



BACKGROUND // MARCH 2022

Renewable Energies in Germany

Data on the development in 2021

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Contents

Development of renewable energies in 2021	6
Electricity generation from renewable sources declining	7
Photovoltaik (PV)	8
Wind Energy	8
Hydropower	10
Geothermal energy	10
Share of renewable energies in the final energy consumption for heat increases	11
Biomass	11
Geothermal energy and environmental heat	12
Solar thermal energy	12
Share of renewable energies in the traffic sector sinks	13
Biofuels	13
Renewable electricity in the traffic sector	14
Share of renewable energy in the gross final energy consumption increases	15
Renewable energies avoid 221 million tons of greenhouse gases	16
Economic Effects	17
Sources	18
Annex	19

Development of renewable energies in 2021

On behalf of the Federal Ministry for Economic Affairs and Climate Action, 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 2021 – the most important facts:



Share of the renewables in the gross electricity consumption will go down from 45.2 to 41.1 per cent

In 2021 the share of the renewable energies in the gross electricity consumption has not further increased. Unfavourable weather was responsible for less electricity from wind energy plants at a rising demand for electricity. As a result, the share of the renewable electricity went down from 45.2 to 41.1 per cent.



Share of renewables in the final energy consumption of heat increases from 15.3 to 16.5 per cent

Cooler weather was responsible for a stronger use of renewable energy carriers in 2021. The cold weather resulted also in a higher consumption of fossil energy carriers for heating purposes. Yet, this is only partly reflected in the energy statistics as the heating oil sale was strongly declining due to high storage stocks and increasing prices. As a result, the share of renewable energies increased disproportionately.



Share of the renewables in the final energy consumption Traffic goes down from 7.6 to 6.8 per cent

In 2020 the sale of biofuel increased strongly by the increase of the greenhouse gas reduction quota. In 2021, the same quota was reached using different fulfillment options. Thus, notably the use of biodiesel was reduced. Altogether the share of the renewables in the final energy consumption traffic went down from 7.6 to 6.8 per cent.



Share of renewables in the total gross final energy consumption goes up to 19.7 per cent

After Germany overfulfilled its 18 per cent target in conformity with the Renewable Energies Directive of the EU with 19.3 per cent in 2020. The renewable share in the gross final energy consumption – through all sectors – slightly increased to 19.7 per cent in 2021.



Renewables avoid 221 million of greenhouse gas emissions

By using renewable energy the use of fossil energy carriers and thus the output of greenhouse gases and air pollutants goes down. The contribution of renewable energies to climate protection totalled nearly 221 million tons of CO₂ equivalents in 2021. Owing to the decrease of the production of renewable electricity these are nearly 11 million tons less than in the previous year.



Investments and economic effects

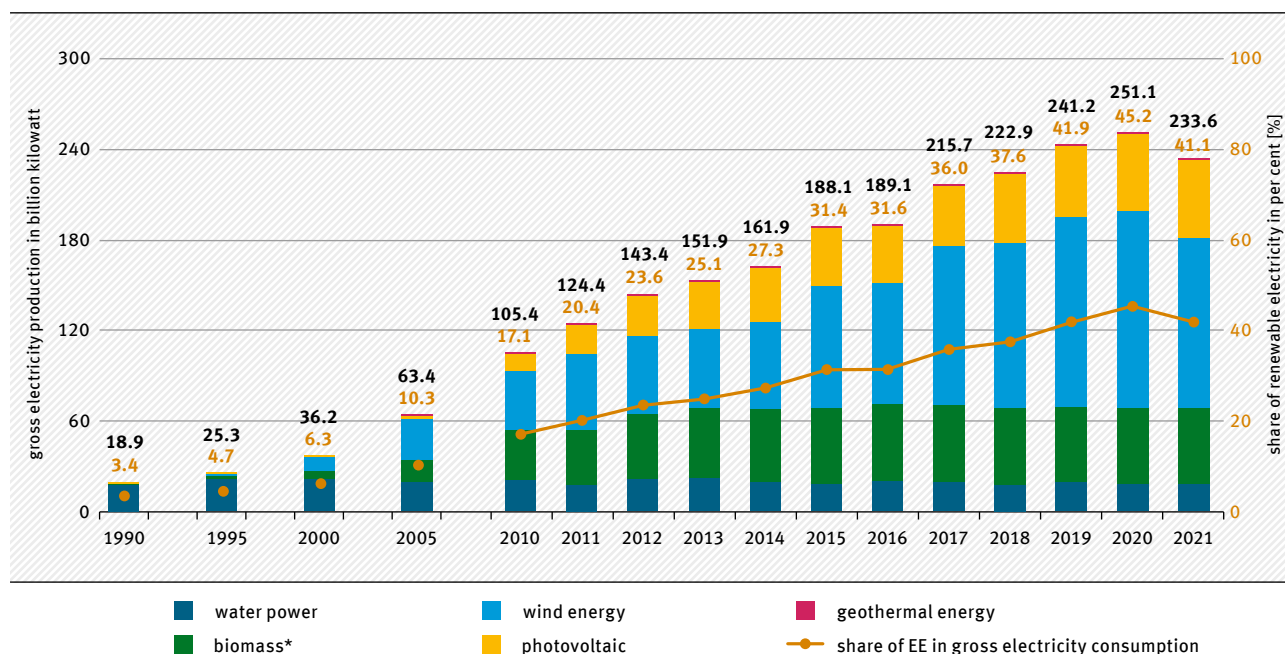
Altogether the investments in plants for using renewable energies slightly increased in the second year in succession and totalled about 13.4 billion Euro in 2021. The economic impulses by the operation of the existing plants increased also, thus amounting to 20.2 billion euro in 2021.

Electricity generation from renewable sources declining



Figure 1

Development of electricity generation from renewable energies



* incl. solid and liquid biomass, biomethane, gas produced by decomposing waste, waste gas, waste sludge and the biogenic share of the waste

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

After a continuous growth in the previous years the electricity generation from renewable energies went distinctly down in 2021. With now 233.6 billion kilowatt hours about seven percent less “green electricity” was generated than in the previous year (251.1 billion kWh). Thus, the quantity of electricity generated was under the level of 2019 (241.2 billion kWh).

The main reason for the decrease were distinctly more unfavourable weather conditions as compared with the previous years. Whereas the shorter sunshine duration was compensated by building many solar power plants the low capacity construction of wind energy plants could not make up for the bad wind year.

The share of renewable electricity generation in the gross electricity consumption totalled altogether 41.1 per cent in 2021 and was thus 4.1 per cent points below the value of the previous year (45.2 per cent). In addition to the decreased renewable electricity volume the rising electricity consumption (plus

2.4 per cent) was responsible for the clear decrease of the renewable share.

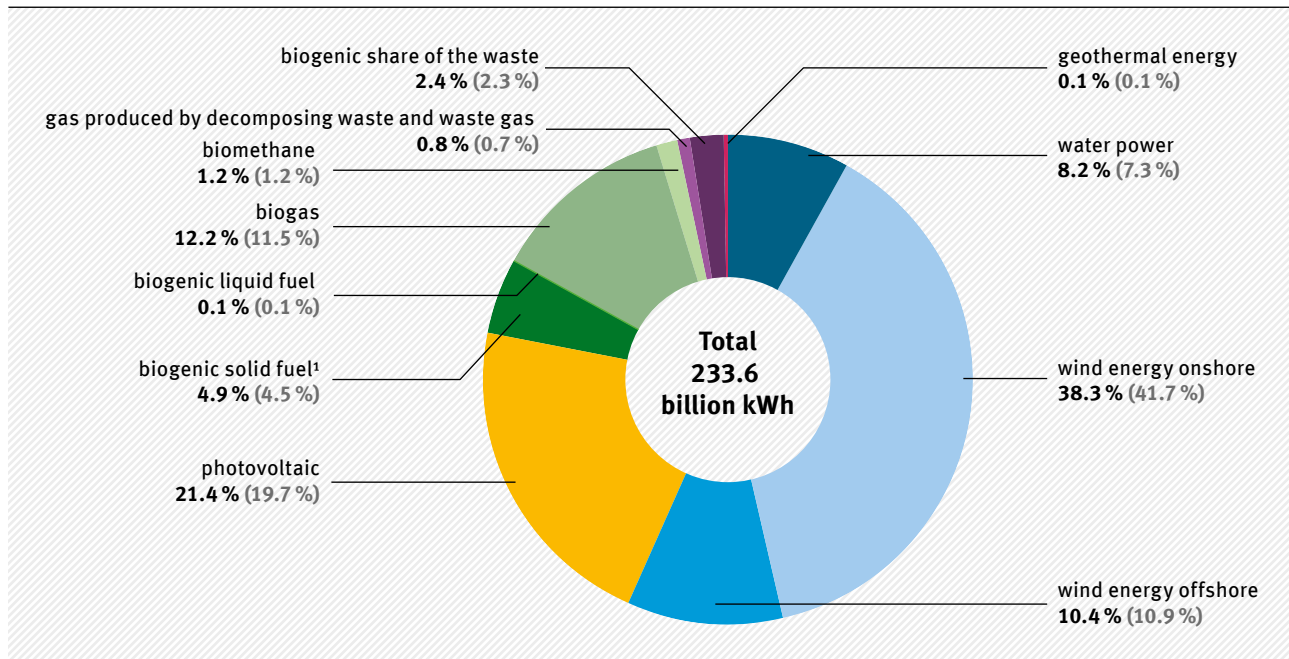
Looking at the electricity generation of the individual energy carriers shows that the development in 2021 was notably marked by the bad result of the wind energy. Though it contributes with nearly 49 per cent furthermore most to the total renewable electricity generation. As compared with the previous year the electricity generation from wind energy plants decreased, by more than 18 billion kWh (minus 14 per cent) and is thus responsible for the whole loss of green electricity. All further energy carriers were not able to compensate the minus of the wind energy, thus remaining approximately at the level of the previous year, with smaller deviations.

Considering the development during the year it becomes apparent that notably the first quarter low in wind was responsible for the loss. In the remaining months of the year the level of the previous year could be approximately reached.



Figure 2

Electricity generation from renewable energies in 2021 share in per cent, values for the previous year in brackets



¹ incl. sewage sludge

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

Photovoltaik (PV)

The electricity generation from PV plants went only slightly up in 2021 as compared with the previous year by one per cent to now 50.0 billion kWh (2020: 49.5 billion kWh). Two opposite effects were responsible for the only moderate increase. Though the capacity of the PV plants installed in Germany increased distinctly also in 2021, the weather was by far less sunny than in 2020.

In the years 2018 to 2020 the photovoltaic profited from much sunshine and a high global radiation (s. Appendix Fig. 14). As compared with it the value of the global radiation which may be regarded as indicator for the PV electricity generation was on a distinctly lower level in 2021 (minus nine per cent compared with the previous year).

At the end of 2021 in Germany PV plants with an capacity of altogether 58,728 MW were installed. Thus, the total capacity of the PV plant parc increased by about nine per cent as compared with

the value at the end of the previous year (53,721 MW). Thus, the total photovoltaic capacity was, for the first time, above the installed capacity of the wind energy plants onshore in 2021.

After the record increase in PV systems in 2012 (8,161 MW) the increased capacity of the newly built plants decreased strongly in the following years. However, since 2015 the yearly increase of the PV capacity goes up again continuously. This trend continued also in 2021, yet in a weakened form: with 5,007 Megawatt (MW) the increase went up only slightly as compared with 2020 (4,807 MW). This small increase is distinctly below the growth which is required for the ambitious climate targets

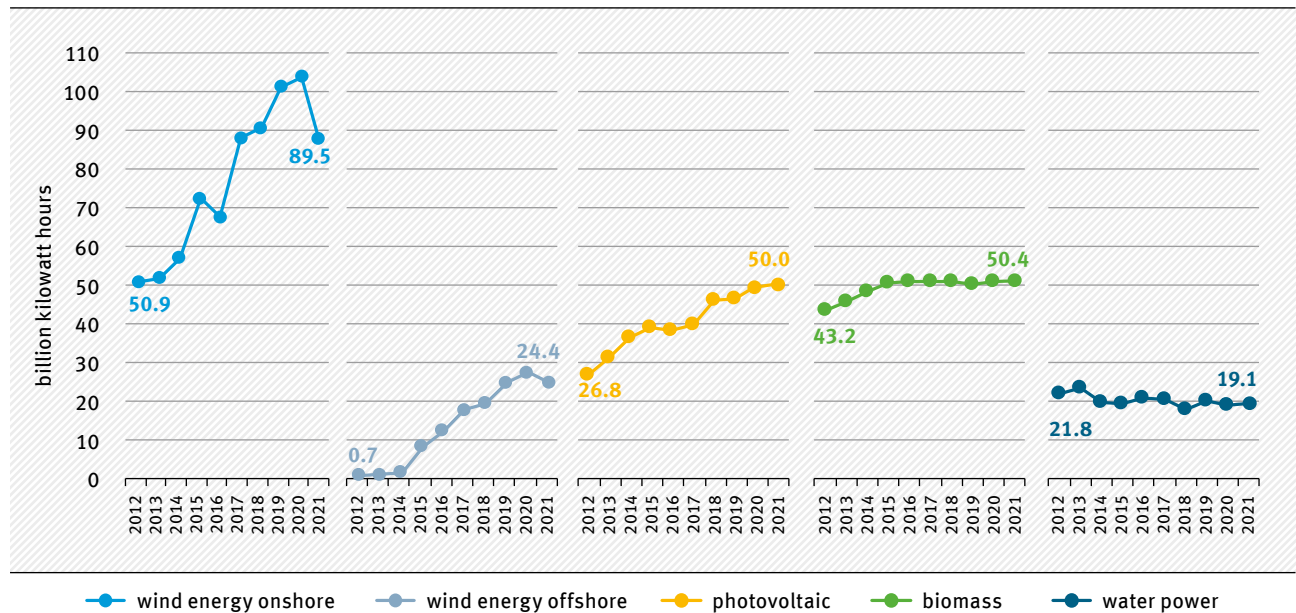
Wind Energy

With the aid of wind energy plants onshore and offshore an electricity quantity of 113.8 billion kWh was generated in 2021 – this corresponds to a distinct decline of 14 per cent as compared with the previous



Figure 3

Development of electricity generation by renewable energy carriers as compared with the last 10 years



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

year (132.1 billion kWh). In spite of this decline the wind energy covered still about 20 % of the German gross electricity consumption. Also in this rather low-wind year it remained (see Annex Figure 15) the most important energy carrier in the German electricity mix.

In the previous years it was possible to compensate weather-caused fluctuations in electricity generation from wind power plants by the strong and continuous construction of new plants. But this was not the case in 2021 due to the rather moderate addition in the last years.

As regards wind energy (onshore) the weather-caused decline of the produced electricity was especially severe. With 89.5 billion kWh nearly 15 per cent less electricity was produced than in 2020 – and also less than in the years 2018 and 2019.

As compared with the record addition in 2017 (4,891 MW) the net capacity addition of onshore wind energy plants with 1,677 MW was also in 2021 at a comparatively low level although more wind energy

plants were installed than 2020 (1,227 MW). At the end of 2021 in Germany onshore wind energy plants with a capacity of 56,091 MW were installed. Thus, the total capacity went up by only three per cent as compared with the previous year.

In 2021 no new offshore plants were connected to the network. Thus, the installed capacity remained unchanged at 7.774 MW. In electricity generation by offshore wind energy plants the worse wind conditions became also apparent: with 24.4 billion kWh the electricity generation went down less strong than onshore (minus 11 per cent).

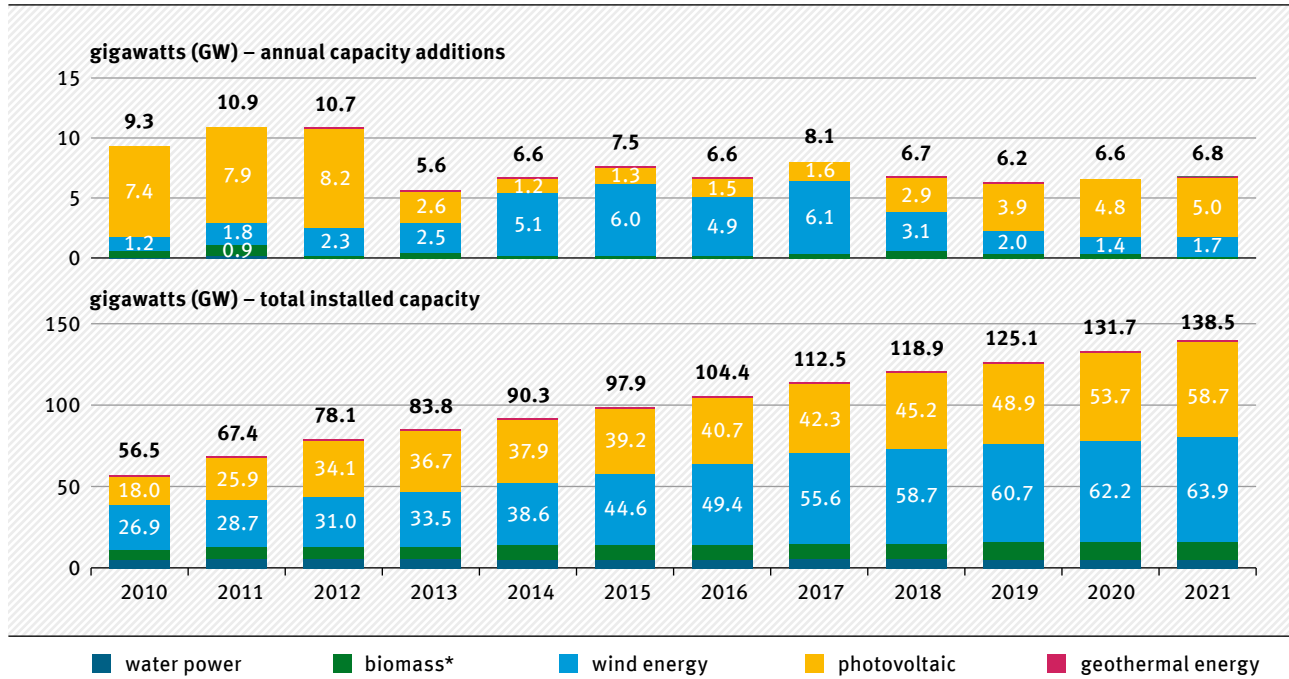
Biomass

Altogether the electricity generation from biomass went down by about one per cent as compared with the previous year. Altogether about 50.4 billion kWh electricity were generated in 2021 (2020: 50.9 billion kWh) from solid, liquid and gaseous biomass and the renewable share of waste. Altogether the biomasses thus represented about 22 per cent of the whole renewable electricity, thus covering nearly nine per cent of the total gross electricity



Figure 4

Development of the increase and the installed capacity for electricity generation from renewable



* incl. solid and liquid biomass, biogas, biomethane, gas produced by decomposing waste and waste gas and waste sludge and including the biogenic share of the waste

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

consumption. For the electricity generation from biogas and biomethane in 2021 with 130 MW distinctly less capacity was added than in 2020. In addition, a big share of the newly installed capacity – as also in the previous years – served greater generating flexibility in existing plants. The electricity generation by these two energy carriers went down slightly from 31.7 billion kWh to 31.3 billion kWh in 2021. However, they thus contributed 62 per cent of the whole electricity generated from biomass. In plants using solid and liquid biomass there were only small changes of the installed capacity and the electricity generation connected with it.

Hydropower

After the comparatively dry previous year the electricity generation from water power plants increased slightly due to stronger precipitation in 2021. With 19.1 billion kWh about four per cent more were produced than in the previous year (18.3 billion kWh). Thus, the share of the whole gross electricity consumption was a bit higher than three per cent.

Geothermal energy

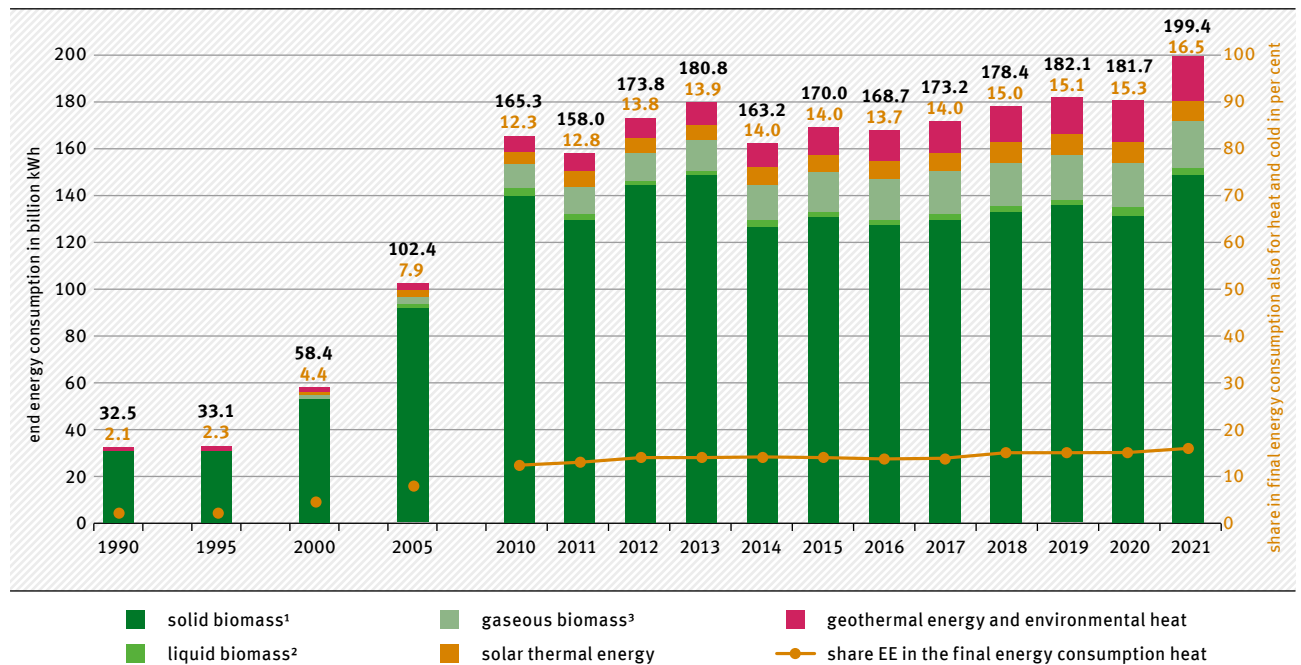
Though the electricity volume generated by geothermal energy increased by about eight per cent in 2021. With altogether only about 0.25 billion kWh its share in the whole gross electricity consumption in Germany is still below 0.1 per cent. In 2021 a new geothermal energy plant was put into operation. Thus, the installed capacity increased by 6 MW to 53 MW.

Share of renewable energies in the final energy consumption for heat increases



Figure 5

Development of the energy consumption for heat from renewable energies



¹ incl. sewage sludge and biogenic share of the waste

² incl. biofuel consumption in forestry and agriculture, inbuilding trade and in the army

³ biogas, biomethane, sewage gas and gas produced by decomposing waste

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

According to the data available at present the final energy consumption of renewable energies for heat and cold in 2021 was with 199.4 billion kWh distinctly above the level of the previous year (2020: 181.7 billion kWh). This increase by ten per cent is, in the first line, due to the cooler weather as compared with the previous years. In addition to the use of renewable energies the use of conventional energy carriers has also increased – yet distinctly less as at the same time the heating oil sale strongly declined owing to high storage stocks and increasing prices. These developments resulted altogether in a strong increase of the share of renewable heat in the whole heat consumption by 1.2 per cent to 16.5 per cent.

Altogether positive developments are to be stated due to the high heat demand in 2021 for most of the renewable technologies. Thus, an increase of heat generation by more than 10 per cent was to be stated for biomass and biogenic waste.

At the same time the development in geothermal energy and environmental heat use showed a positive direction (plus eleven per cent). Due to the low solar radiation the heat use from solar thermal energy plants receded (minus five per cent).

Biomass

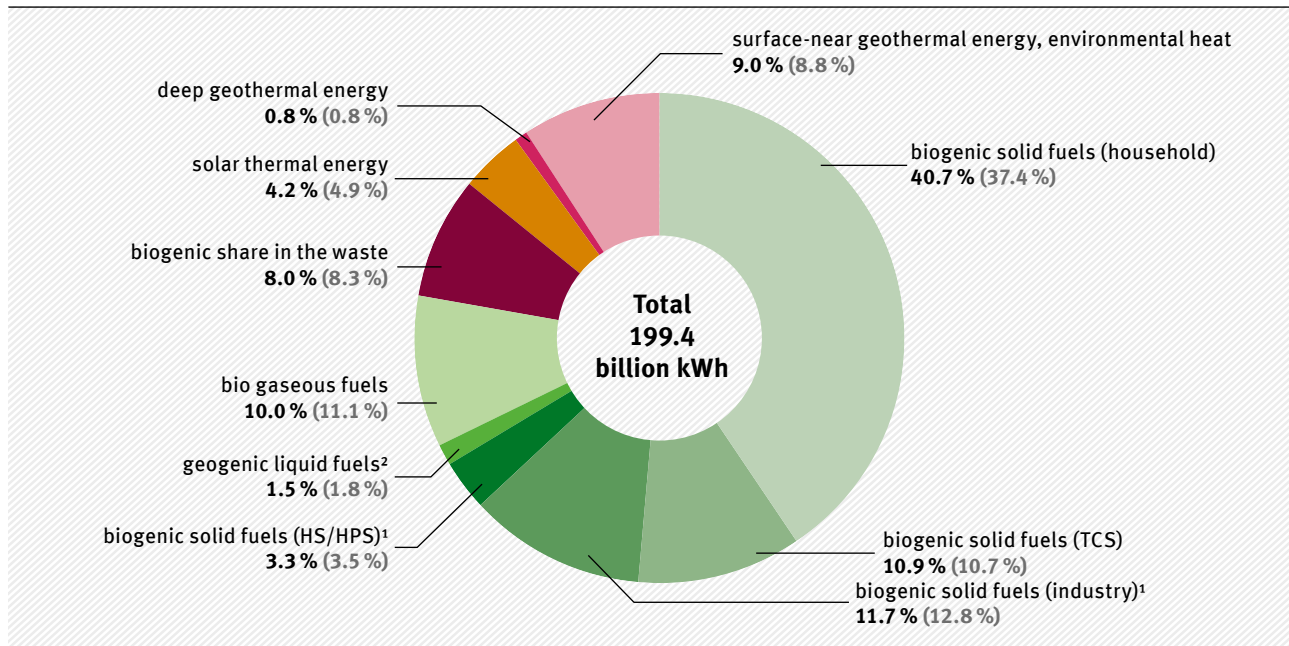
With a share of 86 per cent the biomass (including the biogenic waste) remained the most important heat source. The whole heat quantity provided by biomass increased predominantly temperature driven from 155.3 billion kWh in 2020 to 171.5 billion kWh in 2021. With 77 per cent the solid biomass – mostly fire wood and other energetically used wood products – represents the biggest share in the heat from biomass (132.8 billion kWh). Thereupon the heat is provided from biogas and biomethane (17.4 billion kWh), biogenic waste (15.9 billion kWh) and liquid biomass (2.9 billion kWh).



Figure 6

Final energy consumption for heat from renewable energies in 2021

share in per cent, share for the previous year in brackets



¹ incl. sewage sludge

² incl. biofuel consumption in forestry and agriculture, in building trade and in the army (HS/HPS= heating stations/heating power stations, TCS= trade, commerce, services)

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

Geothermal energy and environmental heat

As in the previous years the market of heat pumps substantially increased also in 2021 according to the Federal Heat Pump Association (BWP). With about 154,000 heat pumps sold about 28 per cent more plants were sold for heating purposes than in the previous year. Also the sales of domestic water heat pumps could be increased (plus 15 per cent). By the sales of the plants furthermore increasing the total stock of heating pumps has increased by about 13 per cent as compared with the previous year. About 1.5 million of heat pumps contributed to the production of renewable heat altogether in 2021.

The increasing use of heatpumps is also reflected in the increase of heat use: together with the deep geothermal and balneological plants (bathing establishments) altogether 19.4 billion kWh of heat were obtained from geothermal energy and environmental heat. These are eleven per cent more than in

the previous year (17.5 billion kWh) and corresponds to nearly ten per cent of the whole renewable energy.

Solar thermal energy

After the construction of solar collectors decreased continuously since 2012 it was possible to stop this trend after 2020. According to data of the Federal Association of the Solar Industry (BSW) the newly installed collector area was with about altogether 640,000 square meters at the level of the previous year. Considering the demolition of old plants thus some more than 21.8 million square meters of collector area were installed in Germany.

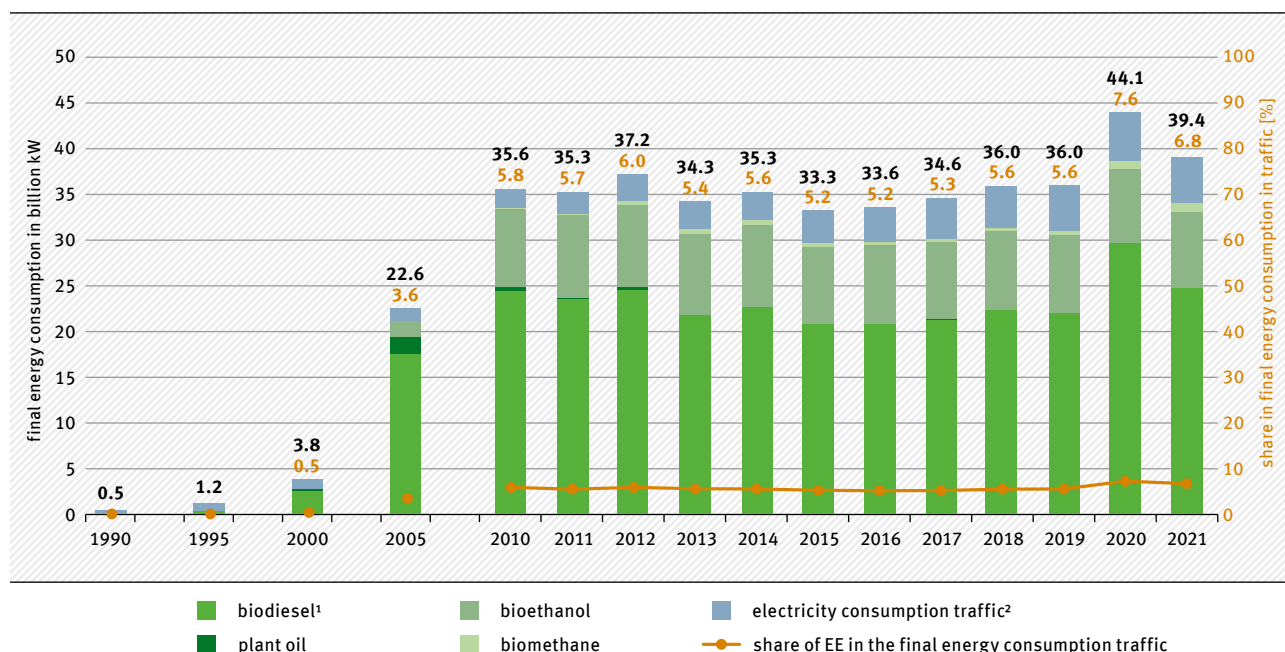
Yet the addition of new plants was not sufficient to compensate the worse weather with less sun radiation. The heat production by solar energy was in 2021 with 8.4 billion kWh about five per cent below the value of 2020 (8.9 billion kWh).

Share of renewable energies in the traffic sector sinks



Figure 7

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



¹ consumption of biodiesel (incl. HVO) in the traffic sector, without agriculture and forestry, building trade and army

² calculated with the share of renewable energies in the gross electricity consumption of the respective year

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

In 2021 the share of renewable energies in the total energy consumption in traffic went down from 7.6 per cent in the previous year to now 6.8 per cent. A decrease of the total use of biofuels was responsible for that. Thus, the sale of biodiesel and hydrated plant oils (HVO) went distinctly down whereas a small increase of bioethanol and biomethane was to be stated.

The consumption of renewable electricity has slightly gone up in the traffic sector in spite of the smaller share of the renewables in the electricity mix owing to the probably higher total consumption (in particular by clear increases in the road traffic), yet was not able to compensate the decrease of biofuels.

The decrease of renewable energy carriers in traffic was accompanied by a further decrease in the total energy consumption in the traffic sector. According to first assessments by the working Group on Energy

Balances the terminal energy consumption amounted to about 580 billion kWh in 2021, thus being by one per cent lower than the value of the previous year (584 billion kWh).

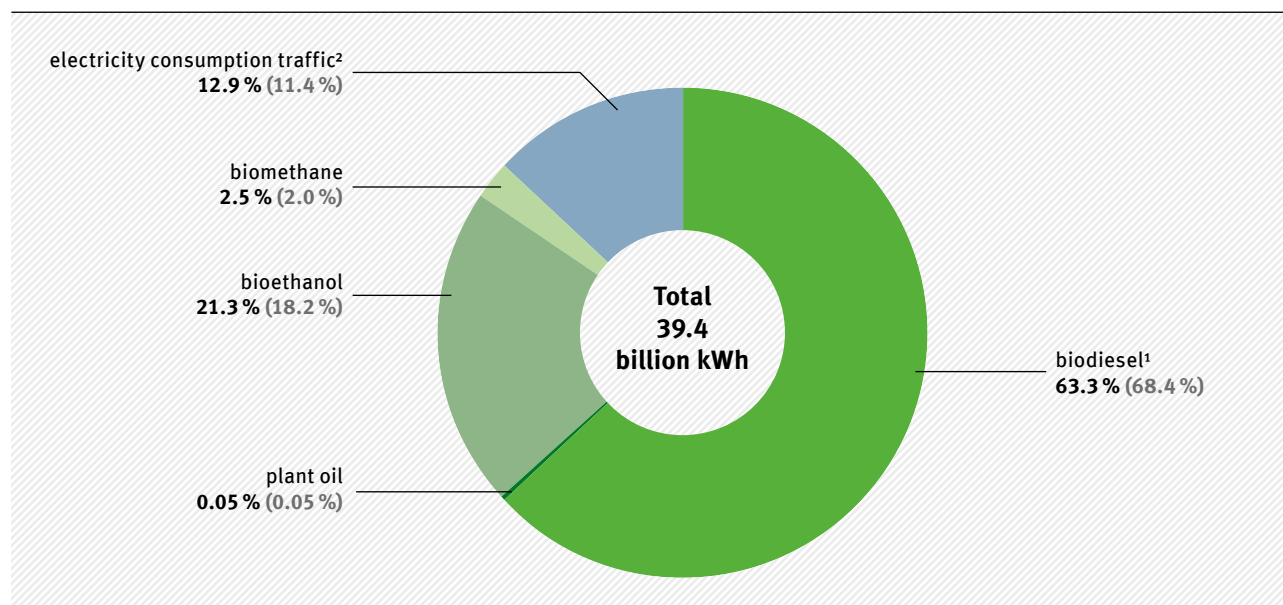
Biofuels

Based on an extrapolation of temporary data of the Federal Office of Economics and Export Control the total sale of biofuels went down by about 12 per cent related to the energy content in 2021. Especially the sale of biodiesel and HVO (minus 17 per cent) went down to now 2.4 million tons. However, the sale of bioethanol increased by nearly five per cent to nearly 1.1 million tons. The use of biomethane as fuel was with 965 million kWh about nine per cent above the value of the previous year (884 million kWh) also due to the improved economic framework conditions as against 2020. Plant oil was furthermore used only to a small scale (about 2,000 tons, 21 million kWh).



Figure 8

Development of the final energy consumption from renewable energies in the traffic sector in 2021 share in per cent, values for the previous year in brackets



¹ consumption of biodiesel (incl. hydrated plant oil (HVO) in the traffic sector, without agriculture and forestry, building trade and army

² calculated with the share of renewable energies in the gross electricity consumption of the respective year

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

Renewable electricity in the traffic sector

Besides biofuel also the electricity consumption in the traffic sector in connection with the high share of renewable energies in the German electricity mix contributes to the energy transition in the traffic sector.

According to the Federal Motor Transport Authority 682,000 new vehicles with electric drive (battery electric, plug-in hybrid, fuel cell) were newly licensed in 2021. These were 26 per cent of all newly licensed automobiles. Nearly 14 per cent of all newly licensed automobiles were purely battery electrically driven. Thus, the electricity consumption of the whole electric vehicles fleet increased strongly as against the previous year. However, with 1.4 billion kWh it is still clearly under the consumption of electricity in rail traffic (about 11.0 billion kWh).

Thus, road and rail traffic are together (12.4 billion kWh) only responsible for a bit more than two per cent of the German gross electricity consumption. The use of renewable electricity in the traffic sector increased only by about one per cent in 2021 to nearly 5.1 billion kWh (2020: 5.0 billion kWh) as the increasing electricity consumption in 2021 faced a decreased share of renewable electricity in the electricity mix.

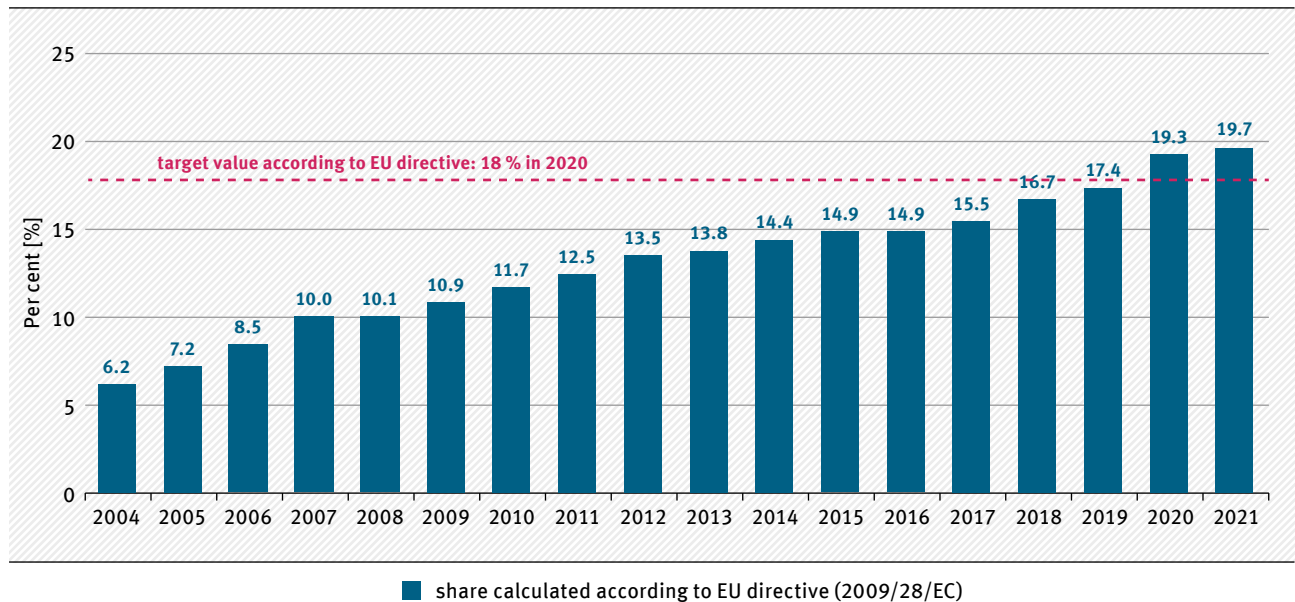
Altogether the consumption of electricity from renewable sources contributes about 13 per cent to the final energy consumption of renewable energies in the traffic sector.

Share of renewable energy in the gross final energy consumption increases



Figure 9

Share of renewable energies in the final electricity consumption according to the EU directive



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

With the EU Renewable Energy Directives (2009/28/EC and 2018/2001/EC) binding targets were set for the whole EU: Until 2020 20 per cent of the gross final energy consumption from renewable energies and a minimum share of 10 per cent of renewable energies should be reached in the traffic sector throughout the EU.

Germany has obligated to make available from renewable energies 18 per cent of the gross final energy consumption. This national target was clearly surpassed in 2020. According to the calculation regulations of the Directive the share of renewable energies in the whole gross final energy consumption went up to 19.3 per cent.

After evaluation of the currently available data the share of renewable energies in the gross final energy consumption increased to 19.7 per cent in 2021. On the one hand the distinct increase of using renewable heat was responsible for this development, on the other hand normalizing the electricity production from water power and wind energy is prescribed in

the calculation regulations for the renewable share according to the EU Directive. Thus, the weather effects are compensated.

In the course of the year with official energy statistical data being available in the field of heat and traffic deviations of the currently estimated share may arise.

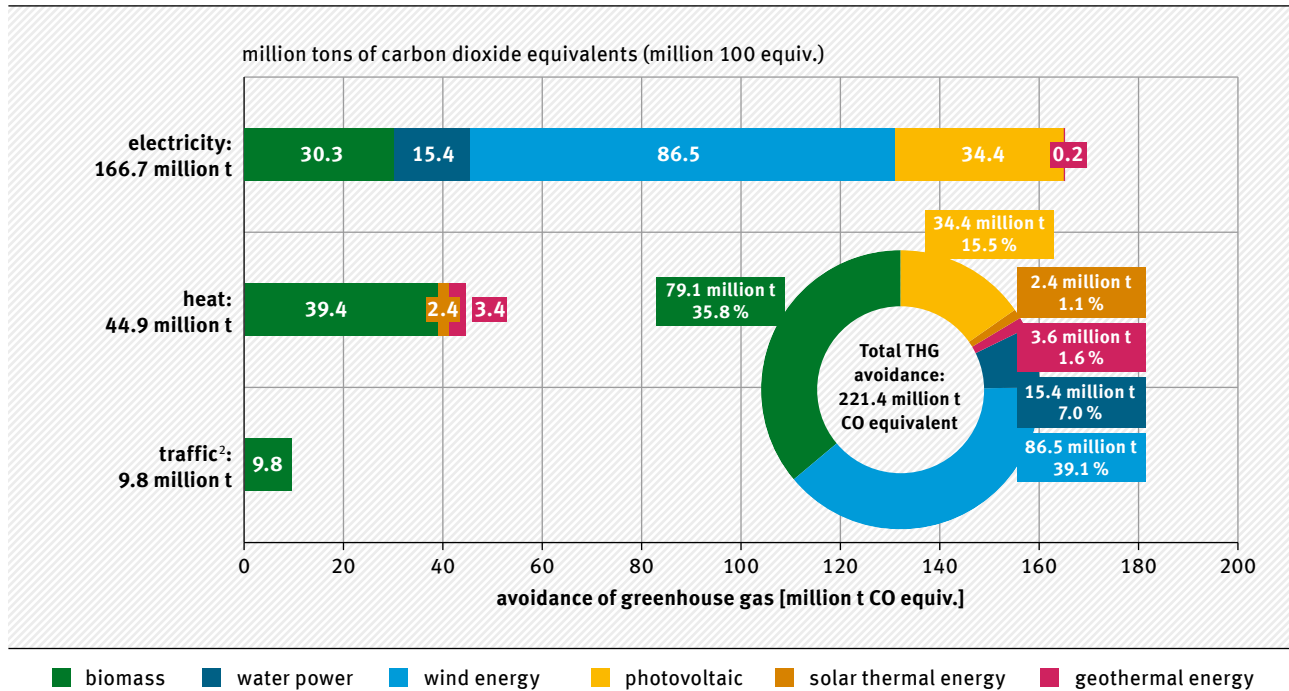
The target value of a minimum share of 10 per cent renewable energies in the traffic sector also contained in the 2009/28 /EC was narrowly missed with 9.9 per cent in 2020. In the actual year this value was declining according to first very provisional data.



Renewable energies avoid 221 million tons of greenhouse gases

Figure 10

Avoided greenhouse emissions by using renewable energies in 2021



¹ without considering the wood coal consumption

² excluding biogenic fuels in the traffic sector (without agriculture and forestry, building trade and army and without electricity consumption) based on the preliminary data of the Federal Agency for Agriculture and Food for the year 2020 and the fossil basic values according to § 3 and § 10 of the 38th BImSchV

Source: Federal Environmental Agency Renewable Energies (UBA)

The expansion of renewable energies contributes essentially to reaching the climate protection targets. By replacing fossil energy carriers by renewable energies the energy caused greenhouse gas emissions from coal, gas and oil are decreased. In 2021 by using renewable energies about 221 million tons of CO₂ equivalents were avoided. Yet, due to the decreased renewable electricity quantity this is less than in the previous year (232 million t of avoided emissions). The biggest share in it had the electricity generation from wind power with around 87 million t of CO₂ equivalents. Around 167 million t of CO₂ equivalents came to the electricity sector.

In the heat sector about 45 million t of CO₂ equivalents and by bio fuels about 10 million t of CO₂ equivalents were avoided. The calculations on the emission avoidance by using renewable energies are based on a net consideration. Thereby the emission caused by providing energy from renewable energies are offset with those which are avoided by the substitution of fossil energy carriers. Thereby off-process chains for winning and providing energy carriers and for the production and the operation of plants are considered. More detailed information on the method may be seen in the publication “Emission Balance of renewable energy carriers” of the Federal Environmental Agency (see infobox).

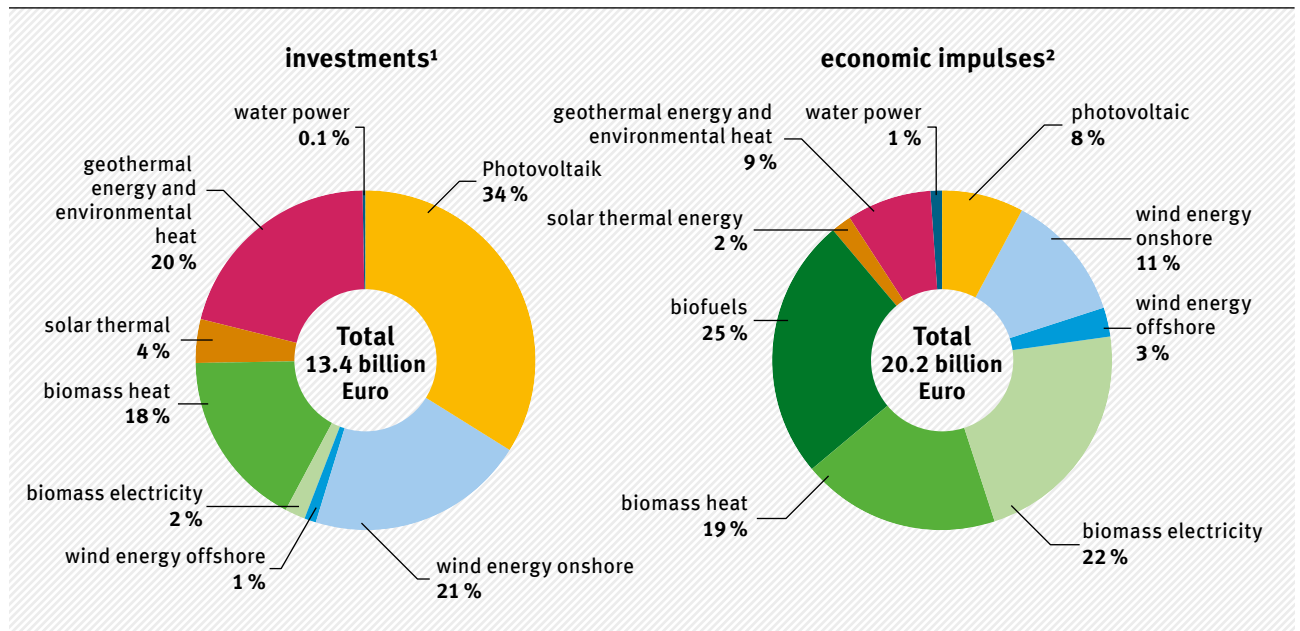
The publication “Emission Balance of renewable energy carriers” is available on the pages of the Federal Environmental Agency under www.umweltbundesamt.de/publikationen/emissionsbilanz-erneuerbarer-energetraeger

Economic Effects



Figure 11

Economic effects of renewable energies in 2021



¹ investments: mainly into new buildings, for a smaller part also for extension or increase of efficiency of plants such e.g. reactivation of old water power stations. In addition to investments in energy supply companies also investments in industry, trade and private households are contained.

² economic impulses of the operation of plants comprise mainly expenditure on operation and maintenance of the plants (incl. fuels) and returns from the sale of biofuels

Source: Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW)

Renewable energies play an important role as an economic factor in Germany. After a decline in previous years investments started to grow again in 2020. In the year 2021 investments in renewable energy sources went up again now reaching nearly 13,4 billion Euro. This represents an increase of approximately 20 per cent.

The strongest absolute increases as compared with the previous year show wind energy plants onshore and heat pumps, followed by biomass plants for using heat and photovoltaic plants. Whereas there were no changes of solar thermal energy as compared with the previous year the investment in biomass plants for electricity generation and in water power plants dropped. A special role played wind energy plants offshore as here no new plants were completed but only preparatory work for offshore wind parks could be taken into account which will be built in the years to come.

Altogether 34 per cent of the investment came on photovoltaic (after 38 per cent in 2020), 22 per cent on wind energy (after 19 per cent in 2020), 20 per cent on geothermal energy and environmental heat (after 17 per cent in 2020) and 18 per cent on biomass plants for using heat (after equally 18 per cent in 2020).

The economic impulses from the operation of plants for using renewable energies (including biofuels) continue their upward trend. They grew as compared with 2020 from 18.3 to 20.2 billion Euro, in particular due to a strongly increased sale from selling biofuels. Thus, they were above the investment in new plants as already in the years since 2015.

Sources

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

Annex

Graphics and tables on the development of renewable energies in Germany

State: February 2021

Table 1

Gross electricity production from renewable energies

	Renewable energies 2020		Renewable energies 2021	
	Gross electricity production in GWh	Share in the gross electricity consumption ⁴ in %	Gross electricity consumption in GWh	Share in the gross electricity consumption ⁴ in %
Water power ¹	18,317	3.3	19,086	3.4
Wind energy onshore	104,796	18.9	89,474	15.7
Windenergy offshore	27,306	4.9	24,374	4.3
Photovoltaic	49,496	8.9	49,992	8.8
Biogenic solid fuels ²	11,306	2.0	11,363	2.0
Biogenic liquid fuels	307	0.1	293	0.1
Biogas	28,757	5.2	28,453	5.0
Biomethane	2,914	0.5	2,890	0.5
Sewage gas	1,579	0.3	1,587	0.3
Gas produced by dumping waste	247	0.04	229	0.04
Biogenic share of the waste ³	5,820	1.0	5,630	1.0
Geothermal energy	231	0.04	249	0.04
Total	251,076	45.2	233,620	41.1

¹ in pumped storage power plants only electricity production from the natural inflow

² including sewage sludge

³ biogenic share of the waste in waste incineration plants set with 50 per cent

⁴ related to the gross electricity consumption, 2020: 555,3 TWh, 2021: 568,8 TWh, fossil gross electricity production according to AGEb, foreign trade balance according to StBA, preliminary estimate

Table 2

Installed power for the generation of electricity from renewable energies

	Water power	Wind		Photo-voltaic	Geo-thermal energy	Solid biomass ¹	Liquid biomass	Gaseous biomass ²	Total
		onshore	offshore						
		Megawatt (MW)							
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	5,436	54,414	7,774	53,721	47	2,621	231	7,467	131,711
2021	5,383	56,091	7,774	58,728	53	2,623	229	7,579	138,460

¹ including biogenic share of the waste² Biogas, biomethane, gas produced by decomposing waste and waste gas

Table 3

Final energy consumption of renewable energies for heat

	Renewable energies 2020		Renewable energies 2021	
	Final energy Consumption heat in GWh	Share in final energy Consumption heat ⁸ in %	Final energy consumption heat in GWh	Share in the final energy consumption heat ⁸ in %
biogenic solid fuels (households) ¹	67,898	5.7	81,130	6.7
biogenic solid fuels (TCS) ²	19,425	1.6	21,768	1.8
biogenic solid fuels (Industry) ³	23,279	2.0	23,279	1.9
biogenic solid fuels (HS/HPS) ⁴	6,296	0.5	6,662	0.6
biogenic liquid fuels ⁵	3,239	0.3	2,932	0.2
biogas	13,603	1.1	13,339	1.1
biomethane	4,023	0.3	4,056	0.3
waste gas	2,378	0.2	2,378	0.2
gas produced by decomposing waste	85	0.01	70	0.01
biogenic share of the waste ⁶	15,060	1.3	15,895	1.3
Solarthermal energy	8,905	0.8	8,449	0.7
deep geothermal energy	1,427	0.1	1,513	0.1
surface-near geothermal energy, environmental heat ⁷	16,049	1.4	17,905	1.5
Total	181,667	15.3	199,376	16.5

¹ predominantly wood including wood pellets² TCS = Trade, commerce, service - sector³ including sewage sludge⁴ including sewage sludge (HS=heating stations, HPS = heating power stations)⁵ including biofuels for agriculture and forestry, building trade and military⁶ biogenic share of waste in waste incineration plants with 50 per cent put⁷ for by heat pumps usable made renewable heat (air-water, waste-water- and sole-water heat pumps and industrial water and gas heating pumps)⁸ without electricity for heat, related to EEV for space heating, warm water and process heat, , 2020: 1.184,4 TWh, 2021: 1.209,4 TWh, according to AGEb (preliminary estimate)

Table 4

Final energy consumption of renewable energies in the traffic sector

	Renewable energies 2020		Renewable energies 2021	
	Terminal energy consumption traffic in GWh	Share in the terminal energy consumption traffic ³ in %	Terminal energy consumption traffic in GWh	Share in the terminal energy consumption traffic ³ in %
Biodiesel ¹	30,148	5.2	24,916	4.3
Plant oil	21	0.004	21	0.004
Bioethanol	8,014	1.4	8,382	1.4
Biomethane	884	0.2	965	0.2
Electricity consumption renewable energies in traffic ²	5,034	0.9	5,083	0.9
Total	44,101	7.6	39,367	6.8

¹ consumption of biodiesel in the traffic sector, without agriculture and forestry, construction trade and military² calculated with the share of renewable energies in the gross electricity consumption of the respective year, total electricity consumption in traffic according to GEB, BDEW³ related to the final energy consumption traffic, 2020: 583,8 TWh, 2021: 580,2 TWh, according to AGE (preliminary estimate)

Table 5

Investment in the erection of renewable energy plants in Germany

	Water power	Wind energy		Photo- voltaic	Solar thermal energy	Geothermal energy & environmen- tal heat	Biomass		Total
		onshore	offshore				elec- tricity	heat	
	Million Euro								
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	1,560	16,480
2014	90	7,060	3,940	1,450	790	1,080	670	1,320	16,400
2015	80	5,370	3,680	1,480	800	1,010	220	1,290	13,930
2016	60	6,910	3,370	1,570	700	1,210	270	1,230	15,320
2017	60	7,450	3,400	1,660	540	1,320	280	1,230	15,940
2018	70	3,390	4,100	2,580	490	1,520	390	1,240	13,780
2019	60	1,560	2,130	3,420	440	1,410	350	1,260	10,630
2020	40	2,080	70	4,220	530	1,920	320	1,950	11,130
2021	10	2,840	160	4,570	530	2,620	210	2,410	13,350

Source : Own calculation of the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), State: February 2022

Table 6

Economic impulses by the operation of renewable energy plants in Germany

	Water power	Wind energy		Photo-voltaic	Solar thermal energy	Geothermal & environmental heat	Biomass			Total
		onshore	offshore				elec- tricity	heat	Bio- mass fuels	
		Million Euro								
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	1,000	4,300	3,030	2,640	14,570
2015	200	1,730	280	1,420	260	1,090	4,440	3,190	2,440	15,050
2016	210	1,890	350	1,440	270	1,180	4,430	3,390	2,560	15,720
2017	210	2,080	420	1,470	290	1,280	4,450	3,410	2,710	16,320
2018	210	2,230	500	1,500	300	1,390	4,470	3,430	2,700	16,730
2019	220	2,300	560	1,540	310	1,510	4,560	3,450	2,830	17,280
2020	220	2,300	600	1,590	320	1,650	4,580	3,470	3,540	18,270
2021	230	2,310	620	1,660	330	1,830	4,400	3,860	4,970	20,210

Source : Own calculation of the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), State: February 2022

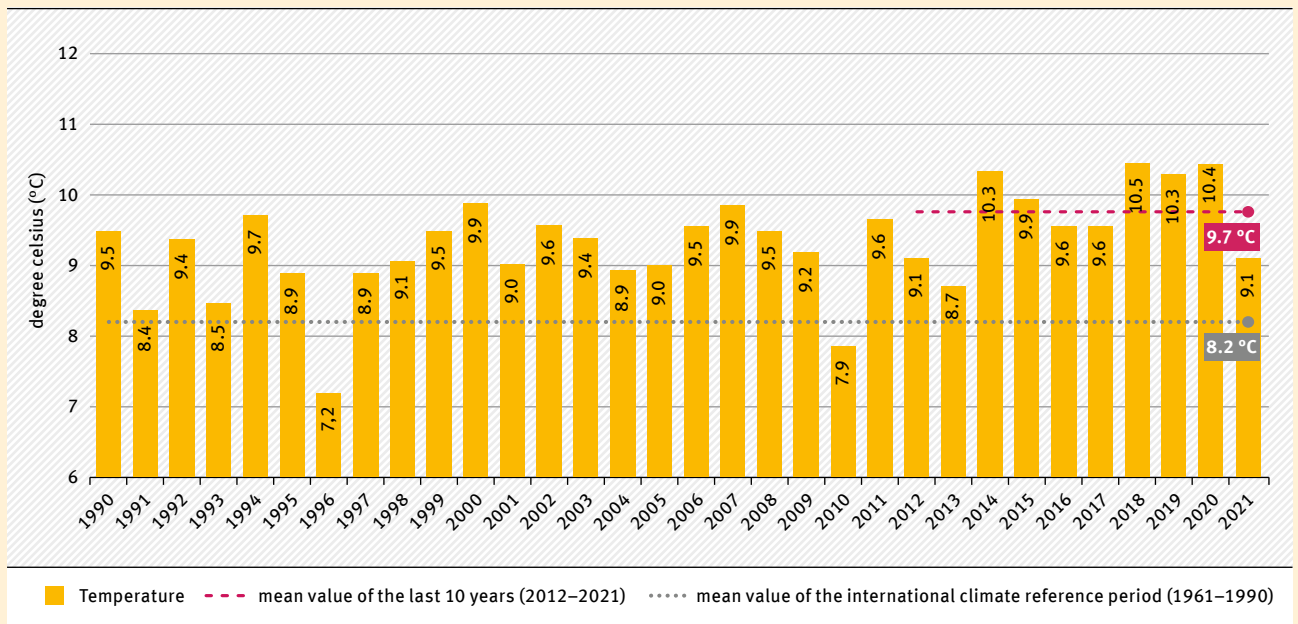
Table 7

Avoided Greenhouse gas emission by using renewable energies

	Water power	Wind energy		Photo-voltaic	Solar thermal energy	Geothermal & environ-mental heat	Biomass			Total
		onshore	offshore				elec-tricity	heat	fuels	
	Million tons of CO ₂ -equivalents									
2010	16.7	27.4	0.1	8.1	1.5	1.0	20.1	33.3	6.5	114.8
2011	14.7	37.6	0.4	14.2	1.8	1.1	22.5	31.7	6.4	130.3
2012	16.6	33.5	0.5	16.6	1.8	1.2	23.3	34.3	7.0	134.8
2013	16.3	36.4	0.6	18.1	1.9	1.3	22.1	34.9	6.4	138.0
2014	15.4	43.2	1.1	23.4	2.0	1.6	27.2	31.2	6.7	151.8
2015	14.8	53.2	6.0	25.4	2.1	1.7	27.6	33.1	6.3	170.2
2016	15.8	49.6	9.1	24.9	2.1	1.9	27.5	32.7	6.9	170.6
2017	14.9	61.3	12.5	24.8	2.2	2.2	26.2	33.3	7.4	184.9
2018	13.2	64.0	13.9	27.7	2.5	2.5	27.1	34.6	7.7	193.3
2019	15.9	76.6	19.0	31.5	2.4	3.0	29.9	36.0	7.5	221.8
2020	14.7	78.9	21.0	34.4	2.5	3.4	30.3	35.7	11.1	231.9
2021	15.4	67.7	18.8	34.4	2.4	3.6	30.3	39.1	9.8	221.4

Source: Federal Environmental Agency), State: February 2022

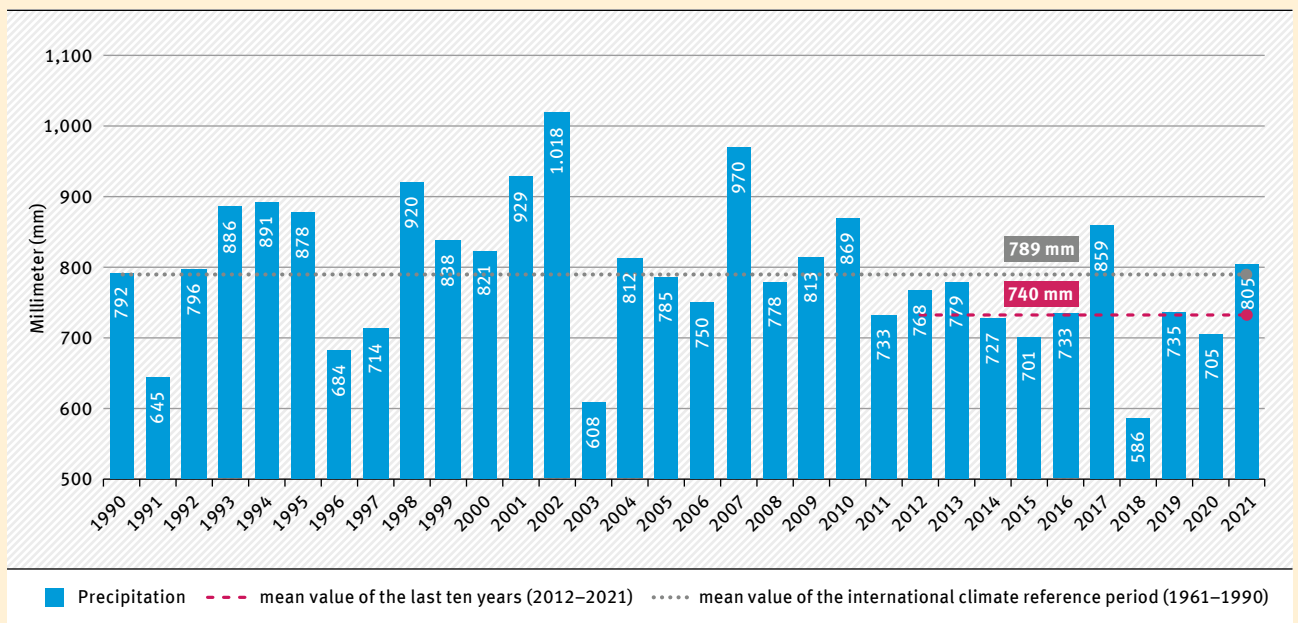
Figure 12

Averaged yearly temperature in Germany (1990–2021)

The year 2021 was with 9.1 eC about 0.9 eC warmer than the means value of the International climate period (1961 – 1990) as compared with the last ten years yet only the year 2012 and 2013 were cooler than the calendar year 2021.

Source: German Weather Service (DWD))

Figure 13

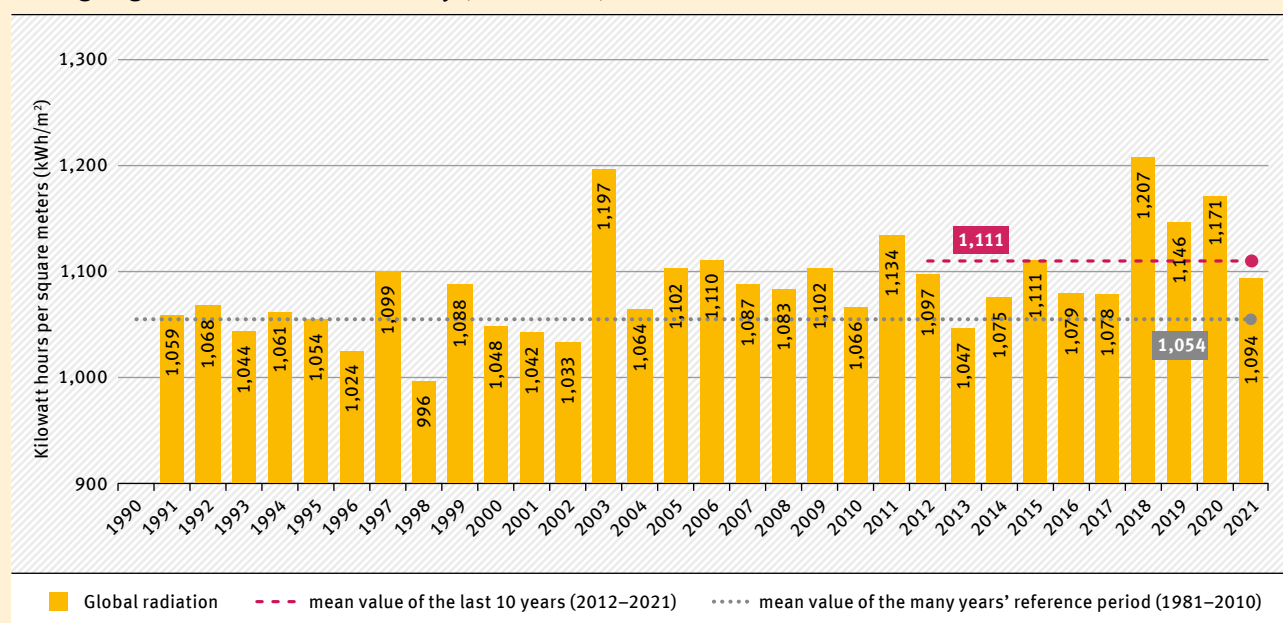
Averaged precipitation quantity in Germany (1990 – 2021)

With about 805mm the year 2021 was slightly above the many years' level. In the last ten years thus only every 2 years (2017, 2021) the precipitation quantity exceeded the long years' mean value of 789mm

Source: German Weather Service (DWD)

Figure 14

Averaged global radiation in Germany (1991–2021)

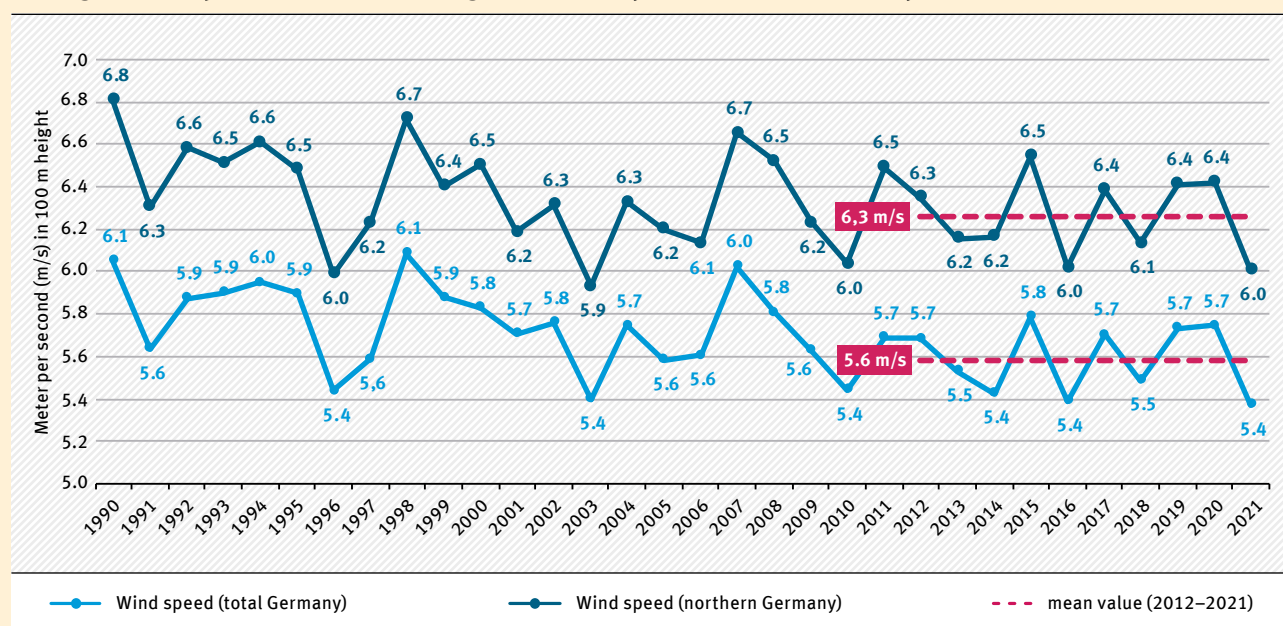


The global radiation is a measure for the sum of direct and diffuse sun radiation per area and thus a direct indicator for the efficiency of PV and solar thermal energy plants. The global radiation is systematically provided by the DWD since 1991. In 2021 the value of the many years' medium was clearly exceeded with 1,094 kWh/m². As compared with the last 10 years the global radiation was, however, below average in 2021.

Source: German Weather Service (DWD)

Figure 15

Averaged wind speed in 100meters height in Germany and Northern Germany (1990–2021)



Yearly mean value of the wind speed in 100 m height over Germany and the northern area of Germany. The data are based on the global atmospheric real analysis "ERA-5" of the European Copernicus Climate Service (C3S) and the mean value of the following areas: Germany about 6eO, about 48eN-55eN; northern Germany: about 6eO-15eO, about 52eN-55eN.

Source: German Weather Service, National Climate Monitoring based on C3S/ERA-5. Hersbach et al.

Further information as time rows on the development of renewable energies in 1990 and respective diagrams are to be found in the „Information Portal Renewable Energies“ des BMWi under www.erneuerbare-energien.de.

Glossary

Gross energy consumption according to EU Directives

The EU Directive 2009/28/EG contains detailed instruction for the calculation of the share of renewable energies in the gross final energy consumption: Thus, the effects of climatic fluctuations are considered in the electricity output in calculating the contributions of wind and water power. By this “normalization” to an average year the value for wind and water power does no longer correspond to the actual output of the respective year, yet it reflects better the respective construction. In addition, only liquid bioenergy carriers and biofuels are considered which fulfil specific sustainability criteria.

Gross electricity production

The gross electricity production comprises the total electricity quantity of a country produced. After deducting the own consumption of the production plants there remains the net electricity production.

Gross electricity consumption

The gross electricity consumption corresponds to the sum of the total national gross electricity production (wind, water, sun, coal, oil, natural gas and others) including electricity flows from abroad and minus the electricity flows to abroad. The net electricity consumption corresponds to the gross electricity consumption minus own consumption of power plants and net and storage loss.

CO₂ equivalents

The unit for the greenhouse potential of a gas shows which quantity of CO₂ in a period under consideration of 100 years would develop the same greenhouse effect as the considered comparison gas. The equivalence factors used follow the values from the IPCC Fourth Assessment Report Climate Change 2007 for the national emission report.

Final energy

The final energy is the part of primary energy reaching the consumer after deduction of the transmission and conversion loss which will be then available for further use. Forms of the final energy are e.g. district heating, electricity, hydrocarbons as petrol, kerosene, heating oil or wood and various gases such as natural gas, biogas and hydrogen.

Renewable energies

Energy sources which according to time standards of men are available for an infinite long time. Nearly all renewable energies are lastly fed by the sun. The sun consumes itself, is no “renewable energy source” also in the strict sense. Yet, according to the present state of science the foreseeable life of the sun is more than one billion of years and nearly unlimited from our human perspective. The three original sources are sun radiation, earth heat (geo-thermal energy) and tidal power. They may be used either directly or indirectly in the form of biomass, wind, water power, environmental heat and wave energy.

Primary energy

Primary energy is the mathematically usable energy content of a naturally present energy carrier before it will be subjected to a conversion. The primary energy carriers include exhaustible energy carriers (e.g. hard and brown coal, natural oil, natural gas, splittable material such as uranium ore) and renewable energies (sun energy, wind energy, water power, earth heat and tidal energy). Primary energy is converted into a further stage of the energetic row in power plants or refineries. Thereby conversion loss occurs. A part of the primary energy carriers comes also to the non-energetic consumption (e.g. crude oil for the plastics industry).



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