.969	508	36.710	30	2.553	263	5.150	83.773
2014	5.580	37.620	994	37.900	33	2.533	232	5.439	90.331
2015	5.589	41.297	3.283	39.224	34	2.554	232	5.643	97.856
2016	5.629	45.283	4.152	40.679	38	2.578	231	5.850	104.440
2017	5.627	50.174	5.406	42.293	38	2.605	230	6.147	112.520
2018	5.585	52.328	6.393	45.158	42	2.669	230	6.761	119.166
2019	5.595	53.193	7.528	49.047	47	2.689	231	7.068	125.398
2020	5.606	54.420	7.747	53.848	47	2.708	232	7.445	132.053

[1] including biogenic fraction of waste
[2] biogas, biomethane, sewage gas and landfill gas

Table 3

Renewables-based final energy supply for heating and cooling

	Renewable Energy 2019		Renewable Energy 2020	
	Energy supply for heating/ cooling in GWh	Share of total consumption[8] in %	Energy supply for heating/ cooling in GWh	Share of total consumption[8] in %
Solid biomass (households)[1]	71.354	5,9	67.898	5,7
Solid biomass (TCS sector)[2]	19.146	1,6	18.996	1,6
Solid biomass incl. sewage sludge (industry)[3]	23.784	2,0	23.784	2,0
Solid biomass incl. sewage sludge (HP/CHP)[4]	6.121	0,5	6.006	0,5
Liquid biomass[5]	2.380	0,2	3.140	0,3
Biogas	13.315	1,1	13.449	1,1
Biomethane	3.314	0,3	3.270	0,3
Sewage gas	2.402	0,2	2.409	0,2
Landfill gas	102	0,01	88	0,01
Biogenic fraction of waste[6]	15.308	1,3	14.739	1,2
Solar thermal energy	8.483	0,7	8.707	0,7
Deep geothermal energy	1.369	0,1	1.413	0,1
Near-surface geothermal energy and ambient heat[7]	14.655	1,2	16.049	1,4
Sum of renewable energy sources	**181.733**	**15,0**	**179.948**	**15,2**

[1] mainly wood, including pellets
[2] TCS = trade, commerce and service sector
[3] including sewage sludge
[4] including sewage sludge; HP = heating plants, CHP plant = combined heat and power plant
[5] including consumption of biofuels in agriculture, forestry and military
[6] biogenic fraction of waste in waste incineration plants estimated at 50 %
[7] renewable heat from heat pumps (air-water, water-water, brine-water, process water and gas heat pumps)
[8] without electricty for heating and cooling purposes, based on total final energy consumption for room heating, water heating and process heat: 2019 = 1.214 TWh; 2020 = 1.186 TWh; based on AGEB (preliminary values)

Table 4

Renewables-based final energy supply in the transport sector

	Renewable Energy 2019		Renewable Energy 2020	
	Energy supply for heating/cooling in GWh	Share of total consumption[3] in %	Energy supply for heating/cooling in GWh	Share of total consumption[3] in %
Biodiesel[1]	22.109	3,4	29.772	4,9
Vegetable oil	10	0,002	10	0,002
Bioethanol	8.375	1,3	8.088	1,3
Biomethane	660	0,1	884	0,1
Renewable electricity consumption in the transport sector[2]	4.886	0,8	5.358	0,9
Sum of renewable energy sources	**36.040**	**5,6**	**44.112**	**7,3**

[1] consumption of biodiesel in the transport sector (excluding consumption in agriculture, forestry, construction and military)
[2] Calculation based on share of renewable electricity consumption in the corresponding year
[3] based on total final energy consumption in the transport sector: 2019 = 647 TWh; 2020 = 604 TWh; based on AGEB (preliminary values)

Table 5

Investments in construction of renewable energy plants

	Hydro-power	Windpower		Photo-voltaics	Solar-thermal energy	Geo-thermal energy	Biomass		Total
		onshore	offshore				(electricity)	(heat)	
	million Euro								
2005	240	2.490	–	4.840	630	410	1.910	1.510	12.030
2006	220	3.220	–	4.010	990	940	2.270	2.300	13.950
2007	330	2.470	30	5.330	760	920	2.280	1.500	13.620
2008	370	2.540	170	7.970	1.700	1.230	1.980	1.760	17.720
2009	500	2.800	470	13.570	1.490	1.140	2.020	1.610	23.600
2010	350	2.110	450	19.580	990	960	2.240	1.210	27.890
2011	300	2.860	610	15.860	1.060	990	3.120	1.320	26.120
2012	200	3.550	2.440	11.980	950	1.060	790	1.500	22.470
2013	130	4.490	4.270	3.380	860	1.090	700	1.530	16.450
2014	90	7.060	3.940	1.450	790	1.080	670	1.360	16.440
2015	80	5.370	3.680	1.480	800	1.010	220	1.270	13.910
2016	70	6.910	3.370	1.570	700	1.210	270	1.230	15.330
2017	50	7.280	3.400	1.660	540	1.320	280	1.230	15.760
2018	60	3.280	4.100	2.580	490	1.520	390	1.240	13.660
2019	50	1.480	2.130	3.540	420	1.410	390	1.230	10.650
2020	30	1.970	70	4.220	530	1.920	420	1.770	10.930

Source: Calculation by Centre for Solar Energy and Hydrogen Research Baden-Württemberg, Stuttgart (ZSW)

Table 6

Economic stimuli from the operation of renewable energy plants in Germany

	Hydro-power	Windpower		Photo-voltaics	Solar-thermal energy	Geo-thermal energy	Biomass			Total
		onshore	offshore				(electric-ity)	(heat)	(bio-fuels)	
	million Euro									
2005	130	550	–	130	50	240	710	1.460	1.790	5.060
2006	130	630	–	190	70	290	1.080	1.740	3.150	7.280
2007	140	710	–	260	90	360	1.620	1.960	3.750	8.890
2008	150	790	–	360	110	440	1.930	2.150	3.530	9.460
2009	160	870	10	530	140	530	2.340	2.450	2.390	9.420
2010	170	970	20	770	170	620	2.770	2.880	2.920	11.290
2011	190	1.060	30	1.040	190	730	3.180	2.870	3.690	12.980
2012	190	1.200	60	1.250	210	820	3.870	3.120	3.720	14.440
2013	200	1.360	130	1.360	230	900	4.020	3.320	3.050	14.570
2014	200	1.550	210	1.400	240	990	4.300	3.030	2.640	14.560
2015	200	1.730	280	1.420	260	1.080	4.450	3.190	2.440	15.050
2016	210	1.890	350	1.440	270	1.170	4.450	3.390	2.560	15.730
2017	210	2.080	420	1.470	290	1.270	4.470	3.410	2.710	16.330
2018	210	2.220	500	1.500	300	1.380	4.500	3.430	2.700	16.740
2019	220	2.290	560	1.540	310	1.490	4.520	3.470	2.830	17.230
2020	220	2.290	600	1.600	320	1.630	4.570	3.470	3.500	18.200

Source: Calculation by Centre for Solar Energy and Hydrogen Research Baden-Württemberg, Stuttgart (ZSW)

Table 7

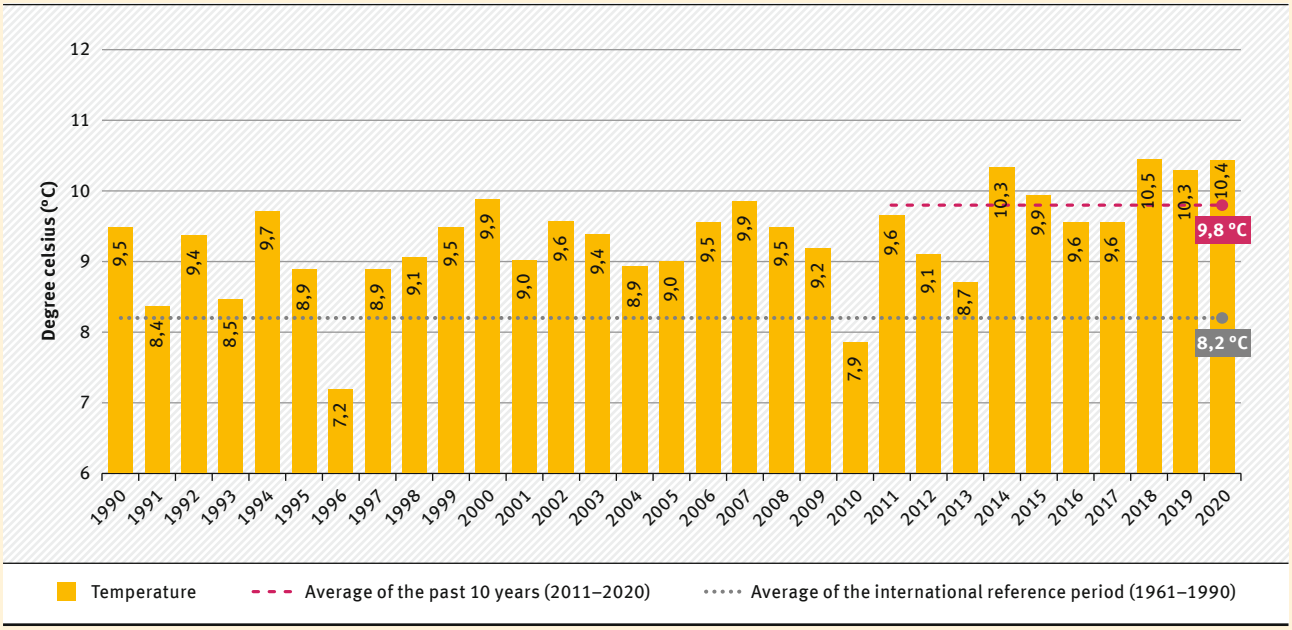
Greenhouse gas emissions avoided through the use of renewable energy sources

	Hydro-power	Windpower		Photo-voltaics	Solar-thermal energy	Geo-thermal energy	Biomass			Total
		onshore	offshore				(elec-tricity)	(heat)	(bio-fuels)	
	million tonnes of CO_2-equivalents									
2005	20,8	22,3	0,0	0,6	0,7	0,4	12,0	21,4	4,2	82,3
2006	17,3	23,3	0,0	1,3	0,8	0,4	13,3	23,6	7,5	87,5
2007	17,7	30,0	0,0	1,8	0,9	0,4	15,6	26,0	8,5	101,0
2008	16,0	28,6	0,0	2,9	1,1	0,6	16,4	28,6	6,8	100,8
2009	15,3	28,2	0,0	4,4	1,2	0,7	18,4	28,6	6,0	102,9
2010	16,7	27,4	0,1	7,8	1,4	0,8	20,0	33,4	6,5	114,2
2011	14,7	37,6	0,4	13,7	1,6	0,8	22,5	31,7	6,4	129,4
2012	16,6	33,5	0,5	16,0	1,7	0,9	23,2	34,2	7,0	133,6
2013	16,2	36,4	0,6	18,0	1,7	1,1	21,9	34,7	6,4	137,0
2014	15,4	43,1	1,1	23,4	1,8	1,2	27,0	31,0	6,7	150,7
2015	14,4	51,8	5,9	24,8	1,9	1,3	26,4	31,1	6,3	163,8
2016	15,7	49,1	9,0	24,6	1,8	1,5	27,0	30,7	6,9	166,3
2017	14,7	60,4	12,3	24,4	1,9	1,7	25,3	31,2	7,4	179,2
2018	13,2	63,6	13,8	28,0	2,1	1,9	26,3	32,0	7,7	188,6
2019	16,0	77,8	19,3	32,0	2,0	2,3	29,7	32,3	7,5	218,9
2020	15,1	79,7	21,2	34,9	2,1	2,5	29,9	31,8	9,3	226,6

Source: Federal Environment Agency (UBA)

Figure 12

Time series of the average annual temperature in Germany (1990–2020)

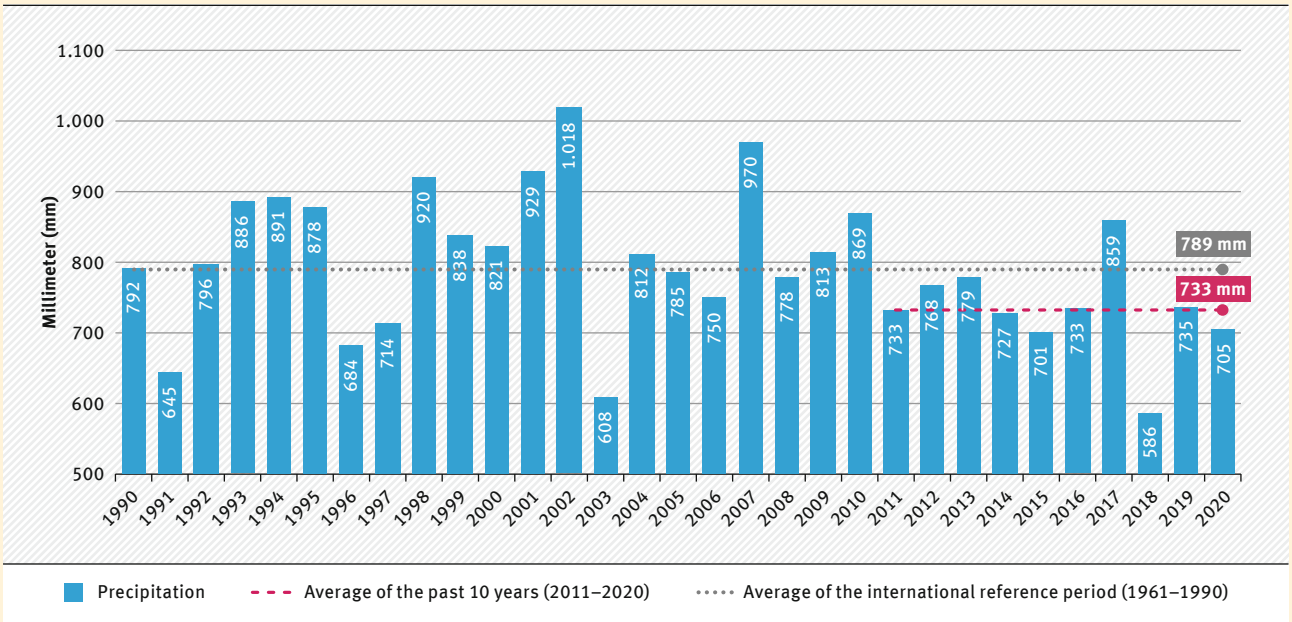


At 10.4 °C, 2020 was the second-warmest year after 2018 since the beginning of the systematic weather recording (1881). Thus, the year 2020 was about 2.2 °C warmer than the mean value of the international climate reference period (1961–1990) and also 0.6 °C warmer than the mean temperature of the last 10 years.

Source: German National Meteorological Service (DWD)

Figure 13

Time series of average precipitation in Germany (1990–2020)

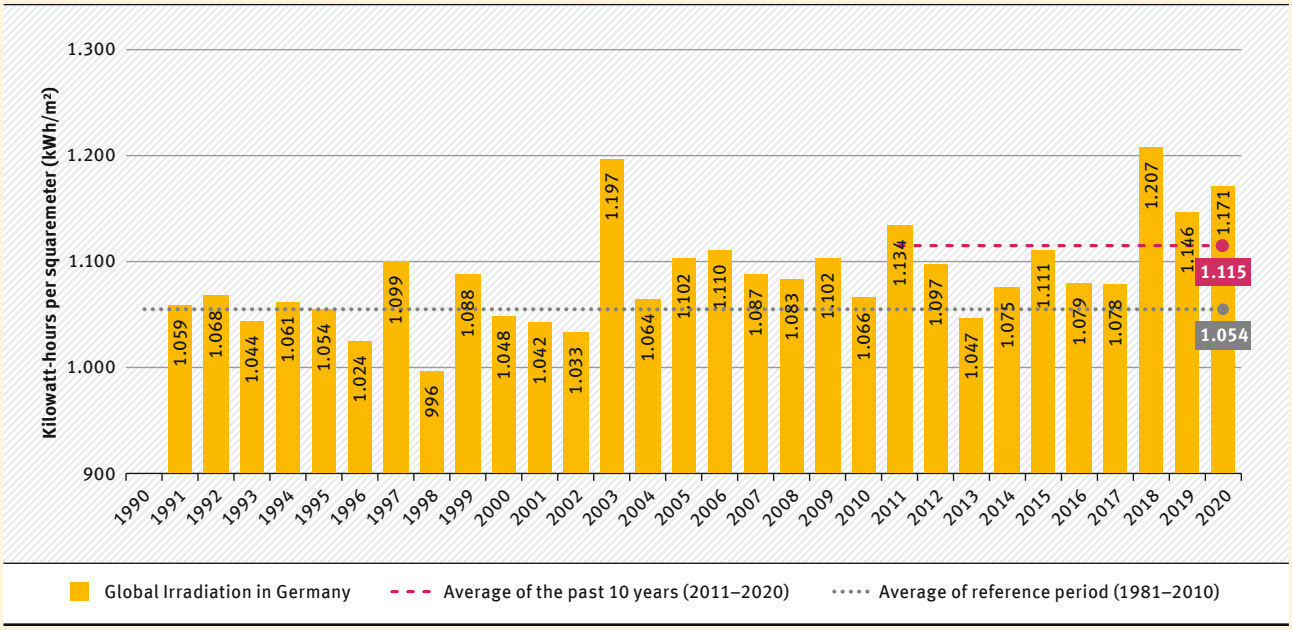


The year 2020 was another year with low precipitation, with 705 mm. In the last 10 years, only 1 year (2017) exceeded the precipitation of the long-term average average (1961–1990) of 789 mm

Source: German National Meteorological Service (DWD)

Figure 14

Time series of averaged global radiation in Germany (1991–2020)

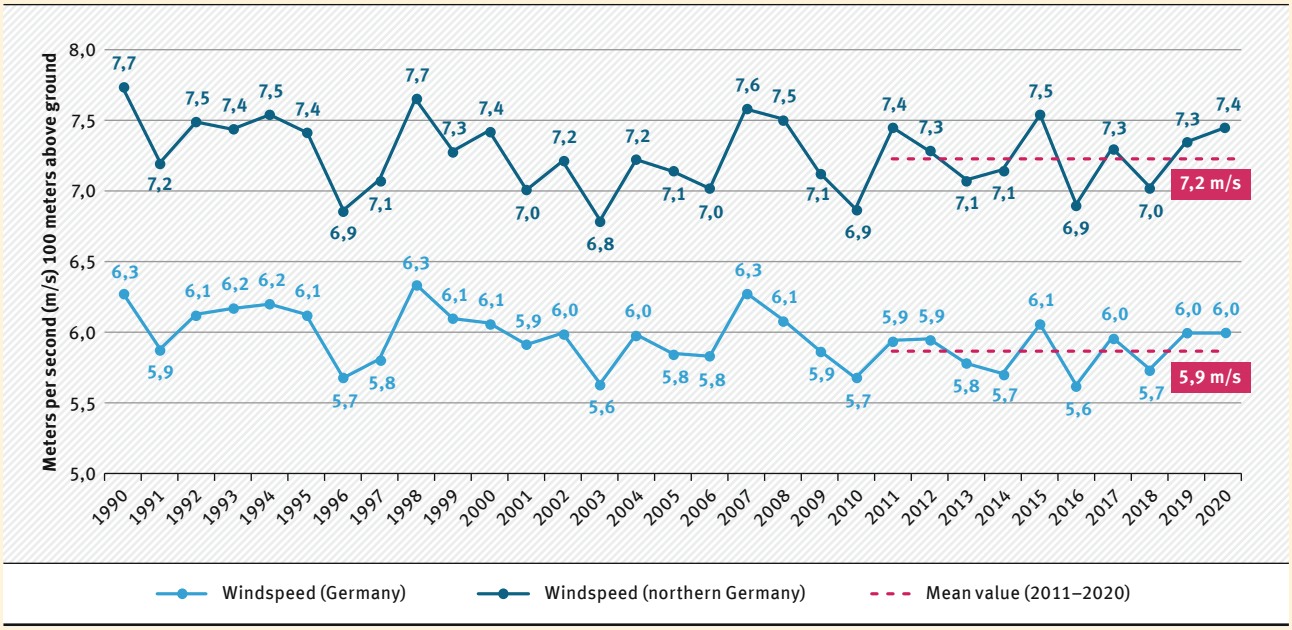


Global irradiance is a measure of the sum of direct and diffuse solar radiation per area and thus a direct indicator for the performance of PV and solar thermal systems. Systematically, the global radiation is provided by the DWD since 1991. In 2020, the third-highest value of the last 30 years was reached with 1,171 kWh/m².

Source: German National Meteorological Service (DWD)

Figure 15

Time series of averaged wind speed at 100 metres in Germany and northern Germany (1990–2020)



Annual average windspeed 100 meters above ground in Germany and northern Germany. Data based on global atmospheric reanalysis "ERA-5" of the European Copernicus climate service (C3S) and represents averages above the following areas: Germany: approximately 6°E–15°E, ca. 48°N–55°N; northern Germany: ca. 6°E–15°E, approximately 52°N–55°N.

Source: German National Meteorological Service, based on C3S/ERA-5: Hersbach et al., 2019 (doi: 10.21957/vf291hehd7)

Further information such as time series on the development of renewable energies since 1990 and corresponding charts in German and English language can be found on the BMWi's "Renewable Energies Information Portal" at: www.erneuerbare-energien.de.

Glossary

CO_2 equivalents

The unit for the global warming potential of a gas indicates the amount of CO_2 that would have the same greenhouse effect as the reference gas under consideration over a period of 100 years. The equivalence factors used follow the values specified for national emissions reporting from the IPCC Fourth Assessment Report Climate Change 2007.

Final energy

Final energy is the part of primary energy that reaches the consumer after subtraction of transmission and conversion losses and which is then available for further use. Forms of final energy are, for example, district heating, electric power, hydrocarbons such as petrol, paraffin, heating oil or wood and various gases such as natural gas, biogas and hydrogen.

Gross electricity consumption

Gross electricity consumption is equal to the sum of all gross domestic electricity generation (wind, hydro, solar, coal, oil, natural gas and others), plus electricity flows from abroad and minus electricity flows abroad. Net electricity consumption is equal to gross electricity consumption minus the power plants' own consumption and grid and storage losses.

Gross electricity generation

Gross electricity generation comprises the total amount of electricity generated in a country. After deducting the own consumption of the generation plants, the net electricity generation remains.

Gross final energy consumption according to EU Directive

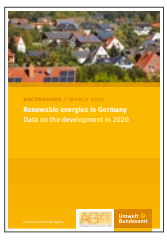
EU Directive 2009/28/EC contains detailed specifications for calculating the share of renewable energies in gross final energy consumption. These specific calculation rules include a "normalisation" of electricity generation from wind and hydropower plants to offset climate fluctuations. Furthermore, in the EU Directive only liquid bioenergy sources and biofuels that meet certain sustainability criteria are taken into account.

Primary energy

Primary energy is the mathematically usable energy content of a naturally occurring energy carrier before it is subjected to conversion. Primary energy sources include exhaustible energy sources (for example, hard coal and lignite, crude oil, natural gas, fissile material such as uranium ore) as well as renewable energies (solar energy, wind energy, hydropower, geothermal energy and tidal energy). Primary energy is converted in power plants or refineries to a further stage in the energy series. There are conversion losses in the process. Some of the primary energy sources are also fed into non-energy consumption (for example crude oil for the plastics industry).

Renewable energies

Energy sources that are infinitely available according to human time scales. Almost all renewable energies are ultimately fed by the sun. The sun consumes itself, so it is not a "renewable energy source" in the strict sense. However, the foreseeable lifetime of the sun, according to the current state of science, is more than a billion years and, from our human perspective, almost unlimited. The three original sources are solar radiation, geothermal energy and tidal power. These can be used either directly or indirectly in the form of biomass, wind, hydropower, ambient heat as well as wave energy.



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