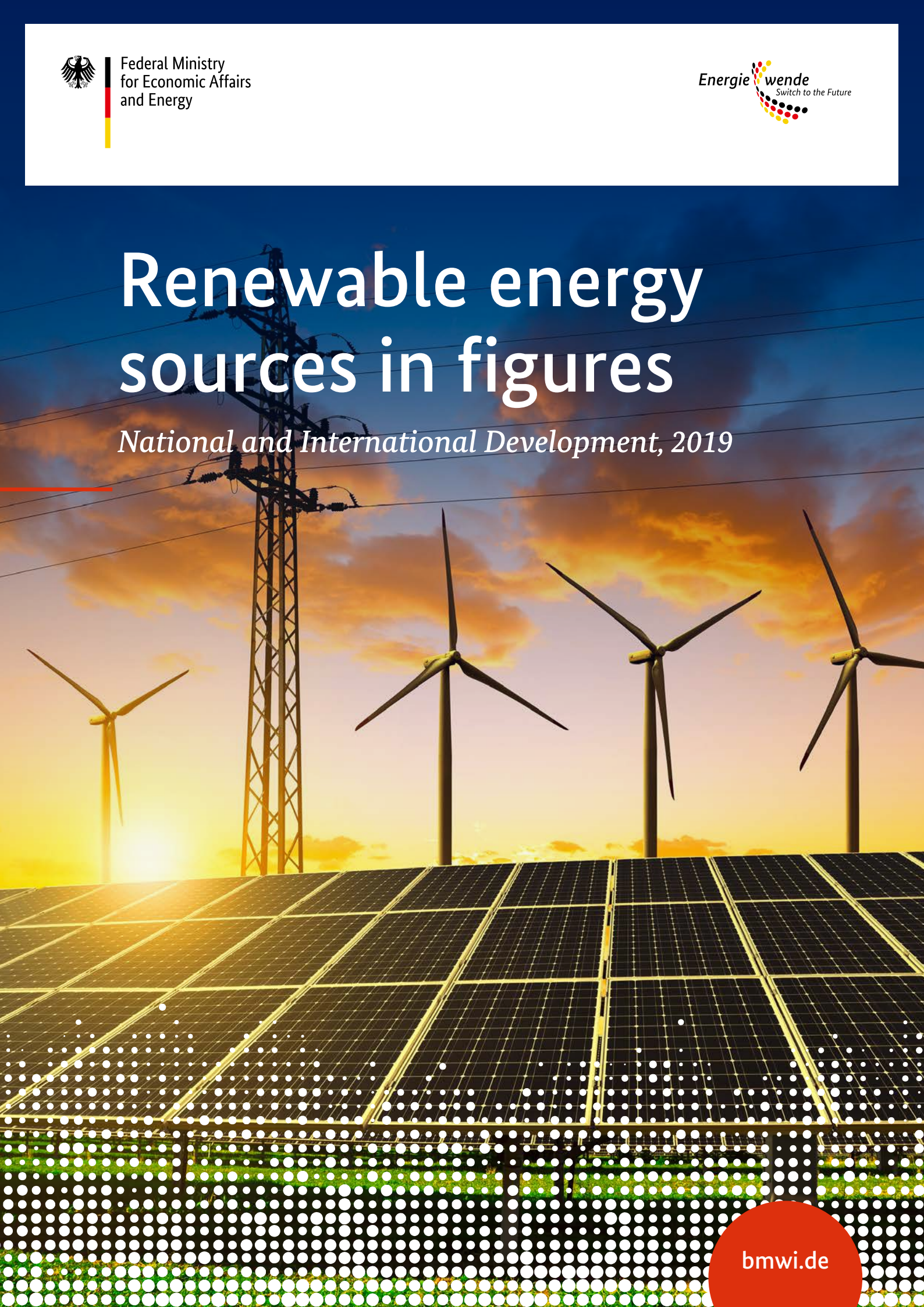
Federal Ministry
for Economic Affairs
and Energy

Energie wende
Switch to the Future

Renewable energy sources in figures

National and International Development, 2019



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Introduction

Dear reader,

in the 2020 edition of "Renewable Energy Sources in Figures – National and International Development", the Federal Ministry for Economic Affairs and Energy presents the latest data on the use of renewable energy in Germany, the EU and the world.

The data contained in this publication on the development of renewable energy in Germany in 2019 also serve as an important basis for monitoring progress towards the Federal Government's goals for the energy transition. The data form the basis for future decisions on the policy framework for the ongoing expansion of renewable energy.

In the areas of electricity, heat and transport, renewable energy in Germany developed as follows in 2019:

Electricity

In 2019, electricity generation from renewable energy again rose further, by 8% to nearly 243 billion kilowatt-hours. Its share of total electricity consumption rose from 37.8% to 42.1%.

Heat

The use of renewables-based heat increased slightly in 2019. As the overall consumption of heat rose due to the weather conditions, the proportion of heat based on renewables fell slightly from 14.8% to 14.7%.

Fuels

In 2019, sales of biofuels remained at the same level as the preceding year. The share of renewables in the transport sector saw a small drop from 5.6 to 5.5%.

The use of renewable energy sources has positive ecological and economic effects:

Renewable energy use cuts greenhouse gases

The expansion of renewable energy means that less fossil fuel needs to be burnt. As a consequence, greenhouse gas emissions amounting to 201 million tonnes of CO_2 equivalents were avoided in 2019.

Economic opportunities provided by renewable energy

Renewable energy is an important factor in Germany's economy. 2019 saw a total of €10.5 billion being invested in plant and equipment, and the stimulus to the economy deriving from the operation of the installations amounted to €17.2 billion.

The main source of data used in this publication is the findings of the Working Group on Renewable Energy – Statistics (AGEE-Stat), which prepares the "balance sheet" for renewable energy sources in Germany on behalf of the Federal Min-

istry for Economic Affairs and Energy. Furthermore, statistics from the Federal Environment Agency, the Federal Statistical Office, the Working Group on Energy Balances and many other sources also feed into the data.

In addition to the data on the development of renewable energy, the publication also provides information on other key aspects, such as the Renewable Energy Sources Act (RES Act), the Renewable Energies Heat Act and the funding of renewable energy in the fields of heat, transport, and research and development.

Not only does it document their development in Germany, it also provides a great deal of information about the use of renewable energy sources in the European Union, which also set ambitious goals for itself in the Clean Energy for All Europeans package of legislation at the end of 2018. Finally, the brochure covers the global development of renewable energy.

All of the information presented in this publication reflects the situation as of the editorial deadline for this brochure (August 2020), meaning certain figures are provisional. Alongside this brochure, on its website the Federal Ministry for Economic Affairs and Energy provides regularly updated time series and a large number of diagrams showing the development of renewable energy sources in Germany since 1990. Complete sets of data from 1990 can be found there – whilst in this brochure most of them have been abridged to make them easier to follow. These timelines and diagrams will be updated at the end of 2020/start of 2021 (see: www.erneuerbare-energien.de/EE/Navigation/DE/Service/Erneuerbare_Energien_in_Zahlen/Zeitreihen/zeitreihen.html and www.erneuerbare-energien.de/EE/Redaktion/DE/Bilderstrecken/entwicklung-der-erneuerbaren-energien-in-deutschland-im-jahr-englisch.html).

For more information about renewable energy and the energy transition in Germany, please visit the Ministry's website at www.bmwi.de/Navigation/EN/Home/ and www.erneuerbare-energien.de (in German only).

Yours sincerely,

The Federal Ministry for Economic Affairs and Energy

Berlin, October 2020

Working Group on Renewable Energy Statistics

Since February 2004, the Working Group on Renewable Energy Statistics (AGEE-Stat) has generated comprehensive and up-to date statistics and data on the development of renewable energy sources in Germany. AGEE-Stat works on behalf of the Federal Ministry for Economic Affairs and Energy. The AGEE-Stat's findings are incorporated into this publication.

AGEE-Stat is an independent expert body with members from various ministries, agencies and academic institutions.

The following institutions are currently AGEE-Stat members:

- the Federal Ministry for Economic Affairs and Energy (BMWi)
- the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
- the Federal Ministry of Food and Agriculture (BMEL)
- the German Environment Agency (UBA)
- the Federal Statistical Office (StBA)
- the Federal Network Agency (BNetzA)
- the Agency for Renewable Resources (FNR)
- the Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg (ZSW) as a representative of the Working Group on Energy Balances (AGEB).

AGEE-Stat is supported in its work by a consortium of academic institutions. The project partners are the Leipzig Institute for Energy (IE Leipzig) as the coordinator, and the Fraunhofer Institute for Solar Energy Systems ISE (Fh-ISE), the German Biomass Research Centre (DBFZ), the German Energy Agency (dena), Ingenieurbüro Floecksmühle, the Hamburg Institute (HIC) and UL International GmbH.

The German Environment Agency in Dessau has been tasked with directing and coordinating the Working Group. The relevant office is located in Department V "Climate change mitigation, Energy, German Emissions Trading Office" and is assisted by officials from Unit V 1.5 "Energy data, office of AGEE-Stat". AGEE-Stat's activities focus on continuously developing and assuring the quality of the statistics on the use of renewable energy sources in Germany. The Working Group also has the task of

- creating a basis for meeting the Federal Government's various national, EU and international reporting obligations on renewable energy and
- providing the public with information on renewable energy data and development.

AGEE-Stat conducts a wide range of research and publishes its findings in order to improve the data pool and the scientific calculation methods that are used. The group's work is supported by workshops and expert consultations on selected topics.

Further information on AGEE-Stat and renewable energy in Germany can be found in the form of diagrams, time series and monthly and quarterly reports on the websites of the Federal Ministry for Economic Affairs and Energy at www.erneuerbare-energien.de (in German only) and of the office of AGEE-Stat in the German Environment Agency at https://www.umweltbundesamt.de/en/topics/climate-energy/renewable-energies/renewable-energies-in-figures.

Part I: The energy transition in Germany

The energy transition entails a fundamental shift in Germany's energy supply from nuclear and fossil fuels to renewable energy, coupled with higher energy efficiency. We have already come a long way in this process – more than 42% of electricity consumption is now covered by wind, solar, biomass and hydropower. The Federal Government is committed to making the energy transition a driver for energy efficiency, modernisation, innovation and digitisation in our electricity and heating sectors. This also applies to the transport sector and agriculture.

Over the last two decades, the share of renewables in electricity consumption has grown steadily – rising from around 6% in 2000 to more than 42% in 2019. This means that the expansion target of 35% for 2020 set out in the 2010 Energy Concept was met well ahead of schedule and has since been exceeded by some distance. Also, we are already within the target corridor of the 2017 Renewable Energy Sources Act, which envisaged a 40-45% share for renewable energy by 2025. The Federal Government is aiming at a further significant increase in the proportion of renewable energy in the electricity sector. In the summer of 2020, it formulated a new target figure of 65% by 2030 in the 2030 Climate Action Programme and in the revision of the Renewable Energy Sources Act in the wake of the Coal Phase-out Act. This will require the continued expansion of renewable energy in a way that is ambitious, efficient, synchronised with the grid and increasingly market-oriented. This is the only way to replace the coal-fired electricity in a secure way and to cover the additional demand for electricity from renewables so that the climate targets can be met in the transport, building and industrial sectors.

A successful Renewable Energy Sources Act

The successful expansion of the use of renewable energy is rooted in the Renewable Energy Sources Act, which entered into force in 2000 and has since been revised several times. The Act originally aimed to facilitate market access for what were still young electricity generation technologies like wind energy and photovoltaics, by guaranteeing their purchase at fixed rates. The broad market introduction due to the Renewable Energy Sources Act has long since freed up these technologies from their niche roles, so that they have since become a major pillar of Germany's electricity supply.

And the successful work has included not only the expansion of renewable energy, but also its integration into the market. Since the revision of the Renewable Energy Sources Act in 2017, the remuneration rates for renewable electricity have no longer been set by the government, but have been determined by auctions on the market. The only exception is for small installations with a capacity of up to 750 kW, so that stakeholder diversity has been maintained, particularly in the field of photovoltaics. The auctions held under the Renewable Energy Sources Act serve to steer the quantities of much of the newbuild, and to bring renewable energy closer to the market. In fact, the auctions have resulted in some clear falls in price since 2017.

The 2017 version of the Renewable Energy Sources Act has also put initial policies in place to ensure that the pace at which renewables capacity is added corresponds to the pace at which the grids are developed. Nevertheless, the growing shares of renewable energy are creating new challenges for the grids: in some cases, electricity needs to travel long distances from the generators in the north to the consumers in the south. Coping with this requires an efficient grid infrastructure and good coordination of the expansion of the grid with the ongoing expansion of renewable energy.

The 2017 Renewable Energy Sources Act introduced funding for landlord-to-tenant electricity. This is electricity that is generated by a solar installation on the rooftop of a residential building and then passed on to final consumers (particularly tenants) living within this building or in a residential building or ancillary facilities located within close proximity of this building, and that are connected directly to the installation rather than via the public grid. In this way, not only the owners of buildings, but also their tenants can contribute to the expansion of renewable energy.

Renewed pick-up in wind energy expansion

Wind energy replaced lignite as the leading source of German electricity in 2019. Contributing factors were a good year for wind, but also the expansion of both onshore and offshore wind energy. However, the roll-out of onshore wind energy has slowed significantly in the last two years. The numbers of new turbines have falling appreciably in comparison with the preceding years. For this reason, the Economic Affairs Ministry presented an action plan in October 2019 to remove major obstacles, boost public acceptance for wind energy, and create greater legal certainty for projects. As a consequence, close cooperation between the Federal government, Federal states and municipalities can pave the way for a contin-

ued expansion of onshore wind energy, which will remain an important pillar in the ongoing roll-out of renewable energy.

The Federal Government has also taken various measures in recent years for the heating market and transport with a view to pursuing the aims of the energy transition. By 2020, renewables are supposed to account for 14% of final energy consumption for heating and cooling. This is laid down in the Renewable Energies Heat Act, which is the major instrument for heating/cooling, alongside which the Market Incentive Programme also provides an additional source of funding for these areas. Also, according to EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources, the proportion of final energy consumption covered by renewable sources in the transport sector is to rise to 10% by 2020. The main instruments deployed by the Federal Government are the Electric Mobility Strategy and the purchase premium for electric vehicles introduced in 2016.

Since September 2018, the 7th Energy Research Programme entitled "Innovations for the Energy Transition" has been in force, under which the Federal Government is providing €6.8 billion for projects between 2018 and 2022. In this context, assistance is aimed primarily at technologies that meet the requirements of the energy transition.

Climate Action Act now in force

The Climate Action Act entered into force on 18 December 2019. It enshrines in legislation the Federal Government's aim of cutting greenhouse gas emissions by at least 55% by 2030 – the first time this has been done by any country. The Climate Action Act prescribes binding greenhouse gas emission targets for all sectors for 2030, with compliance subject to annual monitoring. If a sector fails to meet its target, the Federal Government will respond with appropriate measures. At the UN Climate Summit in New York on 23 September 2019, the Federal Republic of Germany also committed to pursuing greenhouse gas neutrality by 2050 as a long-term goal.

The measures which the Federal Government intends to use to meet its 2030 climate target are described in the Climate Action Programme. One key measure is the termination of the use of coal for electricity generation by 2038 at the latest. Also, a higher aviation tax has applied since this year. At the same time, a cut in the rate of value-added tax has made rail travel somewhat cheaper. Also, carbon pricing is being introduced in 2021, making the use of fossil fuels for heating and transport gradually more expensive. The additional revenue from the carbon pricing benefits the additional funding measures of the climate action programme or is returned to the citizens in the form of relief elsewhere. Some of the revenue is going towards the EEG surcharge in order to reduce the price of electricity. This creates incentives for further electrification and fosters the cross-sectoral energy transition. Also, there have been increases in housing allowance for low-income households and in the commuter tax allowance for long-distance commuters. This implements climate change mitigation – a task for the whole of society – in a socially acceptable manner.

Monitoring the energy transition

The Federal Government's Energy for the Future monitoring process regularly reviews the progress made in the transformation of Germany's energy system. It keeps track of where we are in the energy transition, which of the measures have been realised, and what impact they have. The central task of the monitoring process is to analyse the reams of statistical information on energy that have been collected and then condense it and make it easy to understand. This involves an assessment of measures that have already been taken and work to pinpoint areas in which further efforts need to be made. In this way, each annual report provides an overview of the energy transition and shows whether the set targets can be reached or whether fine-tuning is required.

The Federal Ministry for Economic Affairs and Energy is in charge of the monitoring process for the energy reforms. The annual monitoring reports are approved by the Federal Cabinet and transmitted to the Bundestag and the Bundesrat. Also involved in the process is an independent commission of four renowned energy experts,

Figure1: Renewable energy targets of the Federal Government and the status quo

	2019 (status quo)	2020	2025	2030	2040	2050
	Share of renewable energy [%]					
Share of gross final energy consumption	17.4	18		30	45	60
Share of gross electricity consumption	42.1	at least 35	RES Act 2017: 40 – 45	RES Act amendment 2020: 65*		at least 80
Share of heat consumption	14.7	14				

* Target according to 2030 Climate Action Programme and Renewable Energy Sources following changes due to the Coal Phase-out Act in the summer of 2020. This will require the continued expansion of renewable energy in the coming years in a way that is ambitious, efficient, synchronised with the grid and increasingly market-oriented. A crucial role here is played by the capacity of the power grids to take up electricity.

Sources: Federal Ministry for Economic Affairs and Energy, AGEE-Stat

Figure 2: Renewable energy in Germany – status quo

Categories	2019	2018
Renewable energy share		
of gross final energy consumption	17.4	16.8
of gross electricity consumption	42.1	37.8
of final energy consumption in heating/cooling	14.7	14.8
of final energy consumption in transport	5.5	5.6
of primary energy consumption	14.9	13.7
Avoidance of greenhouse gas emissions through the use of renewable energy sources		
Total greenhouse gas avoidance	201.4 million t CO_2-eq.	188.4 million t CO_2-eq.
of which through electricity with remuneration under the RES Act	136.6 million t CO_2-eq.	124.8 million t CO_2-eq.
Economic impetus through the use of renewable energy sources		
Investment in the construction of renewable energy plants	10.5 billion €	13.8 billion €
Costs/Revenues from the operation of renewable energy plants	17.2 billion €	16.8 billion €

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figures 3 and 6, provisional figures

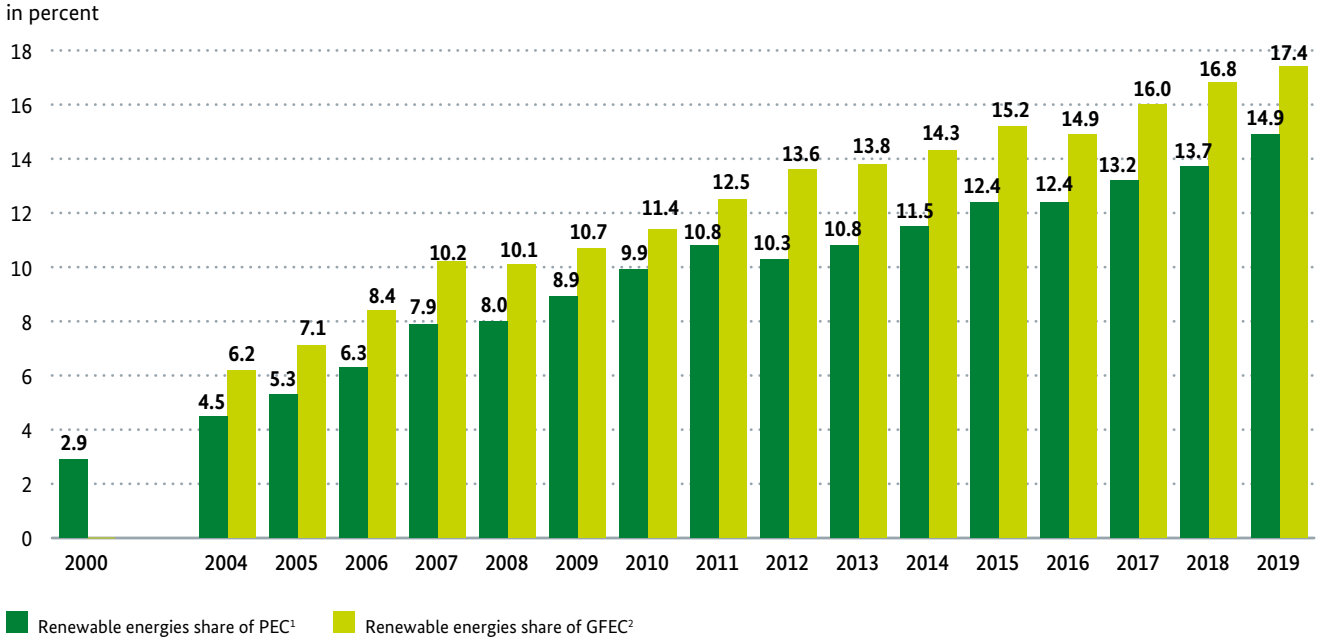
who provide advice for the drafting process and a scientific opinion on the Monitoring Report. Their scientific opinion is published alongside the Federal Government's reports.

In principle, instead of the Monitoring Report, the Federal Government presents the more detailed Progress Report on the Energy Transition every three years; the last such report was published on 6 June 2019. The progress reports contain more detailed analyses covering a longer period and provide a look ahead to the likely future development of key variables. They may also propose ways to remove impediments and hit the targets.

The figures presented in this brochure provide the fundamental data pool for tracking the development of renewable energy. In particular, they are used for the monitoring process described above and for many other reporting obligations which Germany has to meet at national, European and international level.

In addition to the Federal Government's monitoring work, it is also possible to follow the progress made on the energy transition of the electricity market at all times. To provide this transparency, the Federal Network Agency has developed the SMARD (electricity market data) platform. This platform maps the current devel-

Figure 3: Shares of renewable energy sources in gross final energy consumption (GFEC) and primary energy consumption (PEC)



1 Reduction in renewables' share in primary energy consumption due to change in methodology from 2012 onwards, preceding years not yet revised.

2 Method for calculating share of renewable energy in gross energy consumption according to the Federal Government's "Energy concept for an environmentally friendly, reliable and affordable energy supply" (https://www.osce.org/secretariat/101047) does not take account of special calculation rules set out in EU Directive 2009/28/EC. For more details on the methodology for calculating the shares of renewables in gross final energy consumption, see the "Information on methodology" section.

Sources: Federal Ministry for Economic Affairs and Energy; gross final energy consumption based on data from AGEB [1] and other sources; see Figure 6, some figures are provisional

opments on Germany's electricity market and the contribution of renewable energy, almost in real time, providing the information in an accessible manner for in-depth analysis.

Energy transition targets and the status quo

The orientation for the energy transition is provided by the Federal Government's Energy Concept and the 2030 Climate Action Programme. The triad of energy policy goals – security of supply, affordability and environmental compatibility – remains the key principle for Germany's energy policy. Figure 1 provides an overview.

Expansion of renewable energy

Electricity

Further rise in electricity generation from renewable energy sources

In total, nearly 243 billion kilowatt-hours of electricity were generated from renewable energy sources in 2019. This translates to an increase of 8% on the previous year (2018: 225 billion kilowatt-hours). Solar, wind, biomass, etc. were therefore able to build further on their positions in the German electricity mix, generating more electricity than all the lignite-fired and coal-fired power plants together. The share of gross electricity consumption covered by renewables also rose correspondingly clearly, to 42.1% (2018: 37.8%). The rise in the volume of renewables-based electricity generation was helped by generally good wind conditions and the continued roll-out of wind-powered installations, by higher electricity generation from hydroelectric power stations, and by the addition of more photovoltaic installations.

Wind energy leads the field in the German electricity mix

Wind energy replaced lignite as the leading source of electricity in 2019, with a share of 21.9%. Taking onshore and offshore wind energy together, a total of nearly 126 billion kilowatt-hours of electricity were generated from wind-powered instal-

lations, a year-on-year rise of 14.5% (2018: 110 billion kilowatt-hours).

The newbuild of onshore wind capacity did fall further...

Following the slump in the construction of new onshore wind energy capacity in 2018, the volume of newbuild dropped further in 2019. Net newbuild in 2019 was a mere 886 megawatts, down 61% from the preceding year's level (2,273 megawatts). It thus remained well below the expansion target of 2,800 megawatts set out in the 2017 Renewable Energy Sources Act. At the end of 2019, installed onshore wind energy capacity totalled 53,333 megawatts.

However, the figures for electricity generation from onshore wind in 2019 paint a very different picture. Thanks to better-than-average wind conditions, a new record was set with 101.2 billion kilowatt-hours – a year-on-year rise of nearly 12% (2018: 90.5 billion kilowatt-hours).

... but offshore wind energy remains on course

In the field of offshore wind energy, 1,111 megawatts of new capacity was added in 2019, around 12% more than in the preceding year (2018: 990 megawatts). As a result, installed offshore wind power capacity amounted to 7,507 megawatts at the end of 2019. This means that the Federal Government's expansion target of 6,500 by 2020 has already been exceeded. The combination of new capacity and good wind conditions resulted in a clear rise in electricity generation from offshore wind turbines, of 27% in year-on-year terms to 24.7 billion kilowatt-hours (2018: 19.5 billion kilowatt-hours).

Upward trend in photovoltaics continuing

Following a period of slow growth, the expansion of photovoltaics has picked up speed again in recent years, and this continued into 2019: 3,835 megawatts of capacity was newly installed, roughly a third more than in the preceding year

Figure 4: Renewables-based electricity generation in 2019 and 2018

	Renewable energy sources 2019		Renewable energy sources 2018	
	Gross electricity generation (GWh)[4]	Share of gross electricity consumption[5] (%)	Gross electricity generation (GWh)[4]	Share of gross electricity consumption[5] (%)
Hydropower[1]	20,058	3.5	17,974	3.0
Onshore wind energy	101,150	17.6	90,484	15.2
Offshore wind energy	24,744	4.3	19,467	3.3
Photovoltaics	46,392	8.1	45,784	7.7
Biogenic solid fuels[2]	10,386	1.8	10,840	1.8
Biogenic liquid fuels	401	0.1	452	0.1
Biogas	28,932	5.0	28,952	4.9
Biomethane	2,620	0.5	2,602	0.4
Sewage gas	1,550	0.3	1,555	0.3
Landfill gas	287	0.05	306	0.1
Biogenic fraction of waste[3]	5,833	1.0	6,163	1.0
Geothermal energy	196	0.03	178	0.03
Total	**242,549**	**42.1**	**224,757**	**37.8**

1 For pumped-storage power plants only electricity generation from natural inflow

2 Including sewage sludge

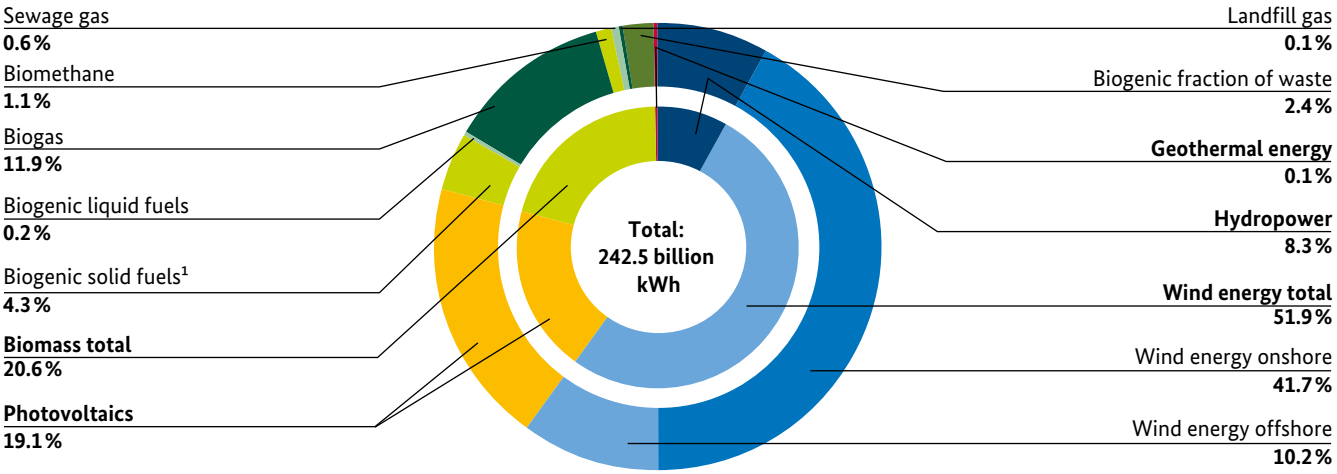
3 Biogenic share of waste estimated at 50% in waste incineration plants

4 1 GWh = 1 million kWh

5 Based on gross electricity consumption, 2019: 575.6 billion kWh; 2018: 594.7 billion kWh, there from fossil based gross electricity production according to AGEB [1]

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 6, provisional figures

Figure 5: Renewables-based electricity generation in 2019



1 Including sewage sludge

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 6, some figures are provisional

Figure 6: Electricity generation from renewable energy sources

	Hydropower[1]	Onshore wind energy	Offshore wind energy	Biomass[2]	Photovoltaics	Geothermal energy	Total gross electricity generation	Share of gross electricity consumption
	(GWh)[3]						(GWh)[3]	(%)
1990	17,426	72	0	1,435	1	0	**18,934**	**3.4**
2000	21,732	9,703	0	4,731	60	0	**36,226**	**6.3**
2005	19,638	27,774	0	14,706	1,282	0	**63,400**	**10.3**
2006	20,031	31,324	0	18,934	2,220	0	**72,509**	**11.6**
2007	21,170	40,507	0	24,616	3,075	0	**89,368**	**14.3**
2008	20,443	41,385	0	28,014	4,420	18	**94,280**	**15.2**
2009	19,031	39,382	38	30,886	6,583	19	**95,939**	**16.4**
2010	20,953	38,371	176	33,924	11,729	28	**105,181**	**17.0**
2011	17,671	49,280	577	36,891	19,599	19	**124,037**	**20.4**
2012	21,755	50,948	732	43,203	26,380	25	**143,043**	**23.5**
2013	22,998	51,819	918	45,513	31,010	80	**152,338**	**25.1**
2014	19,587	57,026	1,471	48,287	36,056	98	**162,525**	**27.4**
2015	18,977	72,340	8,284	50,326	38,726	133	**188,786**	**31.5**
2016	20,546	67,650	12,274	50,928	38,098	175	**189,671**	**31.6**
2017	20,150	88,018	17,675	50,917	39,401	163	**216,324**	**36.0**
2018	17,974	90,484	19,467	50,870	45,784	178	**224,757**	**37.8**
2019	20,058	101,150	24,744	50,009	46,392	196	**242,549**	**42.1**

1 For pumped-storage power plants only electricity generation from natural inflow

2 Solid and liquid biomass, biogas, biomethane, landfill gas and sewage gas, sewage sludge and biogenic share of waste (estimated at 50% in waste incineration plants)

3 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEB [1]; StBA [2], [3]; BNetzA [4]; TSOs [5]; ZSW [6]; DENA [7]; BDEW [8]; VDEW [9]; DBFZ [10], IE [11]; some figures are provisional

(2018: 2,888 megawatts). This significantly exceeded the annual expansion target of 2,500 megawatts. This meant that, by the end of 2019, photovoltaic installations across Germany had a combined total capacity of 49,016 megawatts.

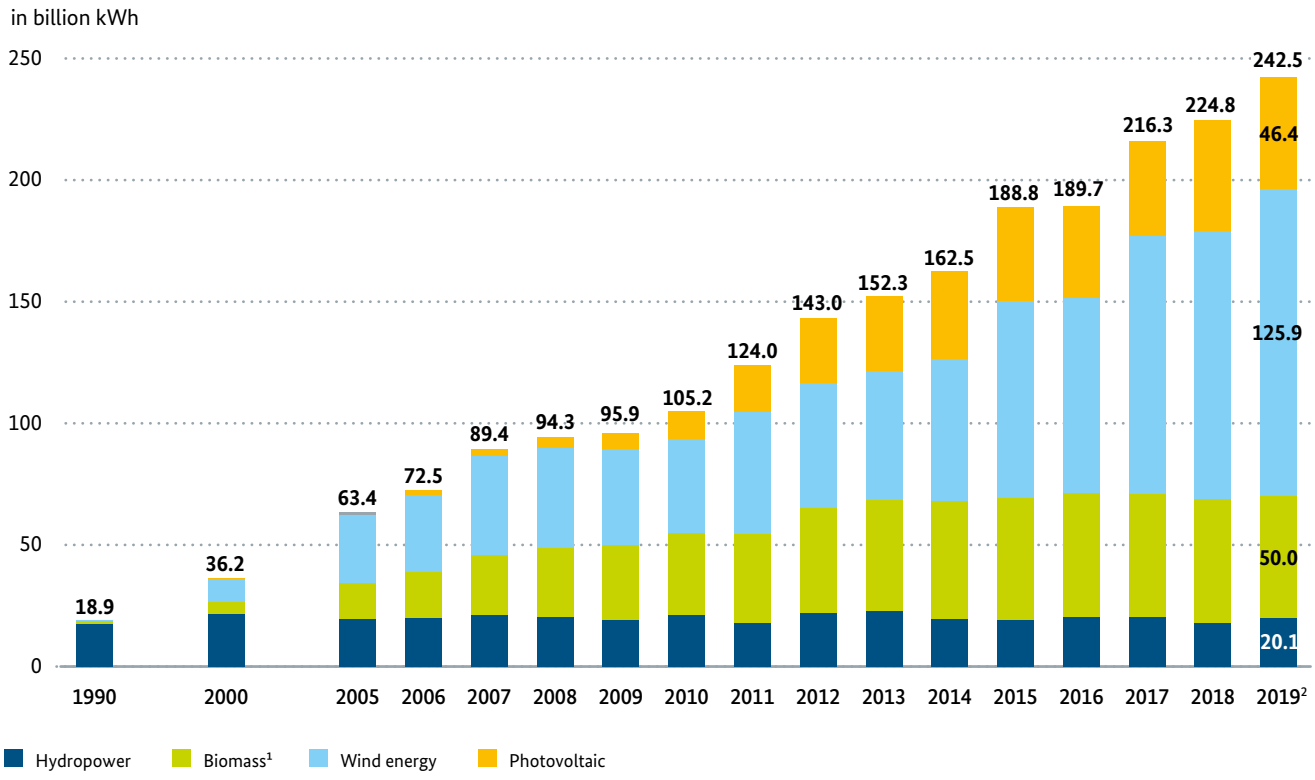
In terms of the number of hours of sunshine, 2019 did not quite match the extremely sunny preceding year. Nevertheless, at 46.4 billion kilowatt-hours – a year-on-year rise of more than 1% (2018: 45.8 billion kilowatt-hours) – a new record was set. Whilst the overall volume of installed photovoltaics capacity is similar to that of onshore wind energy, photovoltaics cover with 8.1 % a much smaller share of German gross electricity consumption (onshore wind: 17.6%), since photovoltaic installations can generate far less electricity per unit of installed capacity than wind-powered installations.

Trend towards the flexibilisation of biogas installations softens

At 304 megawatts, the newbuild of biogas capacity was considerably down in year-on-year terms in 2019 (2018: 424 megawatts). As in previous years, most of the newbuild took the form of an increase in capacity in existing installations. This regeneration of existing installations aims to facilitate flexible, needs-oriented electricity generation. As a consequence, the new capacity is not fully reflected in the annual volume of electricity generation: it remained constant at 28.9 billion kilowatt-hours. Virtually no changes in installed capacity can be reported for solid and liquid biomass.

Total electricity generation from biomass including the use of landfill and sewage gas and the biogenic part of municipal waste amounted to 50.0 billion kilowatt-hours in 2019, slightly below the previous year's figure (50.9 billion kilowatt-hours). Electricity from biomass thus covered 8.7% of Germany's gross electricity consumption.

Figure 7: Electricity generation from renewable energy sources



1 Solid and liquid biomass, biogas, biomethane, landfill gas and sewage gas, sewage sludge and biogenic share of waste

2 Electricity generation of the respective technologies in previous years: see figure 6

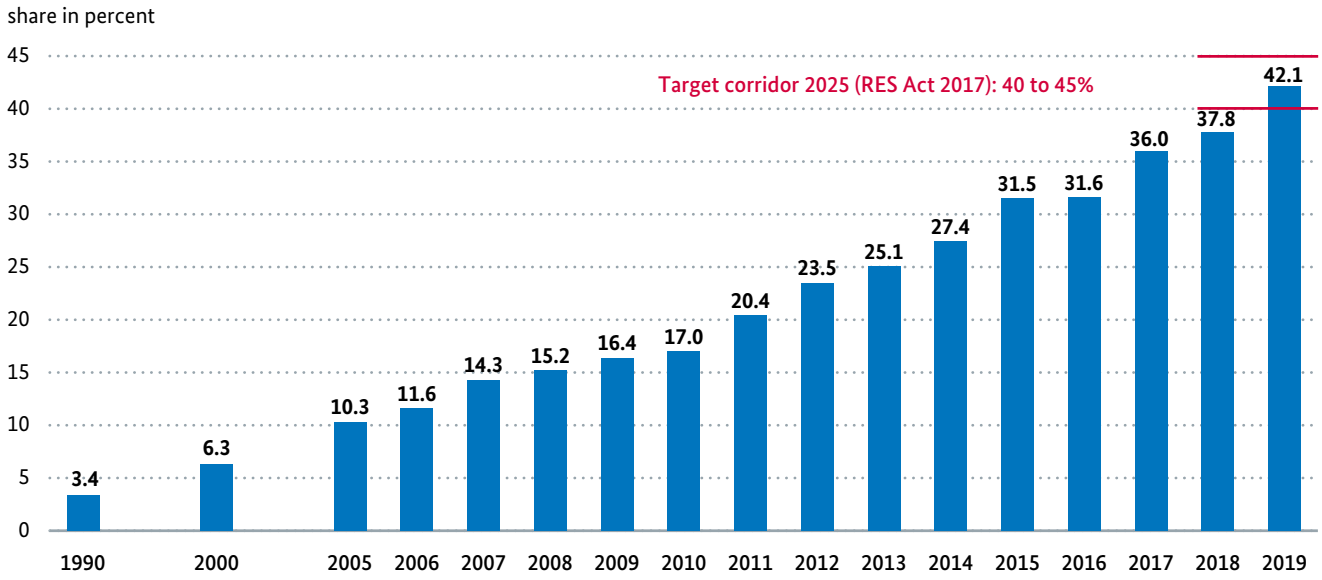
Geothermal power plants are not shown here because of the very small share involved.

Source: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 6, some figures are provisional

Hydroelectric and geothermal energy

Whilst the volume of electricity generation from hydropower was very low in 2018, due to the drought (18.0 billion kilowatt-hours), it recovered by 12% in 2019 to 20.1 billion kilowatt-hours. It thus covers 3.5% of Germany's electricity needs. The volume of electricity generated from geothermal energy rose slightly to 196 million kilowatt-hours (2018: 178 million kilowatt-hours), but it continues to be of minor significance in the electricity mix.

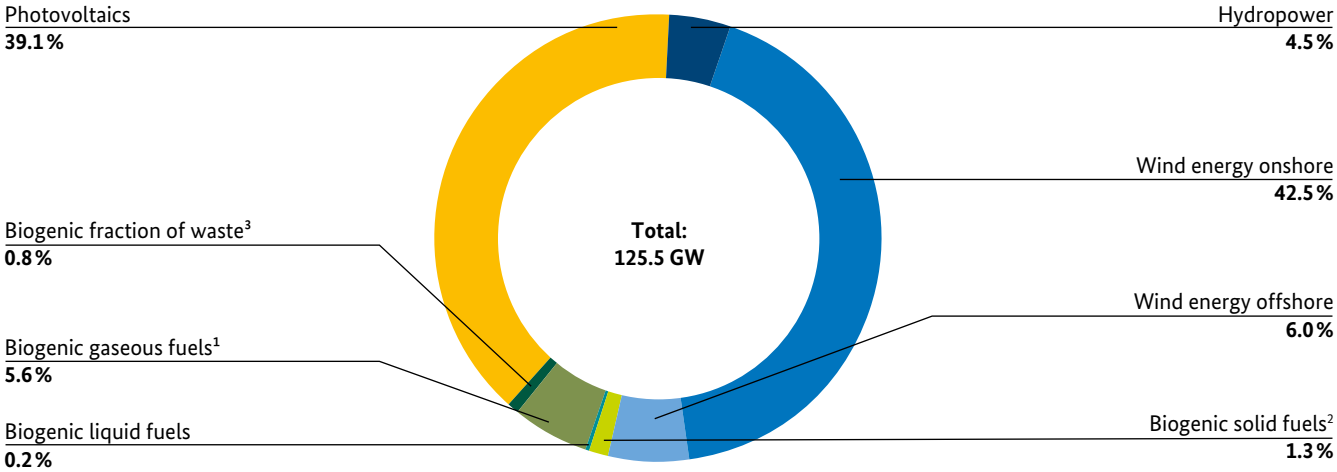
Figure 8: Share of renewables-based electricity generation in gross electricity consumption



Under the 2017 Renewable Energy Sources Act, renewable energy must make up 40–45% of gross electricity consumption by 2025.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 6, some figures are provisional

Figure 9: Installed power generation capacity based on renewable energy source, 2019



Geothermal power plants are not shown here because of the very small share involved.

1 Biogas, biomethane, landfill gas and sewage gas

2 Incl. sewage sludge, excluding biogenic share of waste

3 Incl. biogenic share of waste (estimated at 50 percent in waste incineration plants)

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 10, figures are provisional

Figure 10: Installed power generation capacity based on renewables

	Hydropower[1]	Onshore wind energy	Offshore wind energy	Biomass[2]	Photovoltaics	Geothermal energy	Total capacity
				(MW)[3]			
1990	3,982	55	0	404	2	0	**4,443**
2000	4,831	6,097	0	996	114	0	**12,038**
2005	5,210	18,248	0	2,939	2,056	0	**28,453**
2006	5,193	20,474	0	3,647	2,899	0	**32,213**
2007	5,137	22,116	0	4,006	4,170	3	**35,432**
2008	5,164	22,794	0	4,371	6,120	3	**38,452**
2009	5,340	25,697	35	5,593	10,566	8	**47,239**
2010	5,407	26,823	80	6,222	18,006	8	**56,546**
2011	5,625	28,524	188	7,162	25,916	8	**67,423**
2012	5,607	30,711	268	7,467	34,077	19	**78,149**
2013	5,590	32,969	508	7,966	36,710	30	**83,773**
2014	5,580	37,620	994	8,204	37,900	33	**90,331**
2015	5,589	41,297	3,283	8,429	39,224	34	**97,856**
2016	5,629	45,283	4,152	8,659	40,679	38	**104,440**
2017	5,627	50,174	5,406	8,982	42,293	38	**112,520**
2018	5,585	52,447	6,396	9,648	45,181	42	**119,299**
2019	5,595	53,333	7,507	9,983	49,016	48	**125,482**

The information on installed capacity relates to the figure at the end of the year.

1 Installed hydropower capacity includes pumped-storage power plants with natural inflow.

2 Solid and liquid biomass, biogas, biomethane, landfill gas, sewage gas and sewage sludge, including the capacity of all waste incineration plants for renewable and non-renewable waste. For the time series, 50 percent of the total waste incineration capacity shown as a renewable output.

3 1,000 MW = 1 GW

Sources: Federal Ministry for Economic Affairs and Energy (BMWi) based on data from AGEE-Stat; BDEW; BNetzA [4]; StBA [3]; ZSW [6]; DENA [7]; VDEW [9]; DBFZ [10]; IE [11]; Thünen Institute [12], some figures are provisional

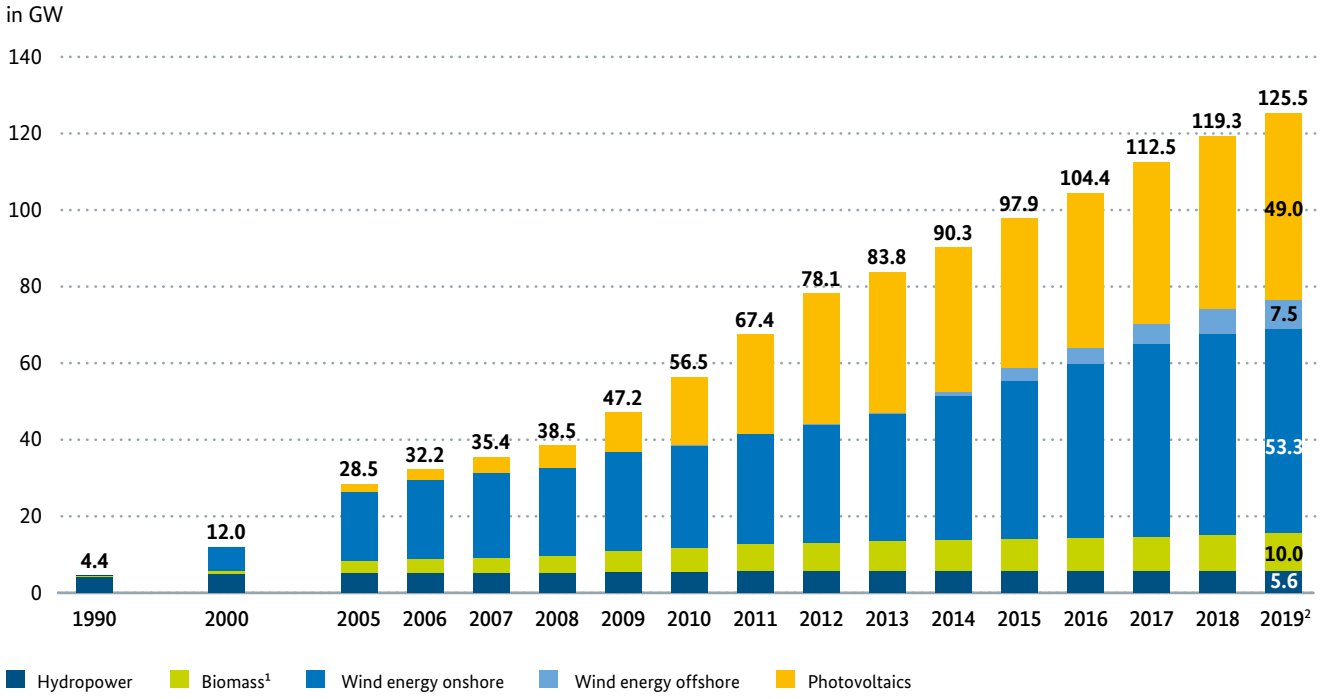
Heat

Slight rise in heat consumption from renewable energy sources

Final energy consumption of renewables-based heating and cooling in 2019 was 1.8% higher than in the preceding year, at 179.6 billion kilowatt-hours (2018: 176.5 billion kilowatt-hours). Since the weather was slightly cooler than in 2018, the consumption of final energy for heating and cooling rose by 1.9% in year-on-year terms, to 1,218 billion kilowatt-hours (2018: 1,195 billion kilowatt-hours). As a result, the share of renewables in total final energy consumption for heating and cooling dropped slightly, from 14.8% in 2018 to 14.7% in 2019. This means that the Federal Government's target that renewable energy should cover 14% of final energy consumption for heating and cooling in 2020 has already been attained. However, this is only an interim target, and further efforts need to be made in the heating sector if Germany's medium-term and long-term energy and climate targets are to be met.

However, there are differences in the development of the various forms of renewable energy in the heating sector. So increased compared to the previous year in particular the consumption of biogenic solid fuels in private households by 1.5 percent to 71.2 billion kilowatt hours (2018: 70.2 billion kilowatt hours). This includes the use of wood (including split logs, wood pellets and wood chips). In this context, the number of heat-

Figure 11: Installed power generation capacity based on renewables



1 Solid and liquid biomass, biogas, biomethane, landfill gas, sewage gas and sewage sludge, including the capacity of all waste incineration plants for renewable and non-renewable waste. For the time series, 50 percent of the total waste incineration capacity shown as a renewable output.

2 Electricity generation of the respective technologies in previous years: see Figure 10

Geothermal power plants are not shown here because of the very small share involved; see Figure 10

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 10, some figures are provisional

ing systems using wood pellets rose further last year by 34,650 systems, 15,000 of which were central heating systems, to a total of 492,000 installations (of which 286,500 are for central heating) [63].

There was also another rise in the provision of heat from near-surface geothermal energy and ambient heat, of 8.5% to 14.7 billion kilowatt-hours (2018: 13.5 billion kilowatt-hours). This was largely down to the sale of electric heat pumps for heating, which rose in year-on-year terms by a further 2% to 86,000 systems, 77% of which were air-source heat pumps and 23% were geothermal heat pumps. In addition, 16,500 new systems for water heating were installed. This means that a total of 1.16 million heat pumps are in place, with a thermal capacity of 11.2 gigawatts. Together with deep geothermal and balneological installations, the heat provided from geothermal energy and ambient heat in 2019 covered 1.2% of the total final energy consumption for heating and cooling.

In contrast, the amount of solar heat provided in 2019 was more than 4% down in year-on-year terms at 8.5 billion kilowatt-hours (2018: 8.9 billion kilowatt-hours). This was affected by the lower number of hours of sunshine compared with the preceding year. The newbuild of solar collectors, which fell by another 11% to 511,000 square metres, was only just able to offset the dismantling of old installations, so that the total installed collector area is currently stagnating at a level of 19.3 million square metres.

Figure 12: Final energy consumption for heat generation based on renewable energy sources in 2018 and 2019

	Renewable energy sources 2019		Renewable energy sources 2018	
	Final energy consumption heat (GWh)[8]	Share of final energy consumption for heat[9] (%)	Final energy consumption heat (GWh)[8]	Share of final energy consumption for heat[9] (%)
Biogenic solid fuels (households)[1]	71,238	5.8	70,193	5.9
Biogenic solid fuels (TCS sector)[2]	18,024	1.5	16,638	1.4
Biogenic solid fuels (industry)[3]	24,047	2.0	24,522	2.1
Biogenic solid fuels (HP/CHP)[4]	5,855	0.5	5,740	0.5
Biogenic liquid fuels[5]	2,173	0.2	2,245	0.2
Biogas	13,307	1.1	13,148	1.1
Biomethane	3,228	0.3	3,191	0.3
Sewage gas	2,495	0.2	2,503	0.2
Landfill gas	104	0.01	110	0.01
Biogenic fraction of waste[6]	14,664	1.2	14,508	1.2
Solar thermal energy	8,483	0.7	8,875	0.7
Deep geothermal energy	1,307	0.1	1,308	0.1
Near-surface geothermal energy, ambient heat[7]	14,655	1.2	13,504	1.1
Total	**179,580**	**14.7**	**176,485**	**14.8**

1 Mostly wood, incl. wood pellets and charcoal

2 Including charcoal, TCS = trade, commerce, services sectors

3 Including sewage sludge

4 Including sewage sludge; HP = heating plants, CHP = combined heat and power plants

5 Including consumption of biodiesel in agriculture, forestry, construction and military

6 Estimated at 50% in waste incineration plants

7 Renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)

8 1 GWh = 1 million kWh

9 Relates to final energy consumption for space heating, hot water, process heat, air conditioning and process cooling, 2019: 1,218 billion kWh; 2018: 1,195 billion kWh according to AGEB [1] and AGEE-Stat, without electricity consumption for heating and cooling

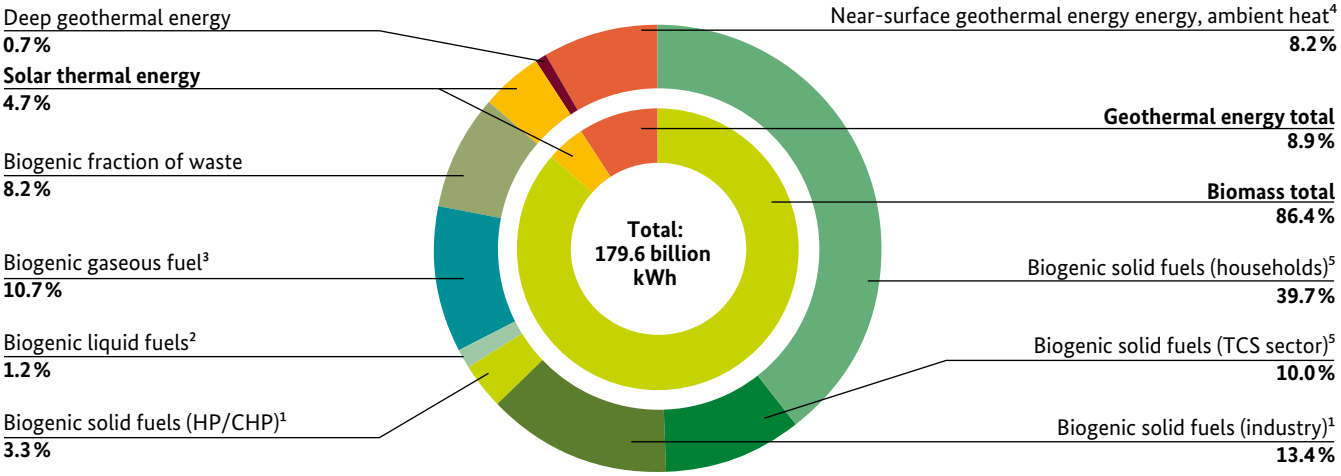
For more details on the methodology for calculating the share and on correspondence to the RES goal for the heating sector, see the "Information on methodology" section.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 14, provisional data

Note

'Final energy consumption for heat generation' also includes energy consumption for cooling purposes.

Figure 13: Final energy consumption for heat generation based on renewable energy sources, 2019



1 Including sewage sludge
2 Including consumption of biodiesel in agriculture, forestry, construction and military
3 Biogas, biomethane, sewage gas and landfill gas
4 Renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)
5 Including charcoal

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 14, provisional data

Figure 14: Final energy consumption for heat generation based on renewable energy sources

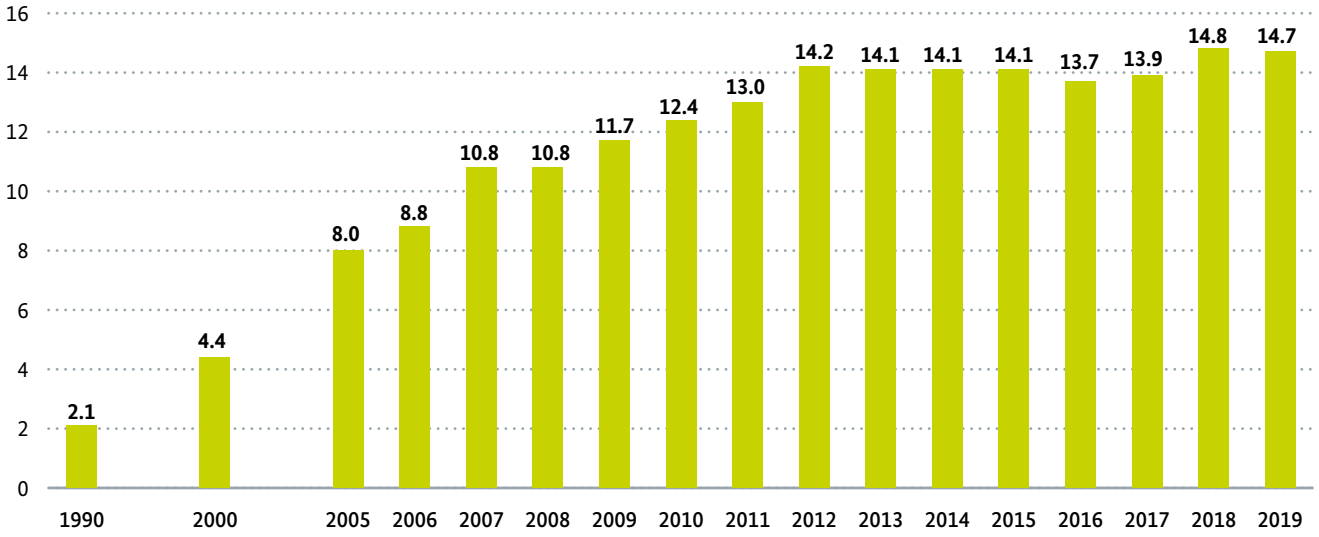
	Solid biomass[1]	Liquid biomass[2]	Gaseous biomass[3]	Solar thermal energy	Near-surface geoth. energy, ambient heat[4]	Total FEC heat	RE share of FEC of heat
			(GWh)[5]			(GWh)[5]	(%)
1990	30,573	0	0	131	1,812	**32,516**	**2.1**
2000	53,604	8	1,355	1,292	2,170	**58,429**	**4.4**
2005	92,425	1,219	3,126	3,028	2,815	**102,613**	**8.0**
2006	103,952	1,778	3,413	3,547	3,272	**115,962**	**8.8**
2007	110,874	2,834	5,727	3,934	3,961	**127,330**	**10.8**
2008	121,293	3,409	5,678	4,474	4,783	**139,637**	**10.8**
2009	117,082	3,660	7,325	5,250	5,719	**139,036**	**11.7**
2010	139,945	3,351	10,078	5,590	6,627	**165,591**	**12.4**
2011	129,824	2,558	11,871	6,388	7,540	**158,181**	**13.0**
2012	144,598	2,090	11,819	6,638	8,571	**173,716**	**14.2**
2013	148,786	2,191	13,214	6,700	9,596	**180,487**	**14.1**
2014	127,384	2,357	15,139	7,204	10,695	**162,779**	**14.1**
2015	131,058	2,174	16,914	7,705	11,479	**169,330**	**14.1**
2016	127,478	2,173	17,822	7,691	12,554	**167,718**	**13.7**
2017	130,088	2,179	18,325	7,852	13,576	**172,020**	**13.9**
2018	131,601	2,245	18,952	8,875	14,812	**176,485**	**14.8**
2019	133,828	2,173	19,134	8,483	15,962	**179,580**	**14.7**

1 Including the biogenic share of waste (estimated at 50% in waste incineration plants), sewage sludge and charcoal
2 Including consumption of biodiesel in agriculture, forestry, construction and military
3 Biogas, biomethane, sewage gas and landfill gas
4 Including heat from deep geothermal energy and renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)
5 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; AGEB [1], [13]; StBA [2], [14]; ZSW [6]; DENA [7]; Thünen Institute [12], [15]; GZB [16]; IEA/ESTIF [17]; FNR [18]; UNI HH [19]; DBFZ; BDH; BSW; DEPV; BWP; some figures are provisional

Figure 15: Share of renewables in final energy consumption for heat generation

in percent

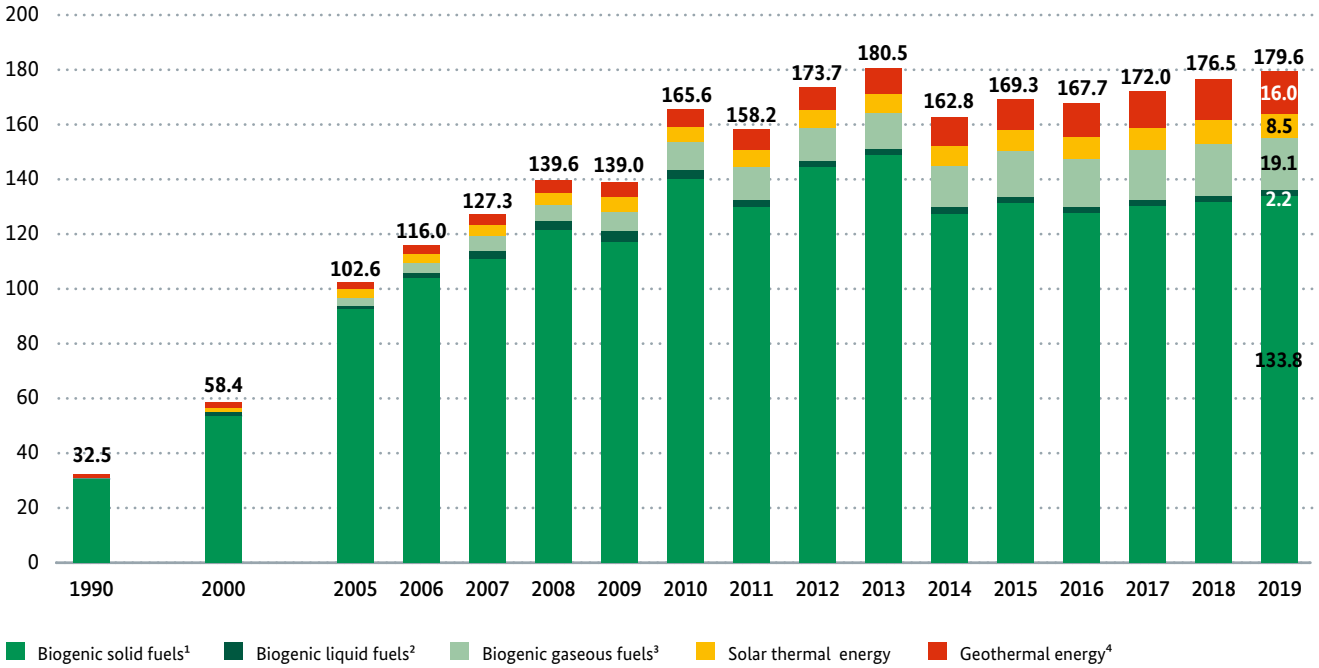


Under the Renewable Energies Heat Act, renewable energy must make up 14% of final energy consumption for heating and cooling by 2020.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 14, some figures are provisional

Figure 16: Final energy consumption for heat generation based on renewable energy sources

final energy consumption in billion kilowatt-hours

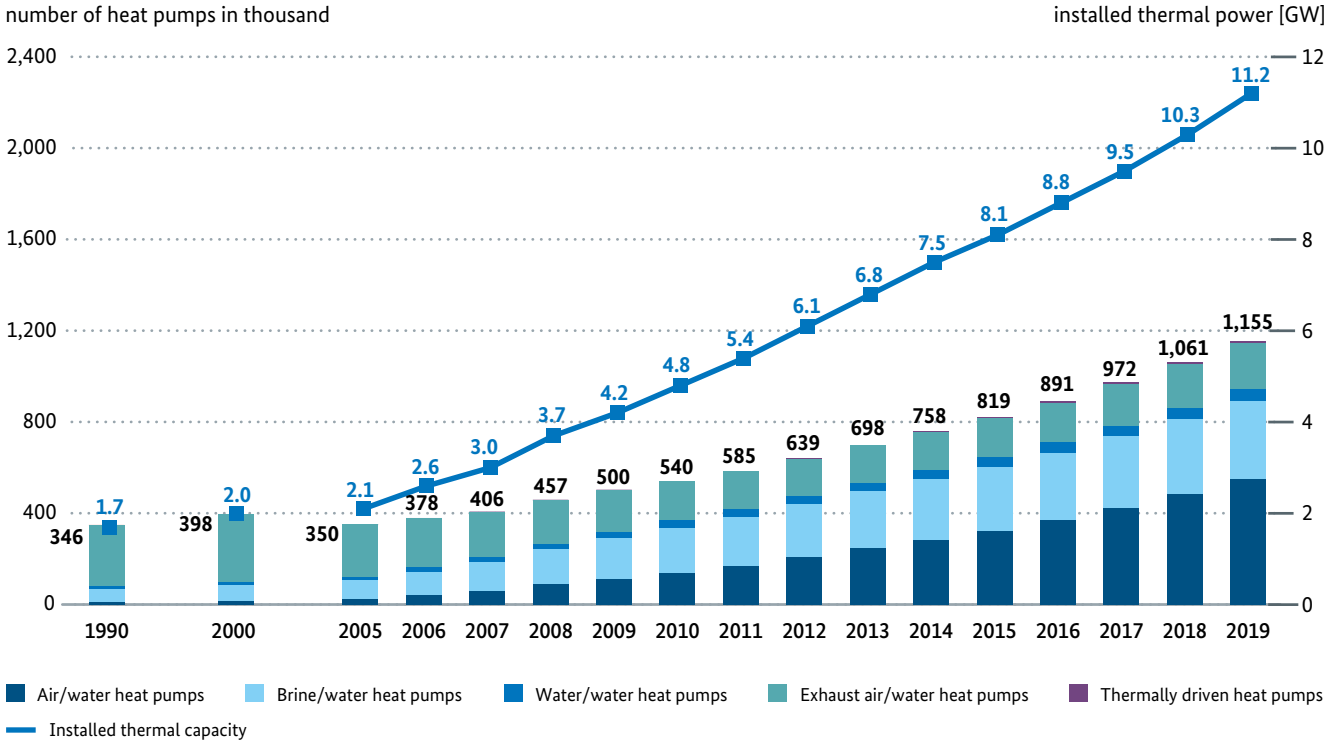


Biogenic solid fuels[1] Biogenic liquid fuels[2] Biogenic gaseous fuels[3] Solar thermal energy Geothermal energy[4]

1 Including the biogenic share of waste (estimated at 50% in waste incineration plants), sewage sludge and charcoal; data for trade, commerce and service sector (TCS) only available from 2003 onwards
2 Including consumption of biodiesel in agriculture, forestry, construction and military
3 Biogas, biomethane, sewage gas and landfill gas
4 Renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)
5 Electricity generation of the respective technologies in previous years: see Figure 14

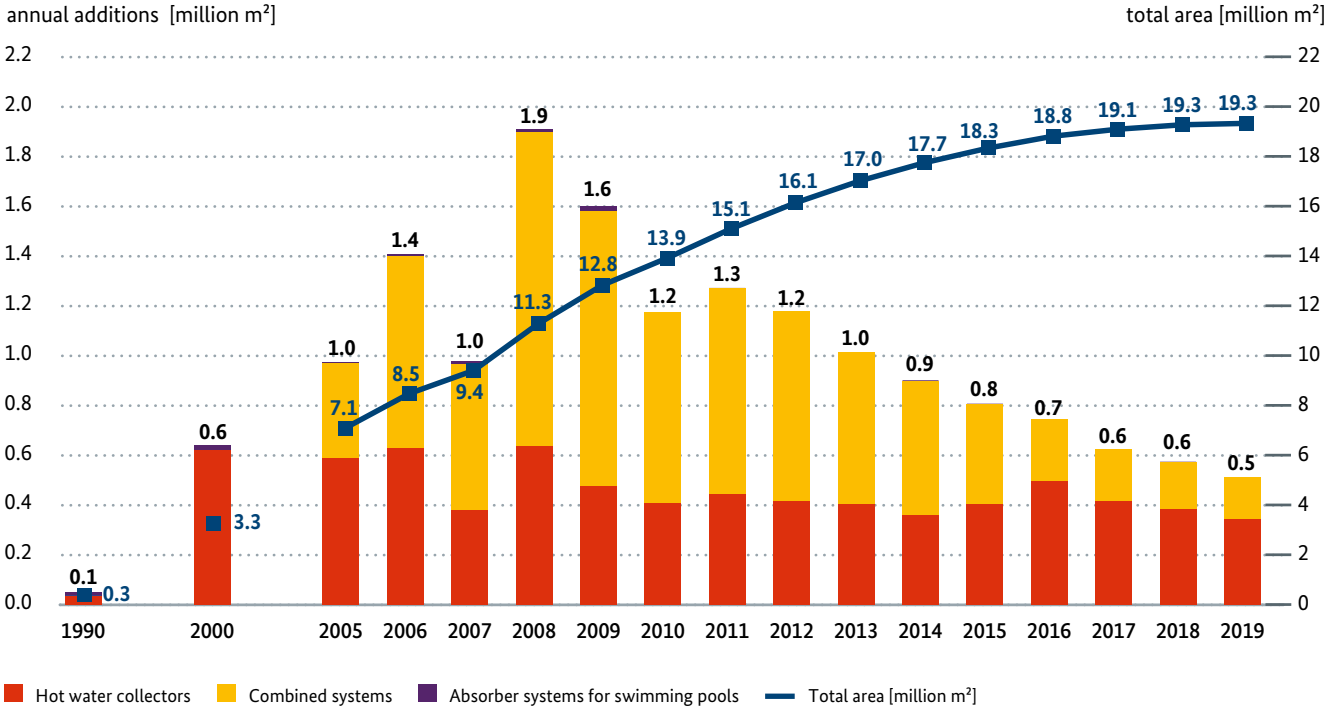
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 14, some figures are provisional

Figure 17: Development of heat pump stock



Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; BWP

Figure 18: Current capacity and growth of solar collectors (solar heat)



Figures take account of old installations taken out of service; combined solar-thermal installations; domestic hot water supply and ancillary heating.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; BDH; BSW

Figure 19: Solar-based heat: area and heat generation capacity of solar collectors in Germany

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Cumulative area (1,000 m²)	348	3,250	7,085	13,914	15,100	16,140	17,020	17,746	18,339	18,812	19,091	19,269	19,326
Cumulative output (MW)	244	2,275	4,959	9,740	10,570	11,298	11,914	12,422	12,837	13,169	13,364	13,489	13,528

Figures take account of old installations taken out of service.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; BDH; BSW

Transport

Share of renewable energy in transport remains constant

In 2019, sales of biofuels totalled 3.3 million tonnes, remaining at the same level as the preceding year. Within this share, sales of biodiesel dropped slightly below the level of the previous year, by 1.4%, amounting to 2.1 million tonnes, whilst the sale of bioethanol declined by 3.8% to 1.1 million tonnes. Sales of biomethane, in contrast, again rose significantly in year-on-year terms, by 70% to 660 million kilowatt-hours.

In the case of electrified transport, despite a growing number of electric vehicles, the increases in the consumption of renewable energy are still largely due to the rising proportion of renewable energy in the electricity mix. As a result, the consumption of renewables-based energy in the transport sector in 2019 was almost 11% higher than in the preceding year, at close to 5.1 million kilowatt-hours. The number of electric and plug-in hybrid vehicles did rise very significantly in 2019, but their share of electricity consumption in the transport sector still amounted to only around 3%, with rail transport accounting for approximately 97%.

Figure 20: Consumption of renewable energy sources in the transport sector in 2018 and 2019

	Renewable energy sources 2019		Renewable energy sources 2018	
	Final energy consumption of transport (GWh)[3]	Share of FEC of transport[4] (%)	Final energy consumption of transport (GWh)[3]	Share of FEC of transport[4] (%)
Biodiesel[1]	22,113	3.4	22,360	3.5
Vegetable oil	10	0.002	10	0.002
Bioethanol	8,375	1.3	8,707	1.3
Biomethane	660	0.1	389	0.1
RE electricity consumption in transport[2]	5,054	0.8	4,569	0.7
Total	**36,212**	**5.5**	**36,035**	**5.6**

1 Consumption of biodiesel (incl. HVO) in the transport sector, excluding use in agriculture, forestry, construction and military

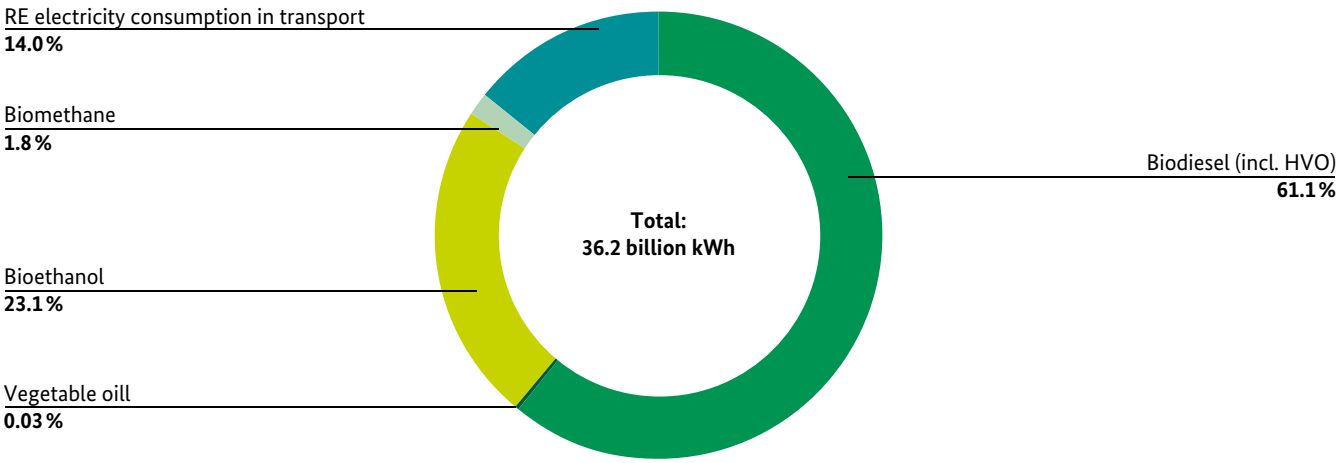
2 Calculated from total electricity consumption in the transport sector according to AGEB [1] and the share of renewable energy in gross electricity consumption according to AGEE-Stat (see Figure 6)

3 GWh = 1 million kWh

4 Based on final energy consumption in transport in 2019: 656.2 billion kWh; 2018: 647.9 billion kWh billion kWh, according to AGEB [1] and AGEE-Stat, without energy consumption for international air traffic

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 22, some figures are provisional

Figure 21: Consumption of renewable energy sources in the transport sector, 2019



Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 22, figures are provisional

Figure 22: Consumption of renewable energy sources in the transport sector

	Biodiesel[1]	Vegetable oil	Bioethanol	Biomethane	RE electricity consumption[2]	Final energy consumption of transport	Share of FEC of transport
			(GWh)[3]			(GWh)[3]	(%)
1990	0	0	0	0	465	**465**	**0.1**
2000	2,583	167	0	0	1,002	**3,752**	**0.5**
2005	17,666	1,828	1,780	0	1,353	**22,627**	**3.6**
2006	27,938	7,206	3,828	0	1,471	**40,443**	**6.4**
2007	32,282	8,533	3,391	0	1,750	**45,956**	**7.3**
2008	25,873	4,042	4,608	4	1,688	**36,215**	**5.9**
2009	22,966	961	6,576	13	1,902	**32,418**	**5.3**
2010	24,359	574	8,552	75	2,054	**35,614**	**5.8**
2011	23,545	188	9,046	92	2,470	**35,341**	**5.7**
2012	24,628	251	9,164	333	2,826	**37,202**	**6.0**
2013	21,934	0	8,847	483	2,993	**34,257**	**5.4**
2014	22,676	52	9,016	449	3,157	**35,350**	**5.6**
2015	20,829	10	8,611	345	3,512	**33,307**	**5.2**
2016	20,896	31	8,626	379	3,709	**33,641**	**5.2**
2017	21,354	31	8,478	445	4,305	**34,613**	**5.3**
2018	22,360	10	8,707	389	4,569	**36,035**	**5.6**
2019	22,113	10	8,375	660	5,054	**36,212**	**5.5**

1 Consumption of biodiesel (incl. HVO) in the transport sector, excluding use in agriculture, forestry, construction and military

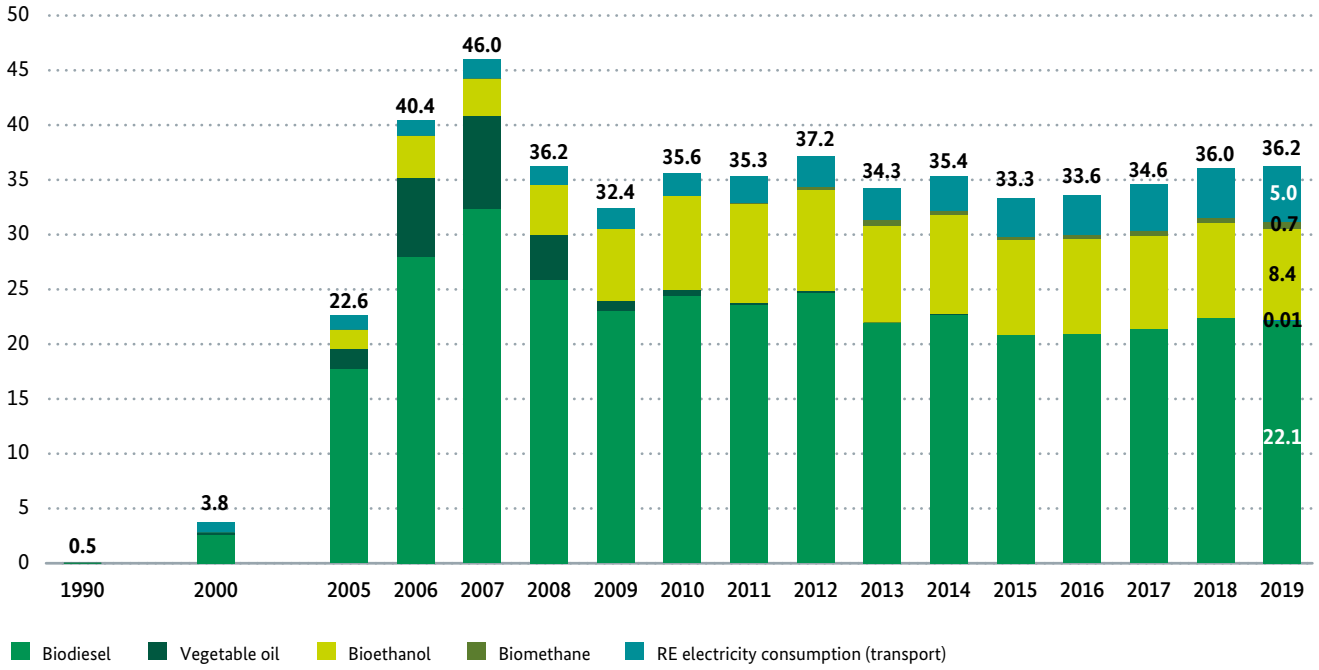
2 Calculated from total electricity consumption in the transport sector according to AGEB [1] and the share of renewable energy in gross electricity consumption for the particular year according to AGEE-Stat (see Figure 6)

3 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; BAFA [20]; BLE [21], [22]; FNR; ZSW; BMF [23]; Fed Govt. [24], [25], [26], [27]; StBA [28]; DBFZ; AGQM; UFOP; some provisional figures

Figure 23: Consumption of renewable energy sources in the transport sector

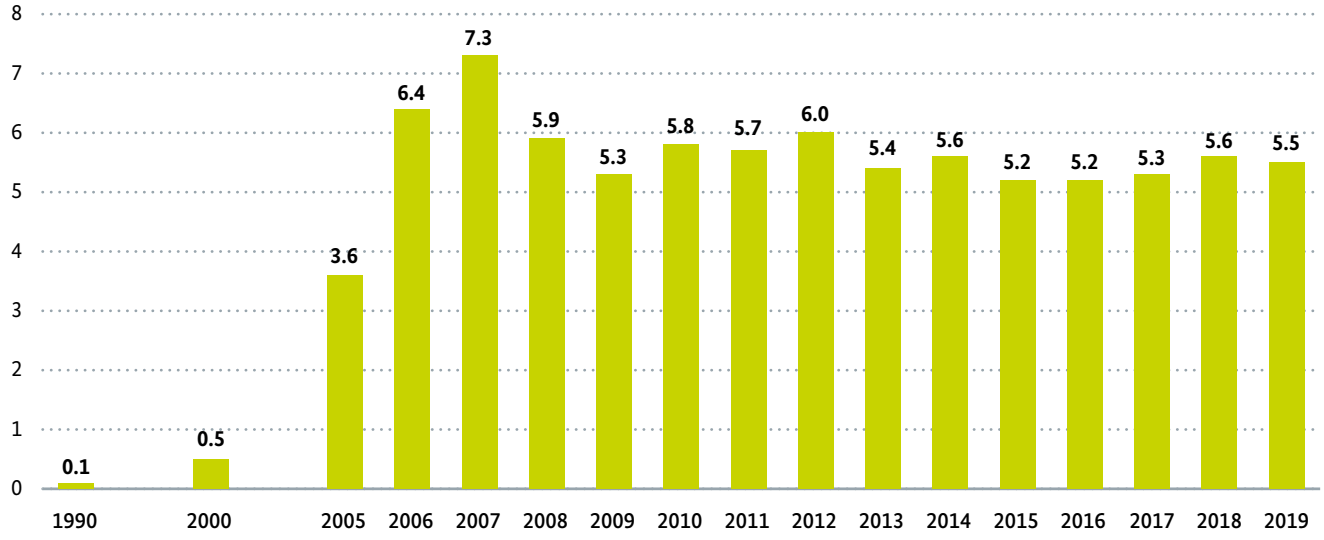
final energy consumption in billion kWh



Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 22, figures are provisional

Figure 24: Share of renewable energy in final energy consumption in the transport sector

in percent



Under EU Directive 2009/28/EC, renewable energy must account for 10% of final energy consumption in the transport sector by 2020. However, the numbers indicated in Figure 22 deviate from the calculation method used in the EU Directive and do not involve double counting. The reference value for total final energy consumption also differs. More information on the calculation methodology is provided in the "Methodology" section of this publication.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 22, some provisional figures

Figure 25: Consumption of renewables-based fuels in the transport sector

	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
						(1,000 tonnes)						
Biodiesel[1]	250	1,720	2,361	2,257	2,322	2,058	2,148	1,998	2,005	2,073	2,172	2,148
Vegetable oil	16	175	55	18	24	0	5	1	3	3	1	1
Bioethanol	0	238	1,160	1,227	1,243	1,200	1,223	1,168	1,170	1,150	1,181	1,136
Biomethane[2]	0	0	6	7	25	36	33	25	28	33	29	49
Total	**266**	**2,133**	**3,582**	**3,509**	**3,614**	**3,294**	**3,409**	**3,192**	**3,206**	**3,259**	**3,383**	**3,334**

1 Consumption of biodiesel (incl. HVO) in the transport sector, excluding use in agriculture, forestry, construction and military

2 Calculated using a calorific value of 48.865 MJ/kg

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see Figure 22, some figures are provisional

Emissions prevented through the use of renewable energy sources

The expansion of renewable energy is making a key contribution to meeting our climate targets. Greenhouse gas emissions of approximately 201 million tonnes of CO_2 equivalents were eliminated in 2019. The largest proportion of the greenhouse gas emissions were avoided thanks to the generation of electricity from wind turbines (89 tonnes of CO_2 equivalents). The overall power sector accounted for 158 million tonnes of these savings. Emissions of around 36 million tonnes were eliminated in the heating sector and, through the use of biofuels in transport, some 8 million fewer tonnes of CO_2 equivalents were emitted (Figure 26).

The calculations of the emissions savings arising from the use of renewable energy sources are based on net figures. This is done by setting off the volume of emissions caused by the use of renewables (final energy supply) against the volume of gross emissions that are no longer being released thanks to fossil energy sources having been replaced with renewables. Most upstream process chains involved in the production and supply of the various energy sources and in plant construction and operation are also taken into account.

Here, technology-specific substitution factors were used in the electricity and heat sector. The underlying model for the electricity sector gives special consideration to the increasing interconnection of the European electricity market. The substitution factors are determined via a comparison between the real development of the European electricity generation sector with a plausible development path, disregarding the German expansion of renewable energy [29]. Further to this, the balance for the heat sector takes account of the difference in efficiency between renewables-based heating installations and those based on conventional energy sources.

The emissions balance for the use of biomass depends on the nature and provenance of the raw materials. The life cycle was also modelled to ascertain the environmental footprint for the purpose of the balancing [30]. If the raw materials are not waste or biogenic waste, the calculations must take account of changes in land use resulting from the agricultural cultivation of energy crops. However, it is difficult to quantify any indirect effects of changes in land use. As a consequence, these changes have not been taken into account in calculating emission balances to date. Various model-based calculations indicate that indirect changes in land use can cause significant greenhouse gas emissions and partially or fully cancel out greenhouse gas emissions savings generated by individual biofuels.

The calculation of emissions from biofuels is based on self-assessment and estimates of the level of greenhouse gas emissions (including the feedstock base), introduced with the greenhouse

Note

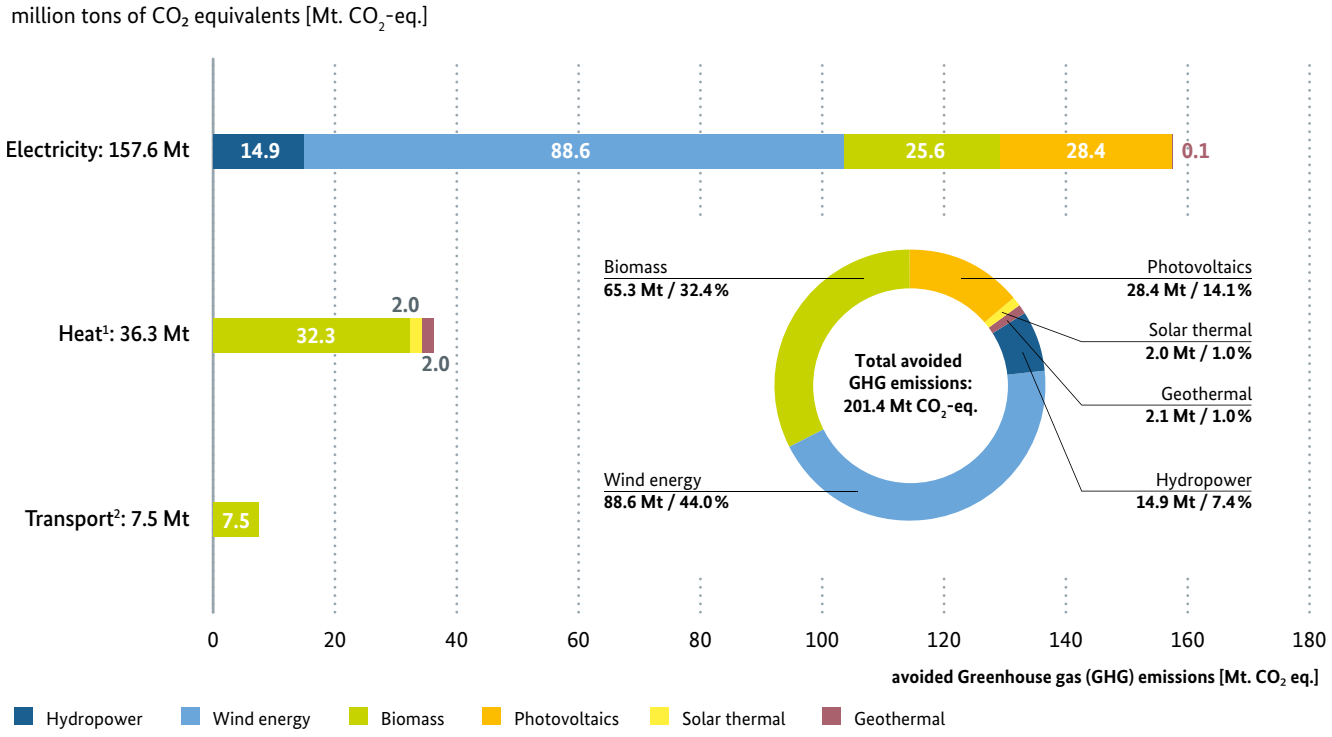
For a detailed explanation of the basic methodology used to calculate the emission balances for renewable energy sources, please see the German Environment Agency publication "Emissionsbilanz erneuerbarer Energieträger – Bestimmung der vermiedenen Emissionen 2018" (only in German) [31]

gas quota, as published by the Federal Office for Agriculture and Food in its annual Evaluation and Progress Report on the Biofuel/Biomass Energy Sustainability Ordinance [21], and the current comparable figure for fossil fuel pursuant to Directive 2009/28/EC (83.8 g CO_2-eq./MJ). The base figure differs in accordance with Section 3 of the 38th Federal Immission Control Ordinance, at 94.1 g CO_2-eq./MJ; the greenhouse gas emissions of fossil petroleum and diesel fuel are calculated in accordance with Section 10 of the 38th Federal Immission Control Ordinance at 93.3 and 95.1 g CO_2-eq./MJ respectively.

The emissions of the individual greenhouse gases and air pollutants were derived by the Federal Environment Agency roughly on the basis of its figures for total greenhouse gas emissions. The findings of the research project 'BioEm' [30] and other expertise, as well as various assumptions and analogous conclusions, were also taken into account.

Overall, it is likely that the figures for emissions reduction based on the use of biofuels are too optimistic. This is due to the general use of the regional NUTS2 values for biomass cultivation and the rules governing the substitution of carbon

Figure 26: Net balance of greenhouse gas emissions avoided through the use of renewable energy



1. Does not include charcoal consumption
2. Only biogenic fuels in the transport sector (excluding use in agriculture, forestry, construction or military, and excluding electricity consumption in the transport sector) based on preliminary data from the Federal Office for Agriculture and Food for 2018, and the current comparable figure for fossil fuel pursuant to Directive 2009/28/EC (83.8 g CO_2-eq./MJ) (base figure differs in accordance with Section 3 of the 38th Federal Immission Control Ordinance, at 94.1 g CO_2-eq./MJ)

Sources: German Environment Agency (UBA) [31] based on the sources quoted therein, provisional figures

Figure 27: Net emissions balance for renewable energy sources used in electricity, heat and transport, 2019

		Renewables-based electricity generation total: 242,549 GWh		Renewables-based heat consumption total: 177,704 GWh[5]		Renewables-based consumption for transport total: 31,158 GWh[6, 7]		Total
Greenhouse gas/ Air pollutant		Avoidance factor	Avoided emissions	Avoidance factor	Avoided emissions	Avoidance factor	Avoided emissions	Avoided emissions
		(g/kWh)	(1.000 t)	(g/kWh)	(1.000 t)	(g/kWh)	(1.000 t)	(1.000 t)
Greenhouse effect[1]	CO_2	647	156,849	212	37,688	263	8,195	202,732
	CH_4	0.39	94.1	-0.18	-31.88	-0.08	-2.42	60
	N_2O	-0.02	-5.3	-0.01	-2.1	-0.07	-2.11	-9
	CO_2-equivalents	650	157,632	204	36,260	241	7,505	201,397
Acidification[2]	SO_2	0.27	64.3	0.06	10.6	-0.02	-0.56	74
	NO_X	0.35	84.1	-0.18	-31.9	-0.18	-5.69	47
	SO_2-equivalents	0.51	122.9	-0.07	-11.6	-0.15	-4.56	107
Ozone[3] Particles[4]	CO	-0.29	-70.9	-2.05	-363.8	-0.01	-0.31	-435
	NMVOC	0.01	2.9	-0.17	-30.8	0.03	0.85	-27
	Particles	0.033	8.1	-0.1	-17.8	-0.01	-0.31	-10

1 Other greenhouse gases (SF_6, CFCs, HCFCs) are not included.

2 Other air pollutants with acidification potential (NH_3, HCl, HF) are not included.

3 NMVOC and CO are important precursors for ground-level ozone, which contributes significantly to 'summer smog'.

4 Here, dust comprises the total emissions of suspended particulate matter of all particle sizes.

5 Does not include charcoal consumption

6 Does not include the consumption of biodiesel (incl. HVO) in agriculture, forestry, construction and the military and electricity consumption in the transport sector

7 Based on preliminary data from the Federal Office for Agriculture and Food

Source: German Environment Agency (UBA) [31] based on the sources quoted therein

dioxide emissions from fossils by biogenic CO_2 emitted in the course of bioethanol production.

Figure 27 shows the balance for greenhouse gas emissions and air pollutants. Greenhouse gas abatement is particularly high in the electricity generation segment. One reason for this is the low level of emissions from the production and operation of the renewable technologies used in comparison to the high-emission fossil-based electricity generation. The balances are negative for precursors of ground-level ozone. This is mainly due to the use of biogas. Emissions of some air pollutants associated with heating have risen as more wood is burned in old stoves and tiled ovens. However, under current legislation, these units will have to be gradually taken out of use or replaced. The negative balances for carbon monoxide, volatile organic compounds and dust emissions (all particle sizes) are particularly significant. When it comes to biofuels, there was an increase in nitrous oxide and methane emissions from the cultivation of energy crops.

Reduction in the use of fossil fuels thanks to renewable energy

Figures 28 and 29 show the amount of fossil fuels saved by using renewable energy sources for electricity, heat and transport in 2019 and from 2009 to 2019. Total savings have risen continuously in recent years.

Since a large proportion of Germany's fossil fuels such as oil, natural gas and coal have to be imported, these savings also lead to a reduction in German energy imports.

Figure 28: Savings in primary energy through the use of renewable energy sources in 2019

	Lignite	Hard coal	Natural gas	Divided into mineral oil:			Total
				Fuel oil	Diesel fuel	Gasolines	
	Primary energy (billion kWh)						
Electricity		381.2	138.3				**519.4**
Heat	11.9	12.5	61.4	52.6	1.4		**139.8**
Transport			0.6		16.5	9.2	**26.3**
Total	**11.9**	**393.7**	**200.3**	**52.6**	**18.0**	**9.2**	**685.5**
	Primary energy (PJ)						
Total	**42.7**	**1.417.2**	**721.0**	**189.3**	**64.6**	**33.1**	**2,467.9**
which corresponds to[1]:	8.4	51.7	20,493	5,297	1,802	1,020	
	million t[2]	million t[3]	million m³	million litres	million litres	million litres	

The savings in fossil fuels are calculated using the same methodology as is used to calculate emission balances, see UBA [31].

1 Savings in primary energy were calculated using the net calorific values determined by AGEB [13].

2 Including approx. 3.1 million t lignite, approx. 0.3 million t lignite briquettes and approx. 0.7 million t pulverised coal

3 Including approx. 28.9 million t hard coal and approx. 0.1 million t coke from hard coal

Source: German Environment Agency (UBA) [31] based on the sources quoted therein

Figure 29: Fossil fuel savings resulting from the use of renewables

	Electricity	Heat	Transport	Total
	Primary energy (billion kWh)			
2007	194.3	97.2	24.3	**315.7**
2008	204.1	105.0	18.7	**327.8**
2009	199.2	107.0	16.1	**322.3**
2010	214.8	128.6	17.8	**361.2**
2011	261.9	123.8	18.6	**404.2**
2012	300.1	133.4	22.0	**455.5**
2013	314.8	137.3	20.9	**473.1**
2014	339.0	126.5	21.5	**487.0**
2015	407.3	129.9	20.0	**557.2**
2016	390.7	130.1	24.5	**545.3**
2017	458.9	134.1	27.0	**620.0**
2018	480.1	137.4	27.9	**645.4**
2019	519.4	139.8	26.3	**685.5**

Source: German Environment Agency (UBA) [31] based on the sources quoted therein

The Renewable Energy Sources Act (RES Act)

The expansion of renewable energy is one of the central pillars in Germany's energy transition. Since its introduction as a successor to the Electricity Feed-in Act, the Renewable Energy Sources Act has proved to be a very effective instrument to expand and promote renewable energy in the electricity sector.

The core elements of the RES Act are priority feed-in of renewable energy into the electricity

grid, remuneration for electricity generated from renewable energy, and the rules on financing of the funding. The Act entered into force in the year 2000 and has since been repeatedly updated.

The aim of the Act is to increase the proportion of gross electricity consumption covered by electricity generated from renewable energy sources and thus to attain climate targets and to transform the energy system. The expansion is to take place in a manner that is steady, cost-efficient and compatible with the grid system.

The Act has already been amended several times in order to take account of advances in technology and to increasingly bring renewable energy onto the market. The move to the use of auctions took place as a result of the 2017 amendment of the RES Act and the Offshore Wind Energy Act. Since then, the remuneration rates for renewable energy installations that exceed a certain size have been determined by competition. The last major changes took place in December 2018 when the Umbrella Energy Act was introduced. Measures included the addition of special auction volumes to the volumes normally up for auction, new auctions for innovative installations, and a provision stating that wind turbines only need to be lit up at night in case of need. This boosts public acceptance.

All the auctions are organised and held by the Federal Network Agency. Further information is available at www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Ausschreibungen/Ausschreibungen_node.html and the renewable energy information platform of the Federal Ministry for Economic Affairs and Energy at www.erneuerbare-energien.de/EE/Redaktion/DE/Dossier/nationale-ausschreibungen-und-ergebnisse.html?cms_docId=577124 (both platforms in German only).

On 3 July 2020, the Bundestag also adopted changes to other legislation in addition to the Act on the Phase-out of Coal-fired Power Plants. For example, a provision was added to the Renewable Energy Sources Act anchoring the Federal Government's target in the 2030 Climate Action Programme whereby 65% of electricity consumption will be covered by renewable energy by 2030. The continued expansion of renewable energy that is ambitious, efficient, synchronised with the grid and increasingly market-oriented is a prerequisite for the attaining of this goal.

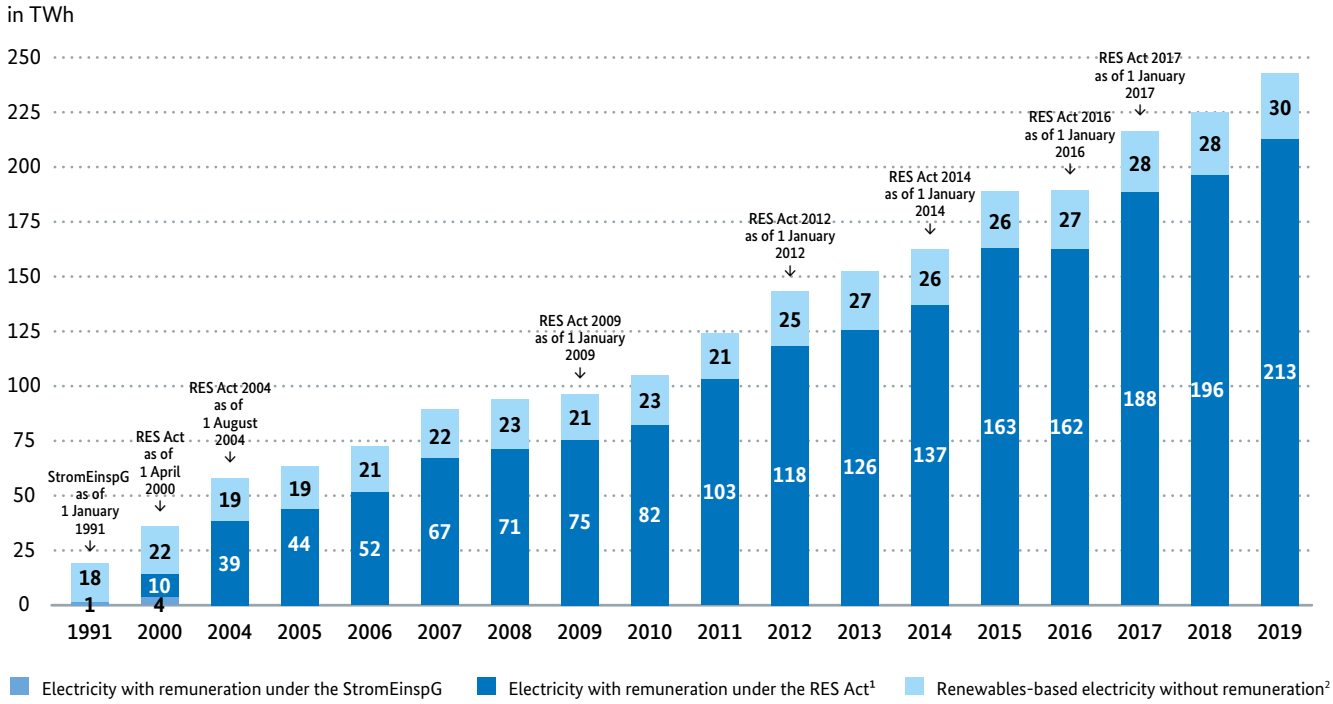
Volumes of electricity pursuant to the Renewable Energy Sources Act

Since the introduction of the RES Act in 2000, electricity generation from renewable energy has risen dramatically: from 36 terawatt-hours to nearly 243 terawatt-hours in 2019. This increase has been driven by onshore wind, solar power (photovoltaics (PV)), biomass, and in recent years, increasingly by offshore wind as well. For instance, the generation of electricity from offshore wind turbines has risen very sharply over the last 10 years, reaching nearly 25 terawatt-hours in 2019. This means that the youngest renewable energy technology generated more electricity in offshore wind farms than hydropower in 2019.

The RES Act does not, however, incentivise all electricity generated from renewable energy sources. For example, it does not provide for support for large hydropower installations or for conventional power stations that incinerate biomass alongside their regular fuel. Electricity incentivised under the RES Act is only part of the total electricity generated from renewable energy sources, as shown in Figure 30. Since 2000, this electricity generation (for which a feed-in tariff is paid under the RES Act) has risen from around 10 to 212.8 terawatt-hours in 2019.

More information is available on the website of the German transmission operators information platform at www.netztransparenz.de (in German only) and from the renewable energy information platform operated by the Federal Ministry for Economic Affairs and Energy at www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/eeg-in-zahlen-pdf.html (in German only).

Figure 30: Electricity generation from renewable energy sources with and without entitlement to remuneration under the Electricity Feed-in Act and RES Act



1 Electricity consumed on-site, fed into the grid and remunerated under the RES Act
2 Electricity generated from large hydropower plants and biomass (combusted alongside regular fuel in conventional power stations, including the biogenic share of waste) and electricity from solar power installations that is fed into the grid and consumed on site and for which there is no entitlement to remuneration under the RES Act.

Source: Federal Ministry for Economic Affairs and Energy, based on data provided by the German transmission system operators (TSOs [5])

Landlord-to-tenant electricity

Until 2017, homeowners were the main beneficiaries of the possibility to generate electricity in rooftop solar installations. The landlord-to-tenant electricity system makes it feasible for tenants to benefit as well. Landlords who have solar installations on the roofs of their buildings can sell the electricity generated by these installations to their tenants.

Landlord-to-tenant electricity is electricity that is passed on to final consumers (particularly tenants) living within a residential building or in a residential building or ancillary facilities located within close proximity of this building, and that are connected directly to the installation rather than via the public grid. In cases where tenants cannot use all of the electricity generated, the surplus electricity is fed into the public grid and landlords are paid the feed-in-tariff. Electricity from other renewable energy sources (e.g. from wind energy) is not covered by this definition.

By using landlord-to-tenant electricity supply, tenants are exempt from a wide range of charges that they would otherwise have to pay if they purchased their electricity via the grid. These include grid charges, grid surcharges, electricity tax and concession fees. In addition to this, landlords have been eligible to receive funding for every kilowatt-hour of electricity they supply to their tenants since mid-2017. This makes supplying electricity to tenants more attractive and profitable for landlords, whilst at the same reducing tenants' electricity bills. They thus help to expand the roll-out of photovoltaics.

The rate of building of new photovoltaic installations funded by the landlord-to-tenant bonus more than doubled between 2018 and 2019, with 722 installations (15.1 megawatts) being added. As of 31 March 2020, the Federal Network Agency had 1,169 PV landlord-to-tenant electricity installations reported to its registers [32],[33] for the period of 2017 to the end of 2019, with capacity totalling around 24.5 MW. Of this, 92 installations with a total of 2.2 MW came on stream in the

remainder of 2017 (after the Act entered into force on 25 July 2017) and 355 installations with a total of 7.2 MW in 2018.

The landlord-to-tenant electricity model was reviewed in the Federal Government's Landlord-to-tenant Electricity Report pursuant to Section 99 of the 2017 RES Act. The report and further information can be found at www.erneuerbare-energien.de/EE/Navigation/DE/Recht-Politik/Mieterstrom/mieterstrom.html and on the website of the Federal Network Agency www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Verbraucher/Vertragsarten/Mieterstrom/Mieterstrom_node.html (both websites in German only).

The renewable energy surcharge (EEG surcharge)

Electricity generation from renewable energy sources is funded under the Renewable Energy Sources Act. The difference between the remuneration rates and the price on the electricity exchange is passed on to the consumers via the "EEG surcharge" ("EEG" is the German abbreviation for the RES Act). It is a state-imposed component of the electricity price. Irrespective of the size of the installation, the remuneration for electricity from wind, solar and biomass installations takes place

- either via statutory remuneration rates (in this case, the renewable electricity is sold by the transmission system operators on the electricity exchange),
- or in the context of auctions via a market premium which is determined in a competitive process. The market premium compensates for the difference between the feed-in tariff and the average trading price for electricity where the operator sells the electricity directly on the market.

The market premium and the (fixed) remuneration are the main factors determining the level of funding needed for renewable energy and thus how high the EEG surcharge shall be. Here, the price on the electricity exchange is a key variable as it determines the value of the electricity sold on the exchange and thus also the funding costs to be covered by the EEG surcharge. A low price on the electricity exchange correspondingly entails a high EEG surcharge.

Every 15 October, transmission system operators calculate the EEG surcharge for the coming year. The surcharge is based on expert forecasts made in accordance with the provisions of the Renewable Energies Ordinance. Before calculating the EEG surcharge, the transmission system operators first have to determine the aggregate EEG surcharge. It consists of three components: in addition to the projected level of financing needed for renewable energy for the following calendar year, it includes a liquidity reserve to cover future forecast errors and an account settlement charge to offset past forecast errors. The EEG account is settled on 30 September. Further information on how the forecast is calculated can be found on the grid operators' EEG information platform (www.netztransparenz.de; German only).

The Federal Government's 2030 Climate Action Programme envisages that the financial requirements deriving from the RES Act from 1 January 2021 and in the following years should increasingly be covered by federal funding. In this way, the Federal Government has introduced a systemic shift in order to relieve the burden on the electricity prices.

Following falls in the EEG surcharge in 2018 and 2019, it rose in 2020 from 6.405 to 6.756 cents/kWh. Since 2014, it has stayed within a window between 6.2 and 6.9 ct/kWh. At the same time, electricity generation from renewable energy sources has risen by 50%.

Aggregate EEG surcharge = forecasted financing needs (in the following calendar year)
+ / - account settlement (EEG account settled on 30 September)
+ liquidity reserve (no more than 10% of the support costs)

As the RES Act guarantees remuneration for 20 years, there is a considerable cost burden linked to the EEG surcharge in the form of the remuneration payments be made to existing installations. A large proportion of existing installations were built between 2009 and 2012 and receive considerably higher rates of remuneration than those built today. Since then, the costs of renewable energy have dropped substantially in many cases, so that new PV installations, for example, only need a much lower rate of funding. Expanding renewable energy is therefore much cheaper than before.

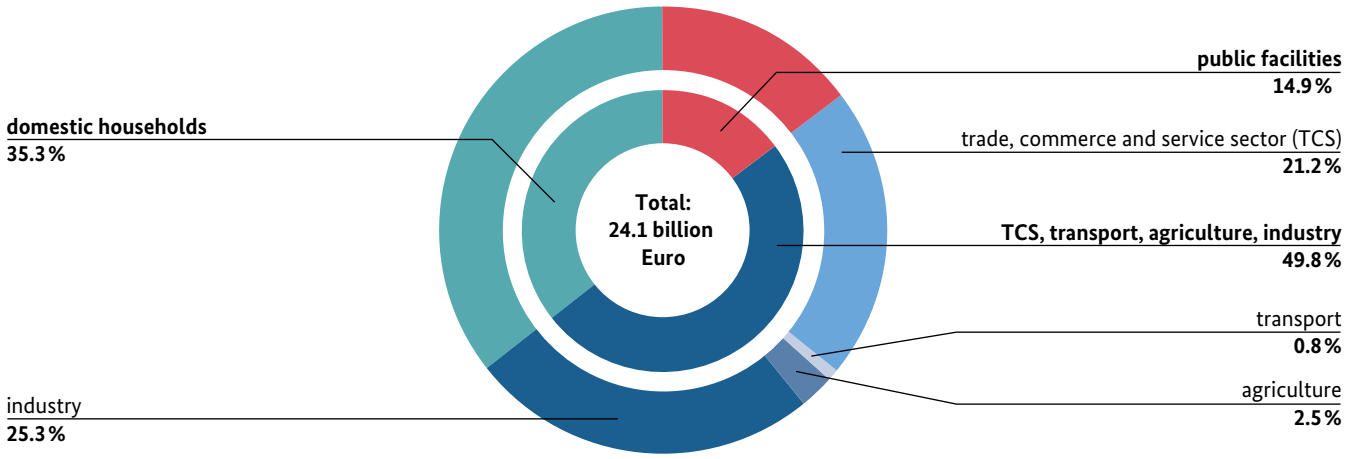
This reduction in financing is also supported by the use of auctions introduced under the 2017 Renewable Energy Sources Act. Under this system, the level of feed-in tariff for new renewables installations entitled to remuneration is determined via competitive auctions. The auctions for photovoltaic installations, onshore wind energy installations and biomass installations have resulted in clear reductions in remuneration rates since 2017. These auctions have also permitted quantitative steering, ensuring that expansion targets are adhered to effectively. This makes the continued expansion of renewable energy sources more predictable, reliable and, most importantly, more cost-effective. For more information (in German), please visit: www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Ausschreibungen/Ausschreibungen_node.html.

In general the RES Act requires every electricity utility and self-consumer to pay the EEG surcharge. Electricity utilities pass this cost on to the final consumer. However, it is beneficial to exempt some consumers from paying the full EEG surcharge – namely, large energy-intensive companies that compete internationally, as well as rail companies. The special equalisation scheme was introduced in 2004 to minimise the impact of the EEG surcharge on the global competitiveness of enterprises with intensive electricity costs and the intermodal competitiveness of rail companies (i.e. competitiveness against other mobility options).

In 2019, 2,058 companies (1,910 in manufacturing, 148 railway companies) benefited from the special equalisation scheme [34]. These companies applied for partial exemptions for a total of roughly 112,1 billion kilowatt-hours of electricity consumption. This volume accounts for roughly 22% of total final consumption in Germany (net electricity consumption minus electricity generated and consumed on-site). It should be noted that these "privileged" companies were not exempted from all of their EEG surcharges. The level depends on the company's specific situation; however, all the companies granted privileges under the special equalisation scheme participate in financing renewable energy.

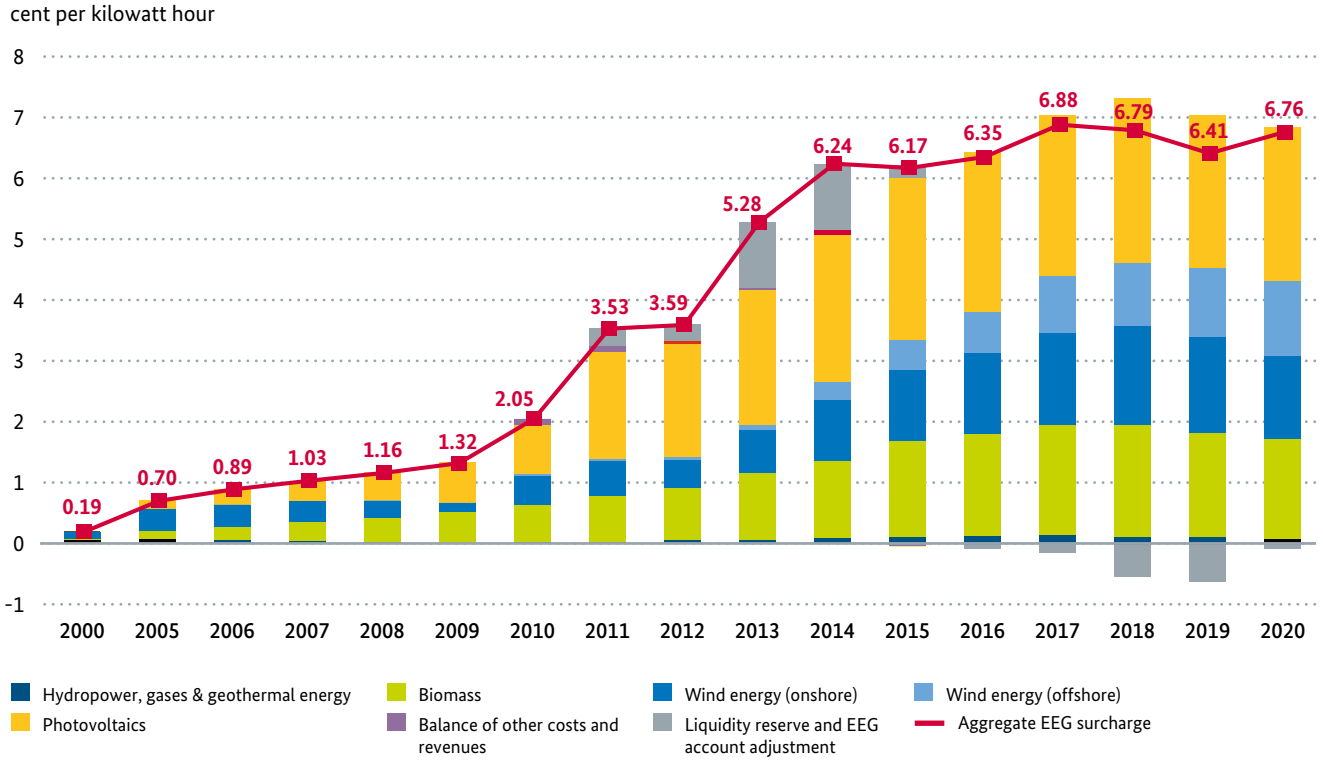
All told, both privileged and non-privileged businesses in Germany together (those in the industrial sector as well as trade, commerce and services, transport and agriculture) pay roughly half

Figure 31: Financing contribution of the EEG surcharge 2020 based on the October 2019 forecast



Source: German Association of Energy and Water Industries (BDEW) [8]

Figure 32: Development of the renewable energy surcharge (EEG surcharge)



Calculated EEG differential costs of all electricity suppliers for 2001 to 2009 based on transmission system operators' annual statements and the average value of EEG electricity. The item 'balance of other costs and revenues' includes the revenues from the payment of the minimum surcharge due to privileged final consumption, the costs of the green electricity privilege, and expenditure by transmission system operators on profile service, exchange listing admission, trading platform connectivity and interest charges. Since 2016, the EEG account, which records revenues from the EEG surcharge and payments made to installation operators, has been in the black. These assets reduce the level of the EEG surcharge, meaning that it can be lower than the total costs of technology-specific funding.
From 2010 onwards, transmission system operators' forecast of EEG surcharge in accordance with the Renewable Energy Sources Ordinance, published on www.netztransparenz.de

Source: Federal Ministry for Economic Affairs and Energy, based on data provided by the German transmission system operators; (TSOs [5]); further information at www.erneuerbare-energien.de (German only)

of the aggregate EEG surcharge, whilst private households pay around one third, and public institutions the rest [8]. Irrespective of this, the exemptions still concentrate the aggregate EEG surcharge onto a smaller amount of electricity known as 'non-privileged final consumption'.

The EEG surcharge is calculated by dividing the aggregate EEG surcharge by the final consumption subject to the EEG surcharge. The final consumption subject to the surcharge equates to the electricity consumption not exempted from the payment of the EEG surcharge. In 2020, the forecast funding requirement is around €24.1 billion. Taking account of the account status as of 30 September 2019 and the liquidity reserve, the forecast amount of the surcharge is €23.9 billion. Taken together with the (forecast) non-privileged final consumption of around 354 billion kilowatt-hours, this results in an EEG surcharge of 6.756 cents per kilowatt-hour in 2020.

$$\text{EEG-surcharge} = \frac{\text{Aggregate EEG surcharge}}{\text{Final consumption subject to the EEG surcharge}}$$

The breakdown of the forecast amount of the EEG surcharge was as follows in 2019: 39% due to photovoltaic installations, 24% due to biomass installations, 19% due to onshore wind turbines, and 17% due to offshore wind turbines (basis: EEG funding minus avoided grid charges, see [35]).

In general, it can be said of the EEG surcharge that, on the one hand, the differential costs for new installations under the Renewable Energy Sources Act dropped substantially in recent years. This is particularly rooted in the way renewable energy was brought closer to the market, as described above, by the 2014 and 2017 Renewable Energy Sources Acts. On the other hand, the recent fall in

the price of electricity on the exchange has cut the revenues from the sales of renewables- based electricity and thus increased the EEG surcharge.

Economic impetus from the construction and operation of renewable energy installations

Rewable energy as an economic factor

The expansion of the use of renewable energy in Germany has established the renewable energy sector as an important factor in the economy. Economic stimuli derive from investment in the roll-out of renewables, and also from the operation and maintenance of the installations.

The development of the investment as a stimulus to the economy reflects both the scale of new capacity construction and the development in the costs of the various technologies. The record figure for investment in renewable energy installations was seen in 2010, at just under €28 billion. Following this, investment dropped to just under €14 billion in 2015, and rose again to €15.8 billion in 2017, only to fall back to €10.5 billion in 2019. This corresponds to a 24% reduction in year-on-year terms. Germany's economy, which continues to hold a large stake in the value chain for constructing and assembling installations, benefits a great deal from this investment [36].

Whilst onshore wind energy was the sector attracting by far the most investment from 2013 to 2017, before offshore wind energy took the lead in 2018, photovoltaics headed the field in 2019 for the first time since 2012. At one third, the proportion of total investment going into photovoltaics was basically equivalent to the combined investment in onshore and offshore wind energy (33.9%).

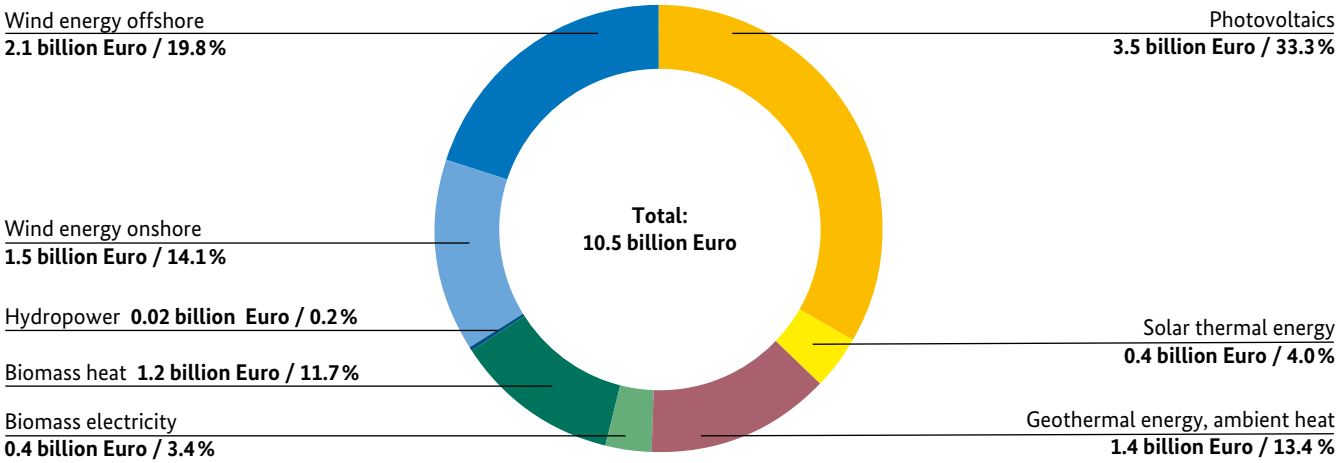
The sharp decline in total investment after 2010 is primarily due to the trend in photovoltaics. Installation prices fell in 2011 and 2012 while new plants continued to be installed at an unchanged pace. From 2013, in contrast, the volume of new photovoltaic capacity dropped substantially whilst prices remained largely stable. Compared to the years 2007 to 2012, when investment in photovoltaic installations constituted between around 40%

Figure 33: Investment in the building of renewable energy installations

	Hydropower	Wind energy onshore	Wind energy offshore	Photo-voltaics	Solar thermal energy	Geoth. energy, ambient heat	Biomass electricity	Biomass heat	Total
	(billion €)								
2000	0.5	1.9	0	0.3	0.4	0.1	0.5	0.9	**4.7**
2005	0.2	2.5	0	4.8	0.6	0.4	1.9	1.5	**12.0**
2006	0.2	3.2	0	4.0	1.0	0.9	2.3	2.3	**13.9**
2007	0.3	2.5	0.03	5.3	0.8	0.9	2.3	1.5	**13.6**
2008	0.3	2.5	0.2	8.0	1.7	1.2	2.0	1.8	**17.7**
2009	0.4	2.8	0.5	13.6	1.5	1.1	2.0	1.6	**23.5**
2010	0.3	2.1	0.5	19.6	1.0	1.0	2.2	1.2	**27.9**
2011	0.3	2.9	0.6	15.9	1.1	1.0	3.1	1.3	**26.1**
2012	0.2	3.6	2.4	12.0	1.0	1.1	0.8	1.5	**22.5**
2013	0.1	4.5	4.3	3.4	0.9	1.1	0.7	1.5	**16.5**
2014	0.09	7.1	3.9	1.5	0.8	1.1	0.7	1.4	**16.4**
2015	0.08	5.4	3.7	1.5	0.8	1.0	0.2	1.3	**13.9**
2016	0.06	6.9	3.4	1.6	0.7	1.2	0.3	1.2	**15.3**
2017	0.05	7.3	3.4	1.7	0.5	1.3	0.3	1.2	**15.8**
2018	0.03	3.3	4.2	2.6	0.5	1.5	0.4	1.2	**13.8**
2019	0.02	1.5	2.1	3.5	0.4	1.4	0.4	1.2	**10.5**

Source: Calculations made by the Centre for Solar Energy and Hydrogen Research (ZSW); rounded figures

Figure 34: Investment in the building of renewable energy installations, 2019



Most of the investment represented here was used for building new installations, with a smaller share being used for expanding or upgrading existing installations, for example for re-activating old hydroelectric power stations. The chart includes not only investment made by utilities, but also investment from industry, the commercial sector, trade and private households.

Source: Calculations made by the Centre for Solar Energy and Hydrogen Research (ZSW); rounded figures

and 70% of total investment, this share fell to under 11% in the period from 2015 to 2017. In 2018, the share rose again to 19% for the first time, reaching 33.3% or €3.5 billion in 2019.

In the case of onshore wind turbines, the sharp fall in capacity newbuild seen in the preceding year continued. The number of newly commissioned offshore installations did rise, but the level of construction activity, which determines the level of investment, dropped significantly. Since the construction of offshore wind farms takes quite some time, with investment being undertaken over several years, there are disparities between the time of investment and the time of commissioning.

Other renewables (electricity and heat from biomass, hydropower, solar, geothermal and ambient heat) accounted for a combined investment of €3.4 billion in 2019 (32.8% of overall investments). In comparison with the preceding year, investment in the aforementioned segments fell, or was at best flat.

At 71%, most of the investments again went into electricity generation installations that qualify for payments under the RES Act. Compared with the preceding year, this share fell by around 5.5 percentage points.

Permanent impulses from the plant operation

In addition to investment, plant operation and maintenance is also of considerable economic importance. Due to the attendant need for personnel, electricity (ancillary energy), replacement parts and fuel, operating (and maintaining) installations sends economic impulses to other sectors as well. The operating expenses incurred by the operator lead to corresponding amounts of revenue not least for suppliers. The economic stimulus from installation operation has risen steadily in past years in tandem with the growing number of installations. For example, since 2000 revenues have risen steadily, climbing from just under €2 billion to more than €17 billion in 2019. This means that the economic stimulus from installation operation has exceeded investment in installations since 2015 – and significantly so in recent years.

In contrast to the other renewable energy installations, biomass installations need fuel in order to generate electricity and heat. The costs of this mean that the largest proportion of the overall economic stimulus derives from the operation of biomass installations. It is followed by the stimulus from the sale of biofuels for transport. Further stimuli derive from the operation of wind energy and PV installations, geothermal and ambient heat installations, and solar thermal and hydropower

installations. These stimuli provide a long-term boost to the economy, as the costs are incurred over the entire life of the installations (in the case of electricity funded under the RES Act, usually 20 years) and increase as more plants are installed.

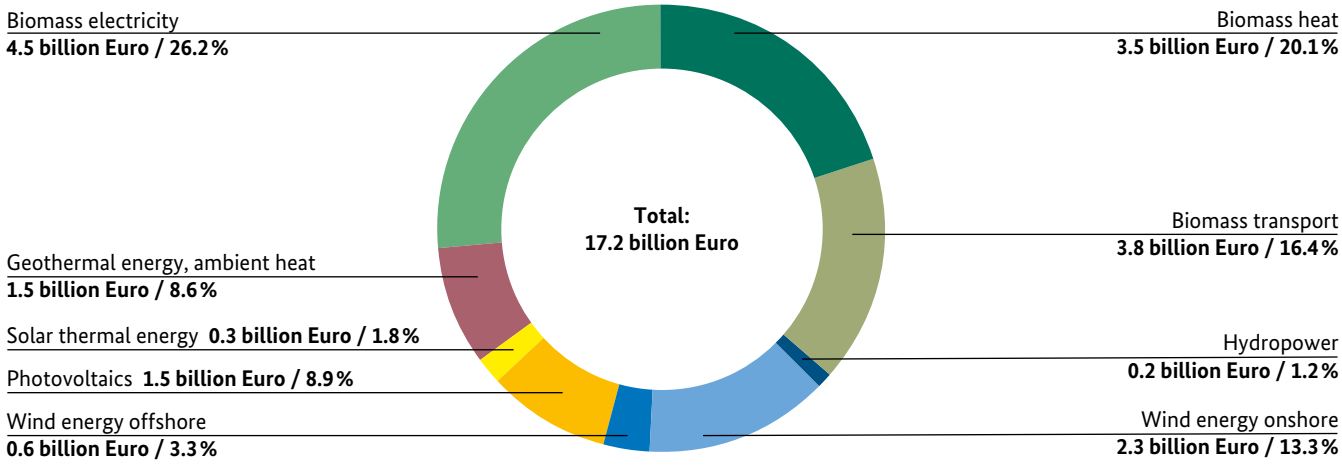
In 2019, more than half of the economic stimulus deriving from plant operation was triggered by electricity generation installations, 31% by heat generation installations, and 16% by sales of biofuels for transport. The development of these shares reflects the number of installations and the sales of biofuels: in 2000, heat accounted for two thirds, and electricity and fuels for 22% and 11% respectively. The rising volume of newbuild of electricity generation installations, and the

Figure 35: Economic impetus from the operation of renewable energy installations

	Hydro-power	Wind energy onshore	Wind energy off-shore	Photo-voltaics	Solar thermal energy	Geothermal energy, ambient heat	Biomass electricity	Biomass heat	Biomass fuels	Total
	(billion €)									
2000	0.1	0.2	0	0.01	0.00	0.2	0.2	1.1	0.2	**1.9**
2005	0.1	0.6	0	0.1	0.05	0.2	0.7	1.5	1.8	**5.1**
2006	0.1	0.6	0	0.2	0.07	0.3	1.1	1.7	3.2	**7.3**
2007	0.1	0.7	0	0.3	0.1	0.4	1.6	2.0	3.8	**8.9**
2008	0.2	0.8	0	0.4	0.1	0.4	1.9	2.2	3.5	**9.5**
2009	0.2	0.9	0.01	0.5	0.1	0.5	2.3	2.5	2.4	**9.4**
2010	0.2	1.0	0.02	0.8	0.2	0.6	2.8	2.9	2.9	**11.3**
2011	0.2	1.1	0.03	1.0	0.2	0.7	3.2	2.9	3.7	**13.0**
2012	0.2	1.2	0.06	1.3	0.2	0.8	3.9	3.1	3.7	**14.4**
2013	0.2	1.4	0.1	1.4	0.2	0.9	4.0	3.3	3.1	**14.6**
2014	0.2	1.6	0.2	1.4	0.2	1.0	4.3	3.0	2.6	**14.6**
2015	0.2	1.7	0.3	1.4	0.3	1.1	4.5	3.2	2.4	**15.1**
2016	0.2	1.9	0.4	1.4	0.3	1.2	4.5	3.4	2.6	**15.7**
2017	0.2	2.1	0.4	1.5	0.3	1.3	4.5	3.4	2.7	**16.3**
2018	0.2	2.2	0.5	1.5	0.3	1.4	4.5	3.4	2.7	**16.8**
2019	0.2	2.3	0.6	1.5	0.3	1.5	4.5	3.5	2.8	**17.2**

Source: Calculations made by the Centre for Solar Energy and Hydrogen Research (ZSW); rounded figures

Figure 36: Economic impetus from the operation of renewable energy installations in 2019



Source: Calculations made by the Centre for Solar Energy and Hydrogen Research (ZSW); rounded figures

increased sales of biofuels, meant that the share of heat generation installations dropped to around 30%, the share of electricity generation installations rose continuously to 53%, and the share of fuels peaked at 43% before falling to 16%.

For more details on the method used in these calculations, see Information on methodology.

Employment in the renewable energy sector in Germany

The latest employment figures are available for 2018: approximately 304,400 individuals were employed in the renewable energy sector that year. That was roughly 10,600 fewer people than in the preceding year (315,000).

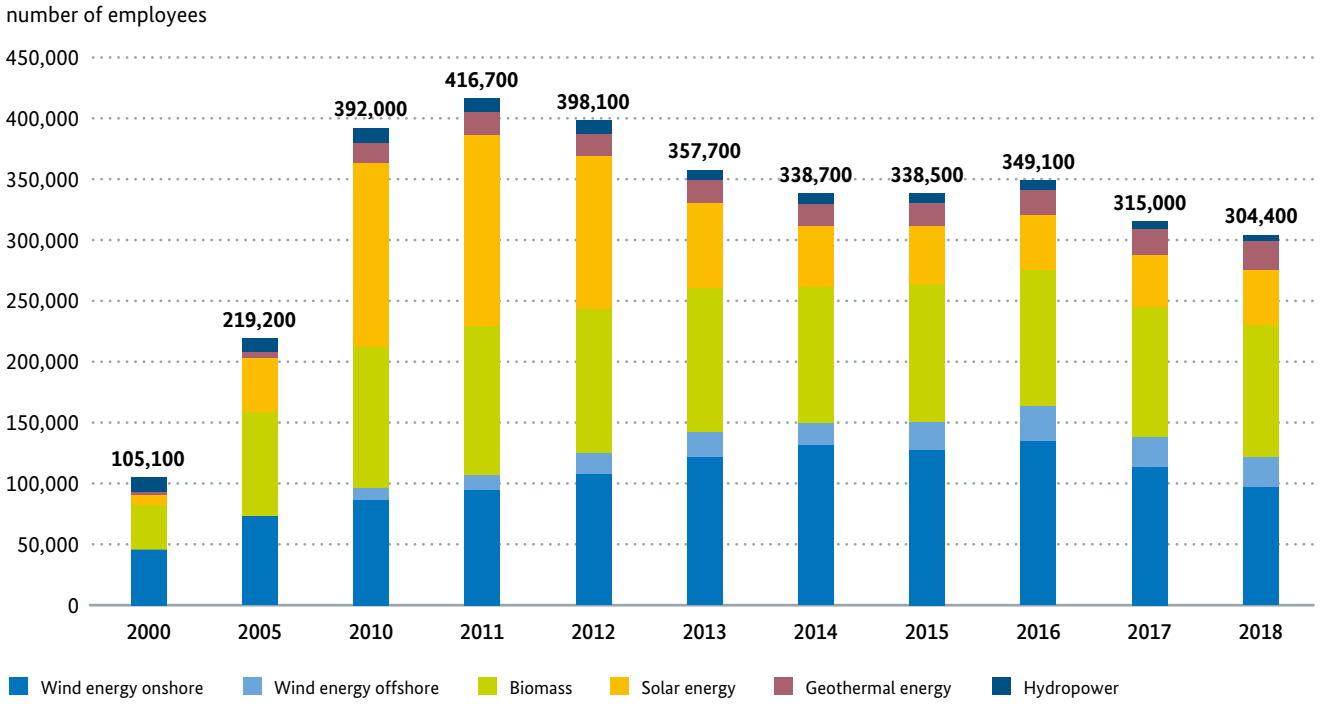
If the development in employment is broken down by technology, differing developments between 2000 and 2018 emerge. These are mainly related to the way the roll-out of the various technologies has taken place. For example, employment in the field of onshore wind energy rose to around 134,600 people by 2016, and then – despite an increasing proportion of exports – dropped by around 30% within two years to approximately 96,600 people as fewer turbines have been installed in Germany.

The use of biomass involves a wide range of technologies, which developed in very different ways during the reference period. Following an initial rise, employment remained relatively steady in these fields, accounting for around 36% (approximately 108,100 people) of total employment in the field of renewable energy in 2018.

The greatest fluctuations between 2000 and 2018 were seen in employment in solar energy. Following a very sharp rise in employment up to 2011, when solar energy accounted for 38% of employment (156,700 people) in the field of renewable energy, more than any other technology, the numbers fell by more than 70% in the period up to 2017. The trend only came to a halt in 2018, when rising amounts of installations of photovoltaics resulted in a renewed increase in the number of people working in the sector. Some 45,700 people were employed in solar energy in 2018.

In 2018, geothermal energy accounted for 8% of employment, with a relatively steady rate of

Figure 37: Development of gross employment from renewable energy in Germany



Sources: DIW, DLR, GWS [37]

employment being attained since 2000 after an initial rise.

In the field of hydropower, in contrast, the technology and the related industry were already very mature in 2000, so that the employment trend has tended to decline. In 2018, the 5,500 people working in hydropower corresponded to 2% of total employment in the field of renewable energy.

Some of the fall in total employment in plant construction was offset by the rising number of people working in the operation and maintenance of renewable energy installations.

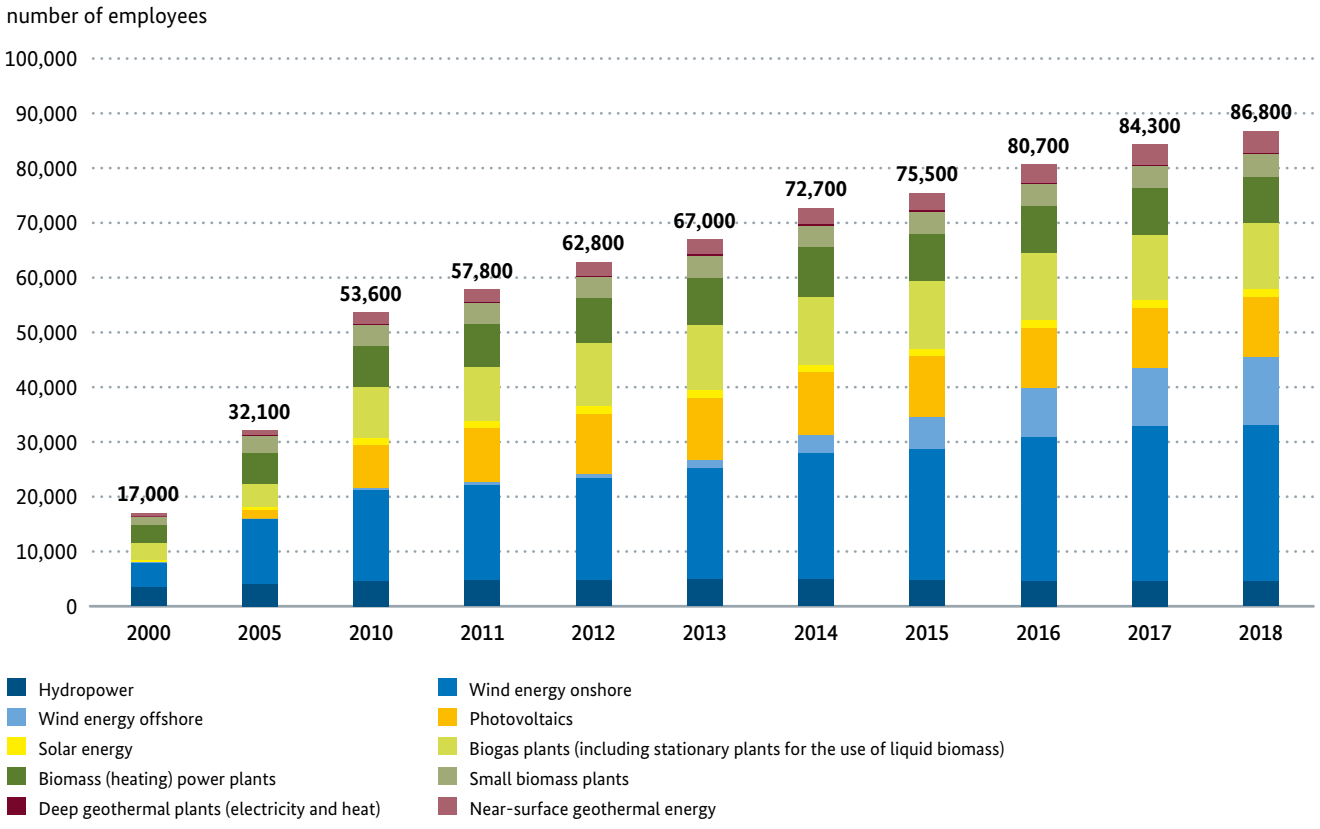
In total, only around 17,000 people were employed in the operation and maintenance of renewable energy installations as recently as 2000, and they were spread fairly equally across onshore wind (27%), hydropower (20%), biomass (combined heat and) power plants (19%) and biogas installations (18%). In 2018, a total of 86,800 people were employed in the operation and maintenance of renewable energy installations, more than five times as many as in 2000, and they were to be found chiefly in onshore wind (33%), offshore wind (14%), biogas installations (14%) and photovoltaics (13%). Biomass (combined heat and) power plants provided 10% of jobs. Small-scale biomass installations, hydropower, near-surface geothermal energy and ambient heat each had a share of just under 5%; solar thermal systems accounted for around 2%. There is still little use of deep geothermal energy, so that this technology only accounts for less than 1% of employment [37].

Promotion of renewable energy in the heating sector

Buildings Energy Act

On 18 June 2020, the German Bundestag adopted the Buildings Energy Act, which had been proposed by the Federal Government at the initiative

Figure 38: Development of employment in the operation and maintenance of renewable energy installations in Germany



Sources: DIW, DLR, GWS [37]

of the Federal Minister for Economic Affairs and Energy and the Federal Minister of the Interior, Building and Community. The Bundesrat approved the Act on 3 July 2020. It will enter into force in autumn 2020.

The Buildings Energy Act merges the Energy Conservation Act, the Energy Conservation Ordinance and the Renewable Energies Heat Act, establishing a new, uniform, coordinated set of rules for the energy requirements to be met by new buildings and existing buildings, and by the use of renewable energy to supply buildings with heating and cooling. This facilitates both application and enforcement.

The Buildings Energy Act implements the European rules on the overall energy efficiency of buildings, and integrates the rules on nearly zero-energy buildings into the harmonised legislation on energy savings. The Act retains the existing energy standards for new buildings and the upgrading of existing buildings.

Like the Renewable Energies Heat Act, the new Act contains a requirement that a proportion of the heating needs of new buildings should be covered by renewable energy. A new feature is the inclusion of electricity from renewable energy as a way to meet the requirements to use renewable energy. Electricity from renewable energy can make a contribution to meeting the heating and cooling needs of buildings, as can for example solar thermal systems. The new Buildings Energy Act again offers the possibility to take substitute measures in place of the use of renewable energy and to combine various measures.

Further information and practical examples can be found on the website of the German Energy Agency (dena) under the rubric “Zukunft Haus“ (www.zukunft-haus.info/start/, German only).

Further information about energy conservation rules can be obtained from the Federal Institute for Research on Building, Urban Affairs and Spatial Development www.bbsr.bund.de/BBSR/EN/home/_node.html;jsessionid=DBE442F5E5809FD67B1043B4282D70D8.live21301 and at the Institute’s dedicated website www.bbsr-energieeinsparung.de/EnEVPortal/EN/Home/home_node.html;jsessionid=213B614B79A574D5994E1A71E19A6F7E.live21302.

The Market Incentive Programme

The Market Incentive Programme (MAP) is a funding programme of the Federal Ministry for Economic Affairs and Energy which provides incentives to make greater use of renewable energy to generate heat: owners of housing, companies and non-profit organisations receive a grant if they replace their old heating system with an efficient solar thermal installation, biomass installation or heat pump. It also supports the construction of new, larger-scale heating installations which use renewable energy, such as deep geothermal installations and local heating networks to distribute heat generated from renewable energy, e.g. neighbourhood systems provided by municipalities.

Since 2000, more than 2.2 million installations have received more than €3.7 billion under the MAP, making the MAP a central instrument for expanding the use of renewable energy on the heating market.The details of the assistance are stipulated in the current guidelines (in German): “Guidelines on the funding of measures to use renewable energy in the heating market”. Further information can be found on the Economic Affairs Ministry’s website at www.erneuerbare-energien.de/EE/Navigation/DE/Foerderung/Marktanreizprogramm/marktanreizprogramm.html.

The funding under the Market Incentive Programme is based on two pillars. Firstly, investment grants are made through the Federal Office of Economics and Export Control for small installations, primarily in existing buildings; applications for such grants mainly come from private investors in the single-family or two-family homes segment. Secondly, repayment grants for low-interest KfW loans from the KfW’s Renewable Energy programme (premium variant) are approved for larger heating solutions and for heating grids and storage solutions. Investments of this kind are mostly made in solutions for commercial or local government use.

From 2000 to 2019, funding under the system of investment grants (from the Federal Office for Economic Affairs and Export Control) amounted to approximately €1.4 billion in investment grants towards some 1.2 million solar thermal installations and approximately €922 million for some 457,000 small-scale biomass heating systems, e.g. pellet boilers. The resulting investment totalled about €10.6 billion in the solar segment and approximately €6.6 billion in the biomass segment.

Up until 2019, some 162,000 investment grants totalling roughly €526 million were disbursed for efficient heat-pump heating systems, which have been eligible for funding since 2008. The resulting volume of investment amounted to around €2.8 billion in the 2008–2019 period.

Under the second funding element of the Market Incentive Programme, the KfW Renewable Energy Premium programme, some 26,500 reduced-interest loans with repayment grants were approved between 2000 and 2019. The total volume of loans granted came to around €3.6 billion and the volume of repayment grants totalled around €922 million. This assistance was provided, for example, for solar thermal installations with relatively large collector areas, biomass installations with relatively high outputs, deep geothermal installations, heat networks, and storage facilities for heat from renewable energy sources.

The number of approvals in 2019 for the two strands of the Market Incentive Programme (Federal Office for Economic Affairs and Export Control; KfW) are presented in Figures 39 and 40.

Figure 39: Market Incentive Programme 2019 – Investment grants, share from Federal Office for Economic Affairs and Export Control (BAFA)

	Number of approvals, BAFA part
Biomass heating systems	26,054
Heat pumps	30,031
Solar thermal plants	18,424
Other	976
Total	**75,485**

Source: Federal Ministry for Economic Affairs and Energy

Figure 40: Market Incentive Programme 2019 – repayment subsidies from KfW Renewable Energy Premium programme

	Number of approvals, KfW part
Solar collector systems	26
Solid biomass combustion plant	59
Biomass heating systems	272
CHP biomass plant	7
Heating networks	925
From renewable-fed heating networks	152
Biogas pipeline for raw biogas	7
Large heat storage	15
RES heat storage	138
Geothermal energy	3
Total	**1,604**

Source: Federal Ministry for Economic Affairs and Energy

The rules for the Market Incentive Programme were thoroughly revised as of 1 January 2020. Since that date, the Federal Office for Economic Affairs and Export Control's section of the programme has offered percentage-based funding rates of 20% for gas-fired condensing boilers which are "renewable-ready", i.e. need to be retrofitted for the use of renewable energy within two years, 30% for gas hybrid installations, and 35% for installations based entirely on renewable energy. At the same time, the "oil exchange bonus" adopted in the 2030 Climate Action Programme was integrated into the Market Incentive Programme in the shape of an increase in funding rates by up to 10 percentage points when an old oil-fired heating system is replaced and an efficient new heating installation is fitted which is based on renewable energy.

The Programme is subject to ongoing evaluation by experts in order to assess the impact of the funding. Current evaluations and further information on the MAP can be found on the website of the Federal Ministry for Economic Affairs and Energy at www.bmwi.de/Redaktion/EN/Meldung/20180119-aenderungen-zur-antragstellung-beim-marktanreizprogramm-map.html and www.erneuerbare-energien.de/EE/Navigation/DE/Foerderung/Marktanreizprogramm/marktanreizprogramm.html (in German) [38].

Information on investment grants under the Market Incentive Programme can be found (in German) on the website of the Federal Office for Economic Affairs and Export Control (BAFA), www.bafa.de in the section on energy/heating with renewable energy.

Details on the KfW Renewable Energy programme under the umbrella of the Market Incentive Programme are available on the KfW website at www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/Erneuerbare-Energien-Umwelt/ (in German).

Promotion of renewable energy in transport

Biofuels for transport

Biofuels were initially subsidised solely via tax concessions in Germany.

The first Biofuel Report by the Federal Ministry of Finance [24] found that considerable overfunding had occurred in 2006, as the tax refund was much higher than the difference in production costs. For this reason, biofuel funding was shifted to a purely regulatory basis [39], [40]. The new biofuel quota introduced in this context required the oil industry to market a minimum proportion of biofuels – in terms of a company's total annual sales of gasoline, diesel and biofuel. From 2010–2014, the overall quota stood at 6.25% (in terms of energy content); the sub-quotas for biofuel substituting diesel fuel were 4.4% (energy content) and for biofuel substituting gasoline 2.8% (energy content). From 2011, it was possible to give certain biofuels (particularly biofuels produced from waste and residues) a double weighting when calculating the biofuel quota.

Biofuels introduced on the market in Germany since the beginning of 2011 can (or could) only be subsidised via the biofuel quota, or via taxes up until the end of 2015, if they meet the requirements of the Biofuel Sustainability Ordinance.

As of 1 January 2015, the reference basis for the quota was switched from the energy content to the net reduction in greenhouse gas emissions. This is 3.5% for 2015 and 2016, 4.0% for 2017–2019, and 6.0% from 2020 [44]. This is also intended to ensure that the target for the use of biofuels and electric mobility (10% by 2020), which applies equally to all EU Member States pursuant to Directive 2009/28/EC, will be achieved (for information on the specific requirements, including multiple counting, see the "Information on methodology" section in the Annex).

The quantitative development in the various biofuels (see Figures 22 until 25) has been closely related to the changes in funding arrangements since 2004.

Electric mobility

Electric mobility is the key to climate-friendly mobility around the world. Particularly when operated using renewables-based electricity, electric vehicles generate much less CO_2, and in the case of purely electric vehicles, mobility is emission-free in local terms. The Federal Government is therefore deploying a range of instruments to promote electric mobility. Since 2009, it has provided around €3 billion for research and development of electric mobility. The promotion of research and development activities embraces all elements of electric mobility. This includes driveline technology, battery storage, energy, standardisation, ways to strengthen the value chain, connected cars, fleet and logistics strategies, digitalisation, grid integration, and charging stations that use smart metering technology.

In order to boost demand for electric vehicles, the Federal Government has set up a package of measures to encourage people to buy them. The package includes an "environmental bonus" (grant towards purchases made by the end of 2025), statutory rules on uniform charging standards and more funding for the roll-out of charging infrastructure, and also privileges for electric car users, e.g. in the form of dedicated parking spaces and exemptions from vehicle tax. Also, further efforts are to be made to foster public procurement of electric vehicles.

At the end of 2019, more than 30 different models of electric vehicles made by German manufacturers were on the market, which can be charged up

at some 24,000 publicly accessible charging points.

Further information can be found at www.bmwi.de/Redaktion/EN/Artikel/Industry/regulatory-environment-and-incentives-for-using-electric-vehicles.html.

The Economic Affairs Ministry's environmental bonus promotes the purchase of electric vehicles. As of 1 July 2020, 214,269 applications had been sent to the Federal Office for Economic Affairs and Export Control. The majority of these applications (137,518) were for pure battery electric vehicles, followed by plug-in hybrid vehicles (76,625) and fuel cell vehicles (129) [41].

On the basis of the decision by the Federal Government and the automotive manufacturers at the "car summit" in November 2019, the Economic Affairs Ministry significantly increased the environmental bonus at the beginning of 2020 and extended it until the end of 2025. For pure battery electric vehicles up to a net list price of €40,000, the bonus was raised from €4,000 to €6,000; in the case of vehicles with a net list price of more than €40,000 to up to €65,000, the bonus was increased from €3,000 to €4,500. The industry is continuing to provide half of the environmental bonus. The Federal Government further expanded its funding of electric mobility by introducing an innovation bonus in July 2020, to run until the end of 2021. In this way, the Federation has doubled its share of the purchase bonus. For more information, please visit: www.bmwi.de/Redaktion/DE/FAQ/Elektromobilitaet/faq-elektromobilitaet.html (in German).

According to data from the Federal Motor Transport Authority, there were the following year-on-year increases in new registrations of vehicles with alternative propulsion in 2019: 64.3% in the case of electric vehicles, and 58.0% in the case of hybrid vehicles. The number of electric vehicles rose from 83,175 to 136,617, and that of plug-in hybrid vehicles from 66,997 to 102,175. Another key measure to boost demand for electric mobility is an improvement in and expanded availability of charging infrastructure. The funding guidelines entitled "Charging infrastructure for electric vehicles", for which the Federal Ministry of Transport and Digital Infrastructure has the lead responsibility, govern funding of €300,000 for a project to create at least 15,000 charging stations (www.bmvi.de/EN/Topics/Mobility/Electric-Mobility/Electric-Mobility-In-A-Nutshell/electric-mobility-in-a-nutshell.html).

By March 2020, 13,006 publicly accessible charging stations (of which 1,662 were rapid charging devices) had been registered with the Federal Network Agency. 11,460 charging stations offered at least two publicly accessible charging points. The Federal Network Agency (www.bundesnetzagentur.de/EN/Home/home_node.html;jsessionid=0590ADB0DD5406974E93567C1A9DECCE) publishes the data reported under the Charging Station Ordinance on publicly accessible charging infrastructure in Germany (https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/HandelundVertrieb/Ladesaeulenkarte/Ladesaeulenkarte_node.html).

In the context of the Immediate Action Programme for Clean Air, the Economic Affairs Ministry is providing an additional €176 million for the expansion of charging infrastructure in conjunction with research questions. Here, the Economic Affairs Ministry is pursuing two goals: the near-term development of charging infrastructures in municipalities, and the monitoring and examination of these measures with regard to weaknesses in grid expansion and grid stability. Further to this, the focus is also on charging options for vehicle owners who do not have a charging point where they park, and on charging options for business applications.

In addition to the funding of electric vehicles, the Economic Affairs Ministry is supporting the establishment of battery cell manufacturing and related value chains in Germany and Europe together with other European countries. To this end, the Economic Affairs Ministry is providing well over €1 billion in funding, to be disbursed as part of an Important Project of Common European Interest (IPCEI). A first consortium has already been approved, and a second consortium is about to notify its plans to the European Com-

mission. These consortia involve 14 EU Member States in the establishment of new, environmentally acceptable value creation in the EU. The funding aims not least to boost the use of renewable energy in battery manufacturing and thus to reduce the lifecycle carbon dioxide emissions of electric vehicles.

Further information about the funding of electric mobility by the Federal Government can be found at www.bmwi.de/Redaktion/EN/Dossier/electric-mobility.html.

Promotion of renewable energy research and development

Funding for energy research is a strategic element of the Federal Government's energy policy, and serves to attain the energy and climate targets of the energy transition. The Energy Research Programme is the main element setting out the principles and priorities of the funding policy. In September 2018, the Federal Cabinet adopted the 7th Energy Research Programme, entitled "Innovations for the Energy Transition". Here, the Federal Government is building on the successful energy research of recent years, setting new priorities, and defining key areas for research funding and innovation policy in the energy sector.

The Federal Government's 7th Energy Research Programme sets out guidelines for energy research funding over the coming years. It lays down a new strategic approach and trains the programme's focus on technology and innovation transfer. This includes the use of regulatory sandboxes to bring new, promising technological solutions to the market, and to explore and master the challenges under real-life conditions. The experience gained will set the course for implementing the technologies tested on a large scale later on. Greater involvement by young, creative start-ups will also play an important role in this process.

The programme is the outcome of a wide-ranging consultation process involving stakeholders from business associations and companies, research and scientific organisations, members of research networks and representatives of the Länder.

The current framework for energy research policy is characterised by four main areas:

- accelerating the transfer of technology and innovations as a precondition for an efficient, cross-sector implementation of the energy transition,
- broadening of the research spectrum of project funding from a focus on individual technologies to systemic and cross-system questions of the energy transition,
- twin-track strategy for the funding instruments: in addition to project funding, support is also given to the institutional research funding of the Helmholtz Association of German Research Centres,
- funding for close international and European networking of research work.

The aim is to develop innovative holistic solutions for the challenges of the energy transition and to bring them rapidly to market.

Within the project funding, the 7th Energy Research Programme has an interministerial, thematically oriented structure. It was drawn up under the lead of the Economic Affairs Ministry, and is being implemented together with the Federal Ministry of Education and Research and the Federal Ministry of Food and Agriculture.

In total, the Federal Government is providing around €6.4 billion under the programme from 2018–2022, for research, development, demonstration and testing of forward-looking technologies and concepts. This was 45% up on the amount available under the preceding programme for the 2013–2017 period. This underlines the relevance of energy research to the success of the energy transition [42].

The following figure shows the development of the research projects approved for renewable energy technologies in the 2016 to 2019 period.

Figure 41: Newly approved projects for renewable energy technologies

	2016			2017			2018			2019		
	Number	1,000 Euro	Share in %	Number	1,000 Euro	Share in %	Number	1,000 Euro	Share in %	Number	1,000 Euro	Share in %
Wind energy	93	92,453	26.6	86	96,668	32.2	121	89,776	29.9	112	78,994	22.7
Photovoltaics	162	109,151	31.4	101	89,946	30.0	96	83,207	27.7	135	100,175	28.8
Solar thermal power plants	13	9,617	2.8	21	5,617	1.9	29	12,962	4.3	28	11,679	3.4
Geothermal energy	33	26,753	7.7	17	7,654	2.6	21	10,471	3.5	25	24,097	6.9
Hydropower	4	3,513	1.0	2	1,208	0.4	0	0	0.0	7	3,541	1.0
Biomass	36	6,120	1.8	42	5,987	2.0	47	9,097	3.0	69	16,959	4.9
Electricity grids and grid integration renewable energy[1]	118	52,184	15.0	85	53,214	17.8	135	67,247	22.4	136	59,182	17.0
Energy storage	36	20,333	5.9	61	22,264	7.4	24	10,969	3.7	57	28,170	8.1
Energy system analysis and overarching questions of the energy transition	65	27,175	7.8	39	17,188	5.7	64	16,646	5.5	60	24,751	7.1
Total	**560**	**347,299**	**100.0**	**454**	**299,746**	**100.0**	**537**	**300,375**	**100.0**	**629**	**347,548**	**100.0**

1 Integration of renewable energy and renewable energy supply systems

The data for project funding in 2020 have been collected retrospectively in line with the new system introduced under the 7th Energy Research Programme. This means that they vary from the figures in the report for the preceding years. Also, the table omits basic research projects, since they are the responsibility of the Federal Ministry of Education and Research.

Source: Federal Ministry for Economic Affairs and Energy

Detailed information about the 7th Energy Research Programme (in German) can be found on the Economic Affairs Ministry's website at www.energieforschung.de/energieforschungspolitik/energieforschungsprogramm/foerderschwerpunkte. Further to this, the website of Jülich (PtJ), the project management agency commissioned by the Economic Affairs Ministry, includes information on fields eligible for funding and on applications for research funding programmes for renewable energy (www.ptj.de/en/landing-page).

Data platforms of the Federal Network Agency

Core market data register – data for the energy transition

MaStR Marktstammdatenregister

The transformation of the German energy system can only take place in a targeted manner if the various stakeholders can draw on comprehensive, uniform and reliable data as a basis for their decisions. Efficient marketing of electricity and gas, the restriction of new grid construction to the necessary extent, and the further development of the energy transition are challenges which can only be tackled on the basis of reliable data.

Back in 2014, the Federal Network Agency was entrusted by the legislature with the introduction and maintenance of an official register of renewable energy installations. It soon became

clear that this register would have to be expanded to include all generating installations and market players. The design of the new overall register is regulated by the Core Energy Market Data Register Ordinance. The main aim of the core energy market data register is to simplify the processes in the energy industry and to improve the quality of the data. It also reduces the amount of bureaucracy borne by individuals and companies.

So far, the data on the installations and market players have been kept in different, uncoordinated registers, so that many stakeholders had to register several times over and keep updating their data in various places. The core energy market data register collates all the main data of the electricity and gas market in a central register. Most of the data are public, but personal data are explicitly protected. Public authorities can access the data. This makes it much easier for them to conduct their own surveys – they may even be spared the need to do so at all. Installation operators and other market players can use their core energy market data register numbers to refer to the data they have entered into the register.

Installation operators need to register themselves and their installations in the register, and are responsible for entering and curating their data. This also applies to all other market players. In this way, all electricity and gas system operators can be found in the register. The list of those obliged to register themselves includes electricity and gas suppliers, direct marketers and public authorities, associations and institutions in the energy sector. A detailed list of who is required to register (in German) can be found at www.marktstammdatenregister.de/MaStRHilfe/subpages/registrierungVerpflichtet.html.

The core energy market data register only contains core data: names, addresses, sites, categorisations, technologies, capacity figures, etc. It does not contain dynamic data relating to the activities of a market player or processes within an installation (e.g. production figures, power flow data or storage levels). A detailed description of what data are contained in the core energy market data register (in German) can be found on the Federal Network Agency's website at www.marktstammdatenregister.de/MaStRHilfe/subpages/hintergrund.html and in the registration aids www.marktstammdatenregister.de/MaStRHilfe/subpages/regCheck.html. Further information on the core energy market data register can be found on the Federal Network Agency's website at www.marktstammdatenregister.de/MaStR.

SMARD Electricity Market Data

SMARD Strommarktdaten

SMARD is a website set up in 2017 by the Federal Network Agency to map the German electricity market and create more transparency. To this end, central electricity market data obtained by the Federal Network Agency directly from the European Network of Transmission System Operators are published on the website in nearly real time. In order to keep improving the quality of the data, the Federal Network Agency is engaged in a permanent dialogue with the providers of the data.

The information on the website is divided into five main areas. Under "Market data visuals", users can compile data from electricity generation and consumption, market and system stability to form individual diagrams. This pool of data is supplemented by helpful explanatory notes ("Electricity market explained"). The section "Electricity market topics" contains special articles on current events and a monthly evaluation of market activity relating to electricity generation and merchandising. The variables are also set in context to special events and weather conditions.

All of the data available on SMARD can be downloaded, saved and used free of charge under the CC BY 4.0 licence ("Data download" section). The fifth section, "German electricity market", is subdivided into a section on power plants and one on bidding zones. In the power plant section, detailed information can be viewed, including generation by individual power stations with an installed generation capacity of 100 MW or more at the level of individual power plant blocks, and

the generation figures can also be obtained from the “Data download” section.

The markt data visuals uses a map to show the geographical electricity generation situation in Germany. Further to this, other key variables like electricity consumption and international wholesale prices are mapped.

SMARD has succeeded in making a complex issue accessible to a broad public via a digital medium, as the published data and background information always provide an up-to-date and comprehensive overview of activity on the electricity market.

The SMARD information platform can be found at www.smard.de/en.

Part II: Renewable energy in the European Union

Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, which entered into force in June 2009, set ambitious targets for the expansion of renewable energy in the EU ten years ago. For example, by 2020, renewable sources were to account for 20% of gross final energy consumption. The new version of the Directive, which entered into force at the end of 2018, extends this target: 32% of the EU's gross final energy consumption is to be covered by renewable energy by 2030.

Directive 2009/28/EC was part of the European climate and energy package which was based on the resolutions passed on 9 March 2007 at the spring summit of the Heads of State and Government (European Council). The binding objective of this Directive was to raise the renewables-based share of total gross final energy consumption in the EU from roughly 8.5% in 2005 to 20% in 2020.

To underpin this 20% target, this Directive also laid down binding national targets for the various Member States regarding their share of energy from renewable sources in gross final consumption of energy in 2020. These were determined on the basis of the 2005 baseline figures and each country's individual potential. In this way, Germany's national target was set at 18%. The calculation of the shares attained is based on certain rules: for instance, weather-related fluctuations in electricity generation from hydropower and wind energy, are normalised, i.e. calculated on the basis of average precipitation and wind conditions using a set formula. The calculation of the attainment of the sub-target of 10% of renewable energy in the transport sector follows special rules.

On the basis of Directive 2009/28/EC and the assigned targets, Member States have presented National Renewable Energy Action Plans (NREAPs) for achieving their targets and, pursuant to Article 22 of the Directive, must report their progress to the Commission every two years. The progress reports are published on the website of the European Commission at https://ec.europa.eu/energy/node/70.

In accordance with Article 23 of the Directive, the European Commission also prepares a progress report every two years documenting the progress made by each country in reaching the targets set out in the EU Directive. The latest, fifth progress report, relating to data from 2017, was published by the European Commission in April 2019 [43]. In it, the Commission found that the EU attained a share of 17.5% of renewable energy in gross final energy consumption in 2017, which lay above the target attainment curve for 2017/18, so that the EU was well on the way to achieving the 20% target by 2020.

Directive 2009/28/EC represents the first EU-wide regulation that covers all energy applications of renewable energy sources. As such, it provides a sound pan-EU legal framework and a clear development path as a basis for the necessary investments and thus lays the foundation stone for the EU-wide expansion of renewable energy.

Directive (EU) 2018/2001 entered into force on 24 December 2018, providing a new version of the Renewable Energy Directive. Basically, it sets a target whereby the share of renewable energy in final energy consumption within the EU is to increase to at least 32% by 2030. In addition to common funding rules for electricity from renewables, the Directive also addresses the heating and transport sectors. For example, the Member States will need to increase the share of renewable energy they use for heating and cooling by 1.3 percentage points from 2021 onwards. In the transport sector, the marketers of fuels are obliged to increase the share of renewable fuels to 14% by 2030. This is primarily to be achieved by means of new technologies and fuels. A role will particularly be played by electric mobility and electricity-based fuels (power-to-X). In contrast, the updated Directive restricts the share of first-generation biofuels – biofuels that are produced from food crops.

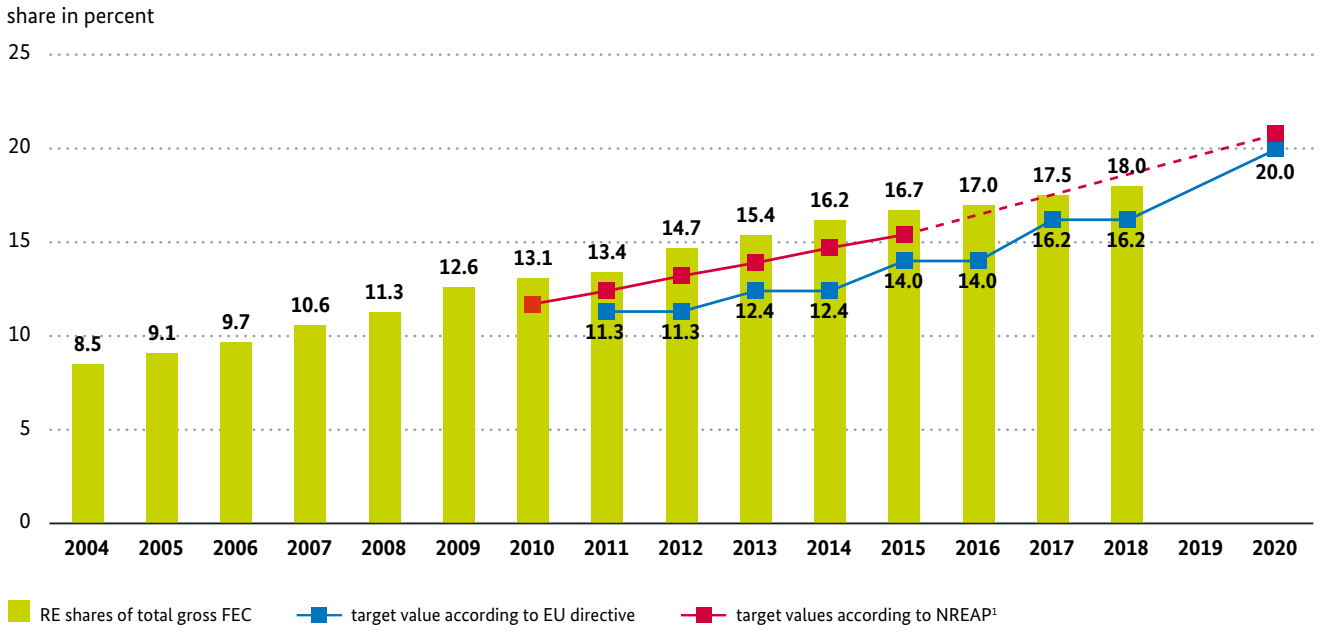
A framework for the new Directive is provided by the European Regulation on the Governance of the Energy Union and Climate Action (Governance Regulation). The European Union has set itself the aim of cutting EU greenhouse gas emissions by at least 40% by 2030 from 1990. In addition to the above-mentioned rise in the share of final energy consumption covered by renewable energy, EU primary energy consumption is to be cut by at least 32.5% compared with a reference scenario. The European electricity markets are to grow closer together and to be made fit for the growing proportion of intermittent renewable energy across Europe. Also, the rights and possibilities for final consumers in the electricity markets are to be strengthened. In December 2019, the European Commission set itself the target of greenhouse gas neutrality by 2050 in the "Green Deal", with backing from the European Council and the European Parlia-

ment. Further to this, the proposal by the European Commission for a regulation on an EU Climate Act presented on 4 March 2020 has led to a debate on raising the EU's climate target for 2030. The European Commission will present an impact assessment on this in autumn 2020.

The Governance Regulation also introduced a new planning and monitoring instrument for the implementation of the goals of the Energy Union, and particularly the EU's 2030 targets for energy and the climate. Each EU Member State had to present an integrated National Energy and Climate Plan (NECP) for the next decade (2021–2030). These NECPs must set out the Member States' national energy and climate targets, strategies and measures and formulate national contributions to the EU's 2030 targets. After the Federal Government sent a first NECP draft on time by 31 December 2018, the federal cabinet adopted the final version on 10 June 2020 and subsequently sent the NECP to the European Commission. The German NECP is based on the targets and measures of the 2010 Energy Concept, the 2030 Climate Action Plan, and the 2050 Energy Efficiency Strategy. It contains the goals of the Federal Government to cut primary energy consumption by 30% by 2030 (from 2008) by boosting energy efficiency and increasing the proportion of renewable energy in gross final energy consumption to 30% by 2030.

From 2023, Member States are expected to send NECP progress reports to the European Commission every two years. They can also present one revision of their NECP by the end of 2024. This must not contain a downward correction of the Member States' level of ambition for their central energy and climate targets for 2030.

Figure 42: Shares of renewable energy in gross final energy consumption in the EU and Renewable Energy Directive and National Renewable Energy Action Plan (NREAP) trajectories



1 The Energy Research Centre of the Netherlands (ECN) was commissioned by the European Environment Agency to process and evaluate the EU Member States' National Renewable Energy Action Plans (NREAPs) with the aim of generating estimates for the EU 27.

Sources: Eurostat (SHARES) [44]; Energy Research Centre of the Netherlands (ECN), European Environment Agency (EEA) [45]

Note:
European and international statistics on the generation and use of renewable energy in Germany do not always match the statistics provided by German sources. This is due to differences in data origins and accounting methods.
To ensure consistency, the international statistics are used for Germany in this section on Europe. As a rule, however, the more detailed information from national sources on the preceding pages is more reliable.

Figure 43: Shares of renewable energy in total gross final energy consumption and gross final energy consumption for electricity

	RE shares of gross final energy consumption (%)						RE shares of gross final energy consumption (%)[1]				
	2005	2010	2016	2017	2018	Target (2020)	2005	2010	2016	2017	2018
Austria	24.4	31.2	33.4	33.1	33.4	**34**	62.9	66.4	72.5	71.6	73.1
Belgium	2.3	5.6	8.7	9.1	9.4	**13**	2.4	7.1	15.9	17.3	18.9
Bulgaria	9.2	13.9	18.8	18.7	20.5	**16**	8.7	12.4	19.1	19.0	22.1
Croatia	23.7	25.1	28.3	27.3	28.0	**20**	35.2	37.5	46.7	46.4	48.1
Cyprus	3.1	6.2	9.9	10.5	13.9	**13**	0.0	1.4	8.6	8.9	9.4
Czech Republic	7.1	10.5	14.9	14.8	15.2	**13**	3.8	7.5	13.6	13.7	13.7
Denmark	16.0	21.9	31.8	34.7	35.7	**30**	24.6	32.7	53.7	60.0	62.4
Estonia	17.4	24.6	28.7	29.1	30.0	**25**	1.1	10.3	15.5	17.4	19.7
Finland	28.8	32.4	39.0	40.9	41.2	**38**	26.9	27.7	32.9	35.2	36.8
France	9.6	12.7	15.7	16.0	16.6	**23**	13.7	14.8	19.2	19.9	21.2
Germany	7.2	11.7	14.9	15.5	16.5	**18**	10.6	18.3	32.3	34.6	38.0
Greece	7.3	10.1	15.4	17.0	18.0	**18**	8.2	12.3	22.7	24.5	26.0
Hungary	6.9	12.7	14.3	13.5	12.5	**13**	4.4	7.1	7.3	7.5	8.3
Ireland	2.8	5.7	9.3	10.6	11.1	**16**	7.2	15.6	26.8	30.1	33.2
Italy	7.5	13.0	17.4	18.3	17.8	**17**	16.3	20.1	34.0	34.1	33.9
Latvia	32.3	30.4	37.1	39.0	40.3	**40**	43.0	42.1	51.3	54.4	53.5
Lithuania	16.8	19.6	25.6	26.0	24.4	**23**	3.8	7.4	16.9	18.3	18.4
Luxembourg	1.4	2.9	5.4	6.3	9.1	**11**	3.2	3.8	6.7	8.1	9.1
Malta	0.1	1.0	6.2	7.3	8.0	**10**	0.0	0.0	5.7	6.8	7.7
Netherlands	2.5	3.9	5.8	6.5	7.4	**14**	6.3	9.6	12.5	13.8	15.1
Poland	6.9	9.3	11.3	11.0	11.3	**15**	2.7	6.6	13.4	13.1	13.0
Portugal	19.5	24.2	30.9	30.6	30.3	**31**	27.7	40.6	54.0	54.2	52.2
Romania	17.6	22.8	25.0	24.5	23.9	**24**	28.8	30.4	42.7	42.0	41.8
Slovakia	6.4	9.1	12.0	11.5	11.9	**14**	15.7	17.8	22.5	21.3	21.5
Slovenia	16.0	20.4	21.3	21.1	21.1	**25**	28.7	32.2	32.1	32.4	32.3
Spain	8.4	13.8	17.4	17.6	17.5	**20**	19.1	29.8	36.6	36.4	35.2
Sweden	40.7	47.0	53.4	54.2	54.6	**49**	50.9	55.8	64.9	65.9	66.2
United Kingdom	1.1	3.8	9.0	9.7	11.0	**15**	3.2	6.9	24	27.4	30.9
EU-28	9.1	13.2	17.0	17.5	18.0	**20**	14.8	19.7	29.5	30.7	32.1

For details on the method used to calculate these shares, see the "Information on methodology" section.

1 In order to determine the shares of renewable energy in gross electricity consumption, electricity production from wind and hydropower was calculated using the normalisation rule defined in the EU Directive.

Source: Eurostat (SHARES) [44]

Figure 44: Shares of renewable energy in gross final energy consumption for heat and cooling and in final energy consumption in transport

	Renewable energy shares of gross final energy consumption in the heating/cooling sector (%)					RE shares of gross FEC for transport (%)					
	2005	2010	2016	2017	2018	2005	2010	2016	2017	2018	Target (2020)
Austria	22.9	30.9	33.5	33.7	34.0	5.1	10.7	10.6	9.7	9.8	
Belgium	3.4	6.1	8.2	8.0	8.2	0.6	4.7	6.0	6.6	6.6	
Bulgaria	14.3	24.3	30.0	29.9	33.3	0.8	1.4	7.2	7.2	8.1	
Croatia	30.0	32.8	37.6	36.5	36.5	1.0	1.1	1.3	1.2	3.9	
Cyprus	10.0	18.8	24.5	26.1	36.8	0	2.0	2.7	2.6	2.7	
Czech Republic	10.8	14.1	19.9	19.7	20.6	1.0	5.1	6.4	6.6	6.5	
Denmark	22.8	30.4	41.3	45.3	46.7	0.4	1.2	6.5	6.6	6.6	
Estonia	32.2	43.3	51.1	51.4	53.7	0.2	0.4	0.4	0.4	3.3	
Finland	39.2	44.2	53.7	54.6	54.6	0.9	4.4	8.9	18.8	14.9	
France	12.4	16.2	20.8	21.1	21.8	2.1	6.5	8.4	8.8	9.0	
Germany	7.7	12.1	13.0	13.4	13.6	4.0	6.4	7.0	7.0	7.9	
Greece	13.4	18.7	25.4	26.6	30.2	0.1	1.9	1.6	4.0	3.8	
Hungary	9.9	18.1	21.0	19.9	18.1	0.9	6.1	7.6	7.6	7.7	
Ireland	3.4	4.3	6.3	6.7	6.5	0.1	2.4	5.2	7.4	7.2	
Italy	8.2	15.6	18.9	20.1	19.2	1.0	4.8	7.4	6.5	7.7	All countries 10%
Latvia	42.7	40.7	51.8	54.6	55.9	2.4	4.0	2.8	2.6	4.7	
Lithuania	29.3	32.5	46.6	46.5	45.6	0.6	3.8	3.6	4.3	4.3	
Luxembourg	3.6	4.7	7.3	7.8	8.8	0.1	2.1	5.9	6.4	6.5	
Malta	1.0	7.3	16.9	19.6	23.4	0	0	5.3	6.8	8.0	
Netherlands	2.4	3.1	5.2	5.7	6.1	0.5	3.3	4.9	6.0	9.6	
Poland	10.2	11.7	14.7	14.6	14.8	1.6	6.6	3.9	4.2	5.6	
Portugal	32.1	33.9	41.6	41.0	41.2	0.5	5.5	7.6	7.9	9.0	
Romania	17.9	27.2	26.9	26.6	25.4	1.9	1.4	6.2	6.6	6.3	
Slovakia	5.0	7.9	9.9	9.8	10.6	1.6	5.2	7.7	6.9	7.0	
Slovenia	18.9	28.1	34.0	33.2	31.6	0.8	3.1	1.6	2.6	5.5	
Spain	9.4	12.6	17.2	17.6	17.5	1.3	5.0	5.2	5.8	6.9	
Sweden	50.7	59.1	65.5	65.8	65.4	6.6	9.6	26.6	26.8	29.7	
United Kingdom	0.8	3.2	6.7	6.9	7.5	0.5	3.3	5.0	4.8	6.5	
EU-28	11.1	15.5	19.1	19.5	19.7	1.8	5.2	6.9	7.1	8.0	

For more information on the method used to calculate these shares, see the "Information on methodology" section.

Source: Eurostat (SHARES) [44]

Estimate of the shares of renewable energy in Germany in 2018 according to Directive 2009/28/EC

Initial estimates and calculations indicate that in Germany renewable energy made up 17.1% of gross final energy consumption in 2019, based on the calculation method set out in EU Directive 2009/28/EC. This signifies a year-on-year rise of 0.6 percentage points (2018: 16.5%). In view of the current share of gross final energy consumption covered by renewable energy, Germany is on the final straight towards attaining the 18% target set by the Directive for 2020.

Figure 45: Shares of renewable energy in total gross final energy consumption (GFEC) and in electricity, heat and transport in Germany

	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019[1]
						(%)					
RES share in GFEC electricity	10.6	18.3	21.0	23.6	25.3	28.2	30.9	32.3	34.6	38.0	
RES share in GFEC heating/cooling	7.7	12.1	12.6	13.4	13.4	13.4	13.4	13.0	13.4	13.6	
RES share in GFEC transport	4.0	6.4	6.5	7.3	7.3	6.9	6.6	7.0	7.0	7.9	
RES share in total GFEC	**7.2**	**11.7**	**12.5**	**13.6**	**13.8**	**14.4**	**14.9**	**14.9**	**15.5**	**16.5**	**17.1**

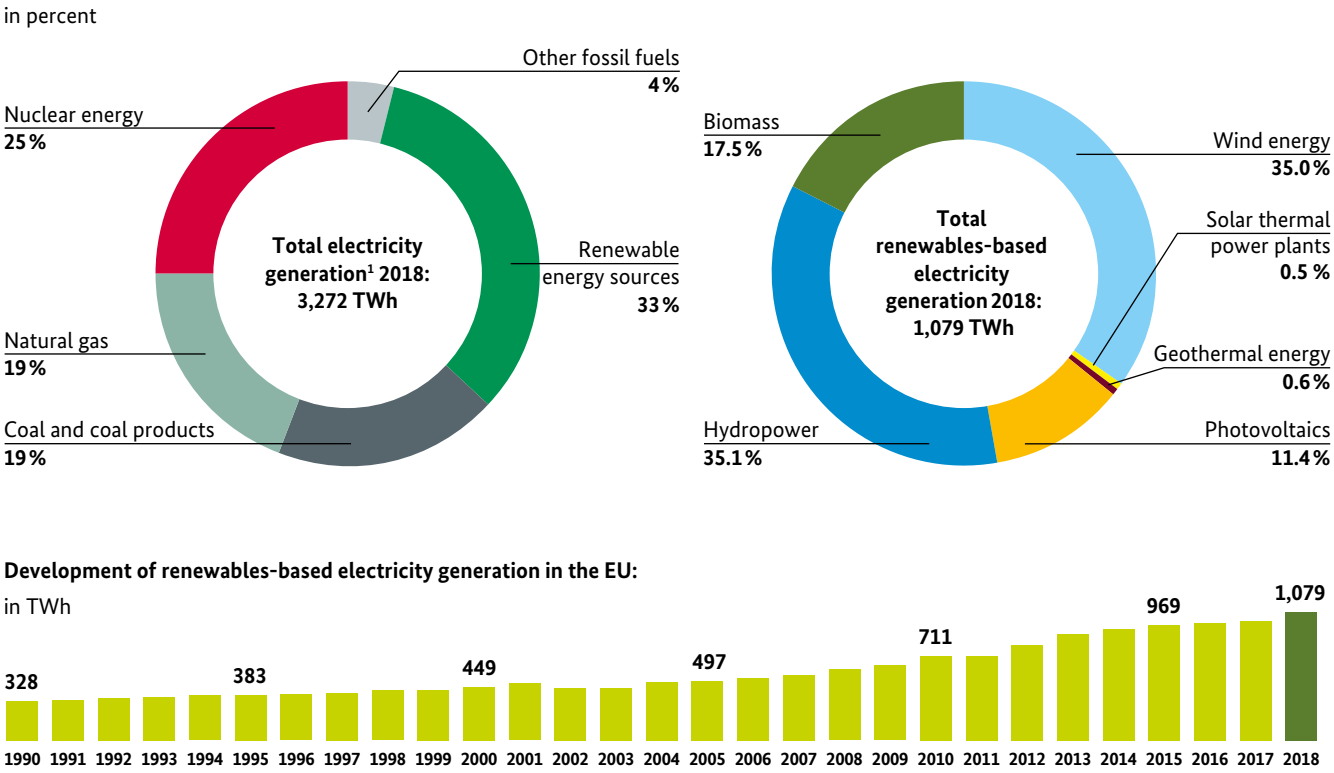
1 This overview is based on currently available statistics. At the time of the editorial deadline, the figure for the RES share of total gross final energy consumption was provisional for 2019.

Source: Eurostat (SHARES) [44]

Renewables-based electricity generation in the EU

In 2005, the share of total EU electricity consumption covered by renewables was only just under 15% [44]. The National Action Plans which the Member States were required to present under Directive 2009/28/EC were however already clearly oriented to an expansion of renewable energy in the electricity sector. In total, they envisaged a doubling of the share of gross electricity consumption covered by renewable energy in the EU by 2020 (from 2005).

Figure 46: Electricity generation in the EU, 2018



Other fossil fuels = industrial waste, non-renewable municipal waste, pumped storage, etc.
Because of its very small share, marine energy is not shown.
1 Does not include net imports

Source: Eurostat [46]

In 2018, this target had already been exceeded by quite some way, since the expansion of renewable energy has made faster progress in the electricity sector than in the heating and transport sectors. For example, in 2018 a total exceeding 1,079 billion kilowatt-hours of electricity was generated in the EU-28 from all renewable sources (2005: 497 billion kilowatt-hours), corresponding to a share of more than 32.7% of gross electricity consumption.

Back in 2005, more than two thirds of green electricity came from hydropower. In 2018, wind energy and hydropower both accounted for roughly equal shares of 35%. Behind them came biomass (over 17%) and PV (over 11%).

Figure 47: Electricity generation from renewable energy sources in the EU

	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019[4]
	(TWh)										
Biomass[1]	70.1	123.7	132.4	147.5	157.0	166.9	177.8	179.8	183.7	188.4	
Hydropower[2]	348.4	408.0	341.4	367.8	404.3	407.4	372.3	381.1	331.2	378.6	
Wind energy	71.0	150.1	181.3	207.3	237.9	254.3	303.5	304.0	361.9	377.4	426.0
Geothermal energy	5.4	5.6	5.9	5.8	6.0	6.3	6.6	6.7	6.7	6.7	
Photovoltaics	1.5	22.5	45.6	67.8	81.3	92.8	102.8	105.9	113.5	123.0	131.8
Solar thermal energy	0.0	0.8	2.0	3.8	4.8	5.5	5.6	5.6	5.9	4.9	
Ocean energy	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	
RE total	496.9	711.2	709.1	800.5	891.7	933.6	969.1	983.5	1,003.5	1,079.4	
RE share of gross electricity consumption[3]	**14.9%**	**21.1%**	**21.4%**	**24.1%**	**27.1%**	**22.2%**	**29.8%**	**30.0%**	**30.4%**	**32.7%**	
	(TWh)										
EU-gross final electricity generation	3,316.0	3,362.3	3,305.3	3,298.1	3,274.4	3,194.5	3,240.4	3,261.4	3,292.0	3,272.2	
Import	335.1	298.7	329.8	363.2	349.6	386.9	410.6	382.5	384.7	393.7	
Export	319.4	291.1	322.6	344.6	337.0	371.4	396.2	364.2	374.5	365.8	

1 Including biogas, sewage gas and landfill gas, liquid and solid biogenic fuels and the renewable share of municipal waste

2 In the case of pumped storage power plants, power generation from natural inflow only

3 Gross electricity consumption = gross electricity generation plus imports minus exports; not calculated using rules in EU Directive

4 This overview is based on currently available statistics (up to 2018 EUROSTAT, 2019 EurObserv'ER – data available for wind energy and photovoltaics).

1 TWh = 1 billion kilowatt-hours

Source: Eurostat [46]; EurObserv'ER [47], [48]

The largest share of electricity consumption covered by renewable energy was seen in Austria in 2018, at 73.1%, followed by Sweden with 66.2% and Denmark with 62.4%. Latvia (53.5%) and Portugal (52.2%) came in fourth and fifth places. The lowest shares were registered by Malta (just under 7.7%), Hungary (8.3%), Luxembourg (9.1%) and Cyprus (9.4%).

In the course of the current expansion of renewable energy, installed renewable capacity is rising more quickly than electricity generation. This is because the large amount of new wind and, especially, solar capacity have fewer hours of full capacity than hydropower, which dominated the stock of renewables-based electricity generation capacity until a few years ago. Installed renewable capacity rose from 176 gigawatts in 2005 to 467 gigawatts at the end of 2018. Back in 2005, hydropower dominated, with two thirds of installed capacity. In 2018, most installed capacity (38%) took the form of wind energy (more than 38%), followed by hydropower (28%) and PV (just under 25%).

Figure 48: Electricity generation from renewable energy sources in the EU, 2018

	Hydro-power[1]	Wind energy	Solid biomass[2]	Biogas[3]	Liquid biogenic fuels	Photovol-taics	Solar thermal power plants	Geo-thermal energy	Ocean energy	Total
	(TWh)									
Austria	41.2	6.0	4.3	0.6	< 0.1	1.4	-	< 0.1	-	53.6
Belgium	1.3	7.5	4.5	0.9	< 0.1	3.9	-	-	-	18.2
Bulgaria	5.4	1.3	1.3	0.2	-	1.3	-	-	-	9.6
Croatia	7.8	1.3	0.3	0.4	-	< 0.1	-	< 0.1	-	9.9
Cyprus	-	0.2	-	0.1	-	0.2	-	-	-	0.5
Czech Republic	2.7	0.6	2.2	2.6	-	2.4	-	-	-	10.5
Denmark	< 0.1	13.9	5.3	0.6	< 0.1	1.0	-	-	-	20.8
Estonia	< 0.1	0.6	1.3	< 0.1	-	< 0.1	-	-	-	2.0
Finland	13.3	5.8	12.5	0.4	< 0.1	< 0.1	-	-	-	32.1
France	70.6	28.6	6.0	2.4	< 0.1	10.6	-	0.1	0.5	118.7
Germany	24.1	110.0	17.0	33.4	0.5	45.8	-	0.2	-	230.9
Greece	5.8	6.3	< 0.1	0.3	-	3.8	-	-	-	16.2
Hungary	0.2	0.6	2.0	0.3	-	0.6	-	< 0.1	-	3.8
Ireland	0.9	8.6	0.7	0.2	-	< 0.1	-	-	-	10.4
Italy	50.5	17.7	6.6	8.3	4.3	22.7	-	6.1	-	116.1
Latvia	2.4	0.1	0.6	0.4	< 0.1	< 0.1	-	-	-	3.5
Lithuania	1.0	1.1	0.4	0.1	-	< 0.1	-	-	-	2.7
Luxembourg	1.3	0.3	0.1	0.1	-	0.1	-	-	-	1.9
Malta	-	< 0.1	-	< 0.1	-	0.2	-	-	-	0.2
Netherlands	0.1	10.6	3.7	0.9	-	3.7	-	-	-	18.9
Poland	2.4	12.8	5.4	1.1	< 0.1	0.3	-	-	-	22.0
Portugal	13.6	12.6	2.9	0.3	-	1.0	-	0.2	-	30.6
Romania	18.1	6.3	0.4	0.1	-	1.8	-	-	-	26.6
Slovakia	3.9	< 0.1	1.1	0.5	-	0.6	-	-	-	6.1
Slovenia	4.9	< 0.1	0.1	0.1	< 0.1	0.3	-	-	-	5.4
Spain	36.8	50.9	5.0	0.9	< 0.1	7.9	4.9	-	-	106.4
Sweden	62.3	16.6	11.9	< 0.1	< 0.1	0.4	-	-	-	91.2
United Kingdom	8.0	56.9	27.2	5.7	-	12.9	-	-	< 0.1	110.6
EU-28	**378.6**	**377.4**	**122.4**	**61.0**	**4.9**	**123.0**	**4.9**	**6.7**	**0.5**	**1079.4**

This overview is based on currently available statistics (see source). The data may differ from national statistics due to different methodologies used or other factors. All data are provisional; discrepancies in the totals due to rounding.

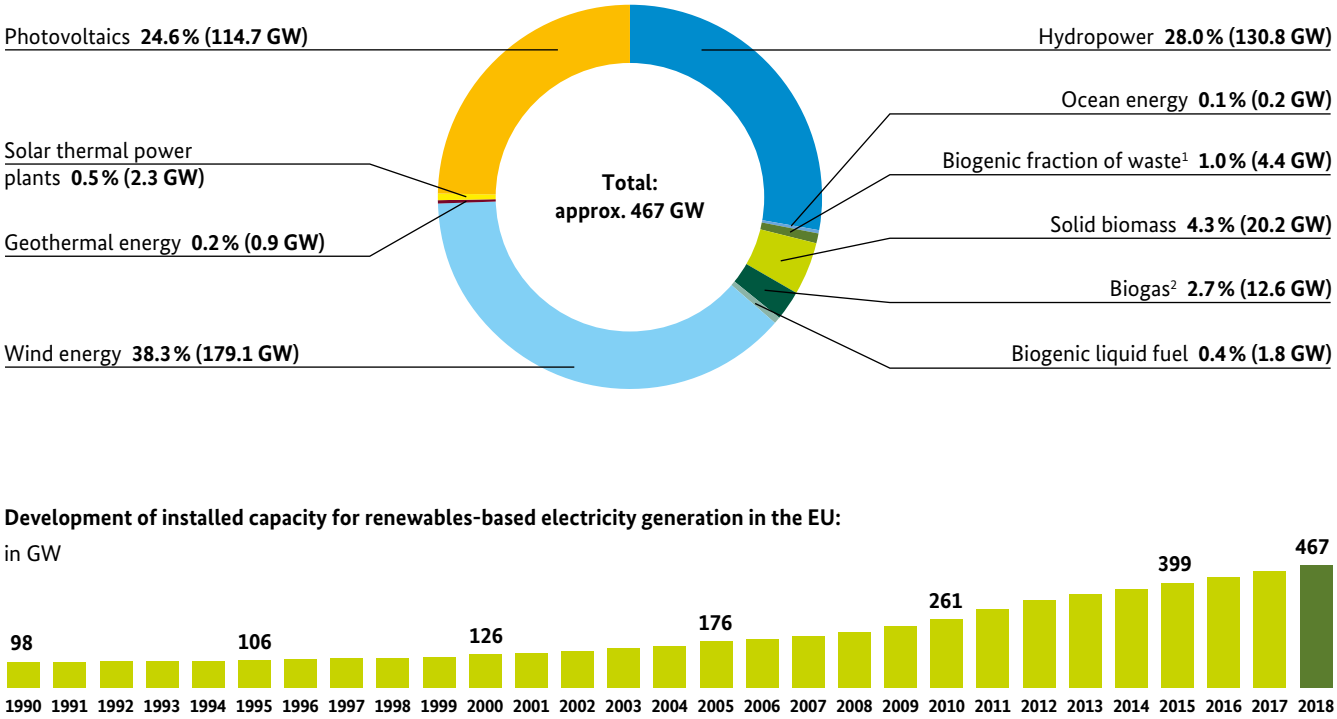
1 In the case of pumped storage power plants, power generation from natural inflow only

2 Including the biogenic share of municipal waste

3 Including sewage and landfill gas

Source: Eurostat [46]

Figure 49: Total installed renewables-based electricity generation capacity in the EU, 2018



If the annual yield of a production plant is divided by its rated capacity, you get the number of hours that the same production plant would theoretically have to be operated at full output to achieve their annual energy yield on the balance sheet.
1 Biogenic share of waste in waste incineration plants estimated at 50%
2 Including landfill gas and sewage gas

Source: Eurostat [49]

Wind energy use

Following a comparatively weak 2018, the EU-wide expansion of wind energy picked up a fair degree of speed again in 2019. According to the European Wind Energy Association (EWEA) [50] net expansion of (onshore and offshore) capacity, at 13.2 gigawatts, was more than a quarter up on the previous year. The United Kingdom ranked first, with 2.4 gigawatts, followed by Spain with over 2.3 gigawatts. Germany only came third, with just under 2.2 gigawatts or 17% of total newbuild (2018: rank 1). Fourth and fifth were Sweden with 1.6 gigawatts and France with 1.3 gigawatts. Most of the newbuild in both the United Kingdom and Germany took the form of offshore wind capacity.

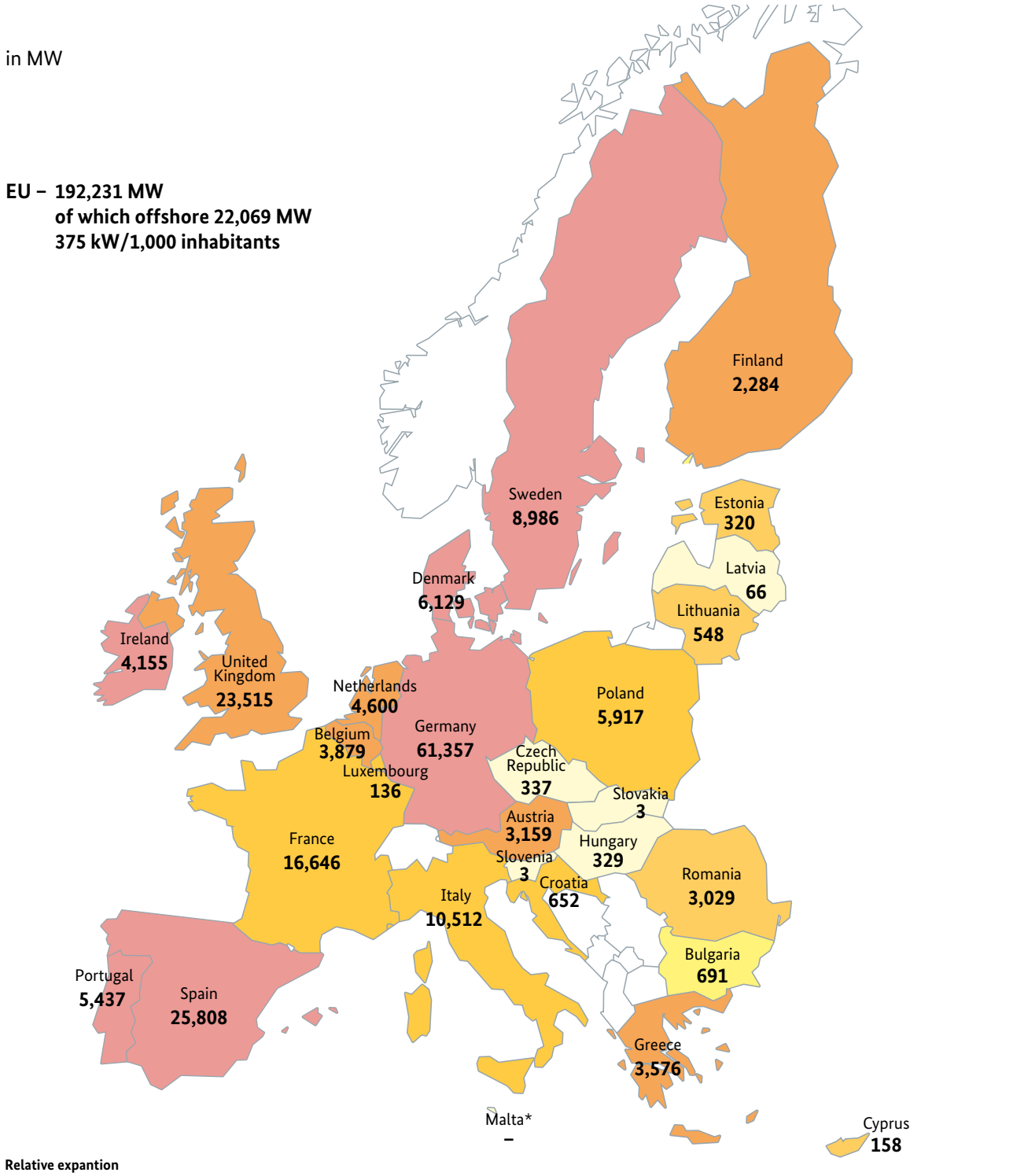
Overall, the EU-28 had 192.2 gigawatts of installed wind energy capacity at the end of 2019. Germany again led the field, with 32%. It was followed by Spain with 13%, the United Kingdom with 12% and France with 9% of EU wind energy capacity.

If the total installed wind energy capacity of the various Member States is considered in per-capita terms, a different picture emerges: at the end of 2019, the EU average stood at 375 kilowatts per 1,000 inhabitants. This time, the country rankings were again headed by Denmark with 1,060 kilowatts per 1,000 inhabitants, just ahead of Sweden (888 kW) and Ireland (860 kW). Germany came in fourth, with 741 kilowatts per 1,000 inhabitants.

If one only considers installed offshore wind energy capacity, the newbuild also rose appreciably in the EU-28 in year-on-year terms, by 36% to 3,627 megawatts (2018: 2,661 megawatts). The highest amounts of newbuild were in the United

Kingdom, with 1,764 megawatts, and Germany with 1,111 megawatts. Denmark (374 megawatts) and Belgium (370 megawatts) also expanded their offshore capacity. This means that nearly 22.1 gigawatts of wind energy capacity was installed in EU-28 waters at the end of 2019. The largest shares of this were in the United Kingdom (48.6%) and Germany (30.6%). The next largest shares were in Denmark (10.3%) and Belgium (10.2%).

Figure 50: Total installed wind energy capacity in the EU at the end of 2019

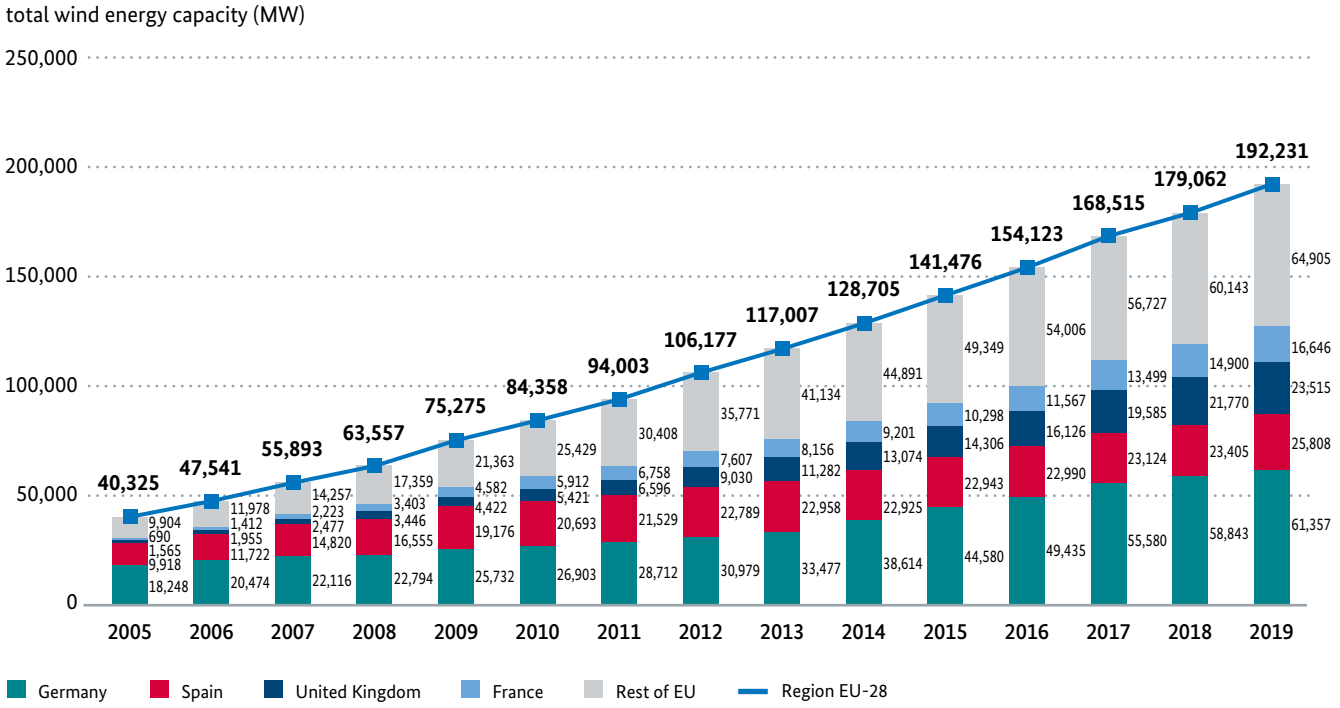


Source: EWEA [50]

All the EU-28's wind energy installations combined generated close to 426 billion kilowatt-hours of electricity in 2019, which translates to an increase of approximately 13% on the previous year (2018: 377 billion kilowatt-hours [47]).

The largest volumes of electricity were generated in Germany (126 billion kilowatt-hours), the United Kingdom (63.5 billion kilowatt-hours) and Spain (more than 54 billion kilowatt-hours).

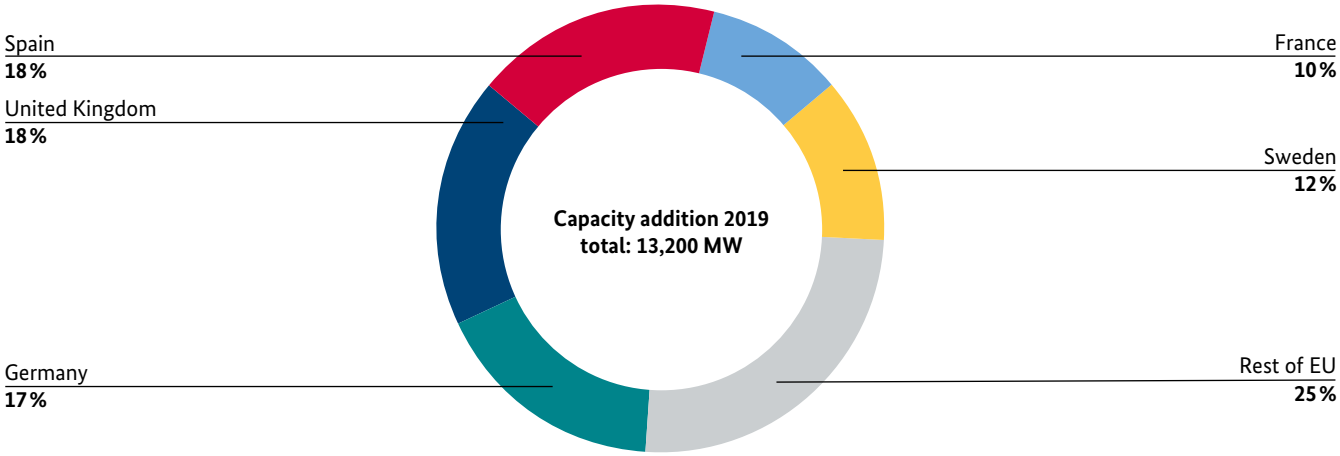
Figure 51: Development of total wind energy output (on land and at sea) in the EU member states



Total wind capacity in 2019 is not exactly equal to the sum of installed capacity at the end of 2018 plus newbuild in 2019; this is due to the repowering and decommissioning of existing wind energy installations and the rounding of data.

Source: Eurostat [49]; EWEA [50]

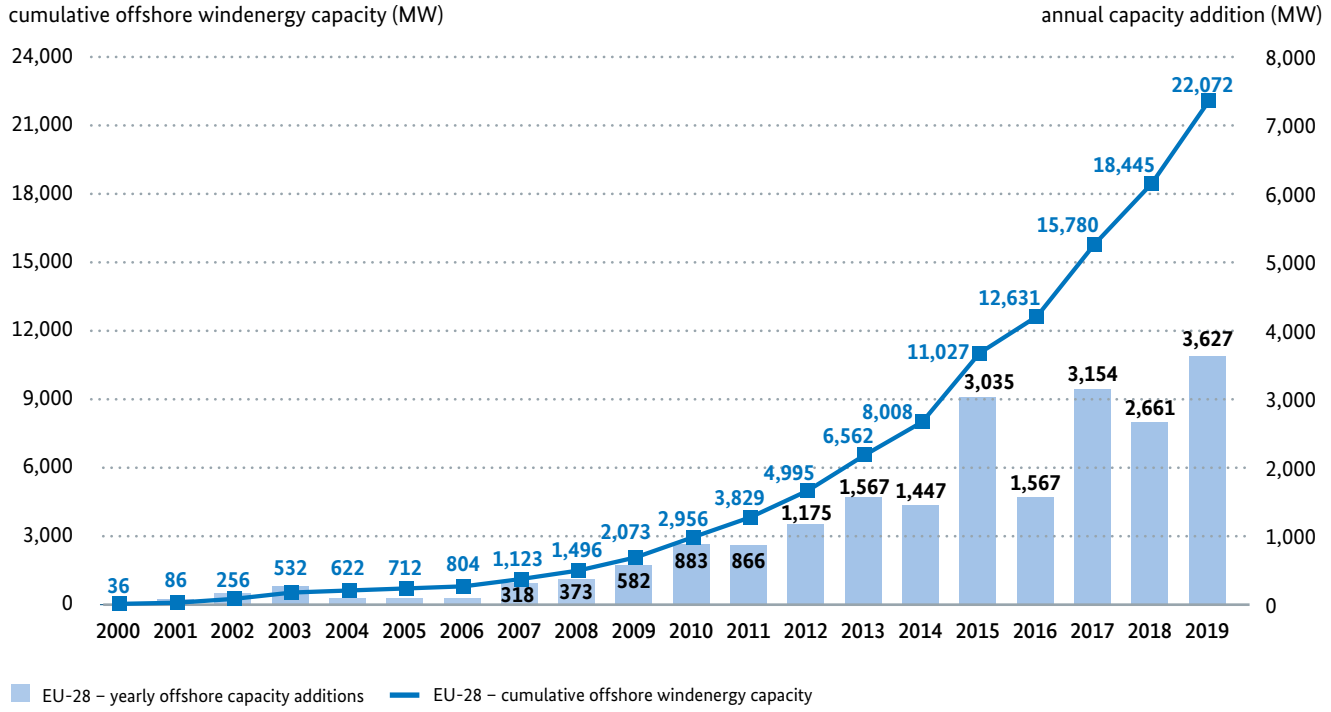
Figure 52: Expansion of wind energy capacity (on- and offshore) in the EU Member States, 2019



Total wind capacity in 2019 is not exactly equal to the sum of installed capacity at the end of 2018 plus newbuild in 2019; this is due to the repowering and decommissioning of existing wind energy installations and the rounding of data.

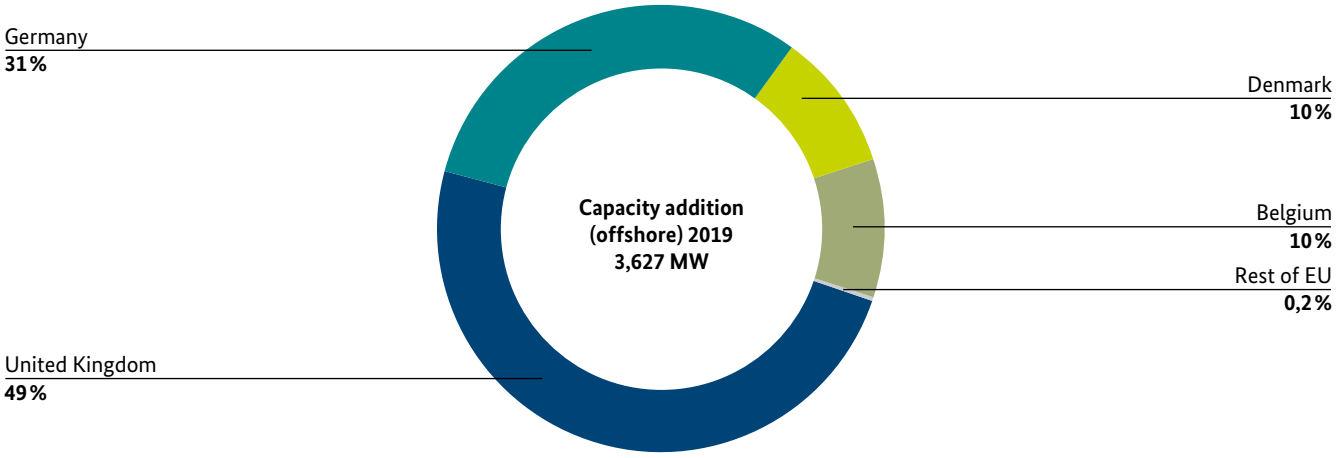
Source: EWEA "Offshore" [51]

Figure 53: Expansion and cumulative installed offshore wind capacity



Source: EWEA "Offshore" [51]

Figure 54: Expansion of offshore wind energy capacity held by individual countries, 2019



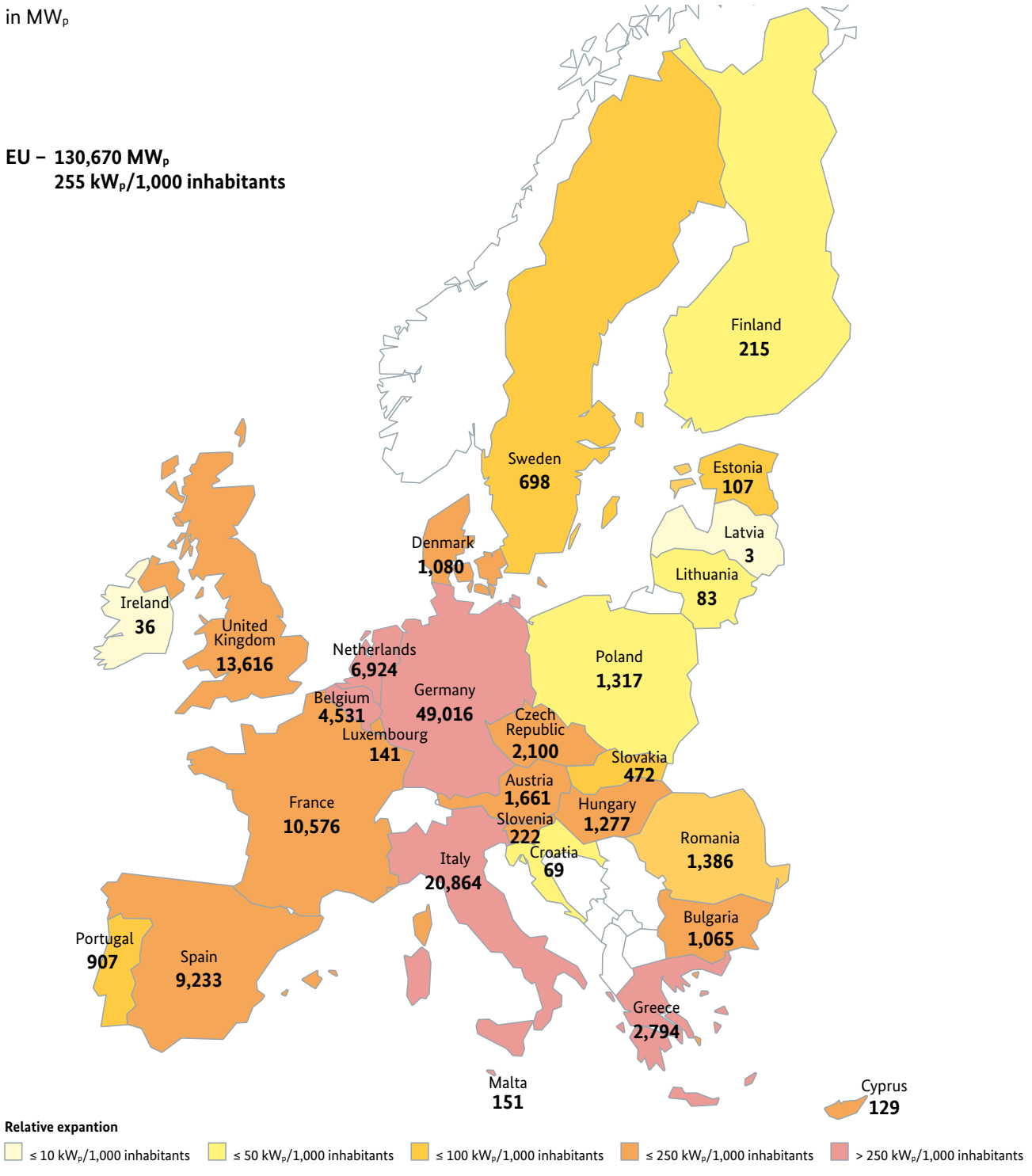
Source: EWEA "Offshore" [51]

Solar energy use – electricity generation

Whilst the European photovoltaics market had already clearly picked up speed in the preceding year, following a weak period, it saw another strong rise in 2019 in year-on-year terms, by more than 80% with newly installed capacity of nearly 15.6 gigawatts (2018: 8.5 gigawatts) [48]. The upward trend was driven not only by the German market, but in particular, for the first time in many years, by a very clear rise in installations in Spain.

In 2019, the largest number of PV installations were built in Spain (3.99 gigawatts) and Germany (3.86 gigawatts). The Netherlands ranked third, with 2.4 gigawatts, followed at some distance by France with 0.97 gigawatts, Italy and Poland with 0.76 gigawatts each, and Hungary with 0.65 gigawatts.

Figure 55: Total installed photovoltaics capacity in the EU, 2019



Source: EurObserv'ER "Photovoltaic Barometer" [48]

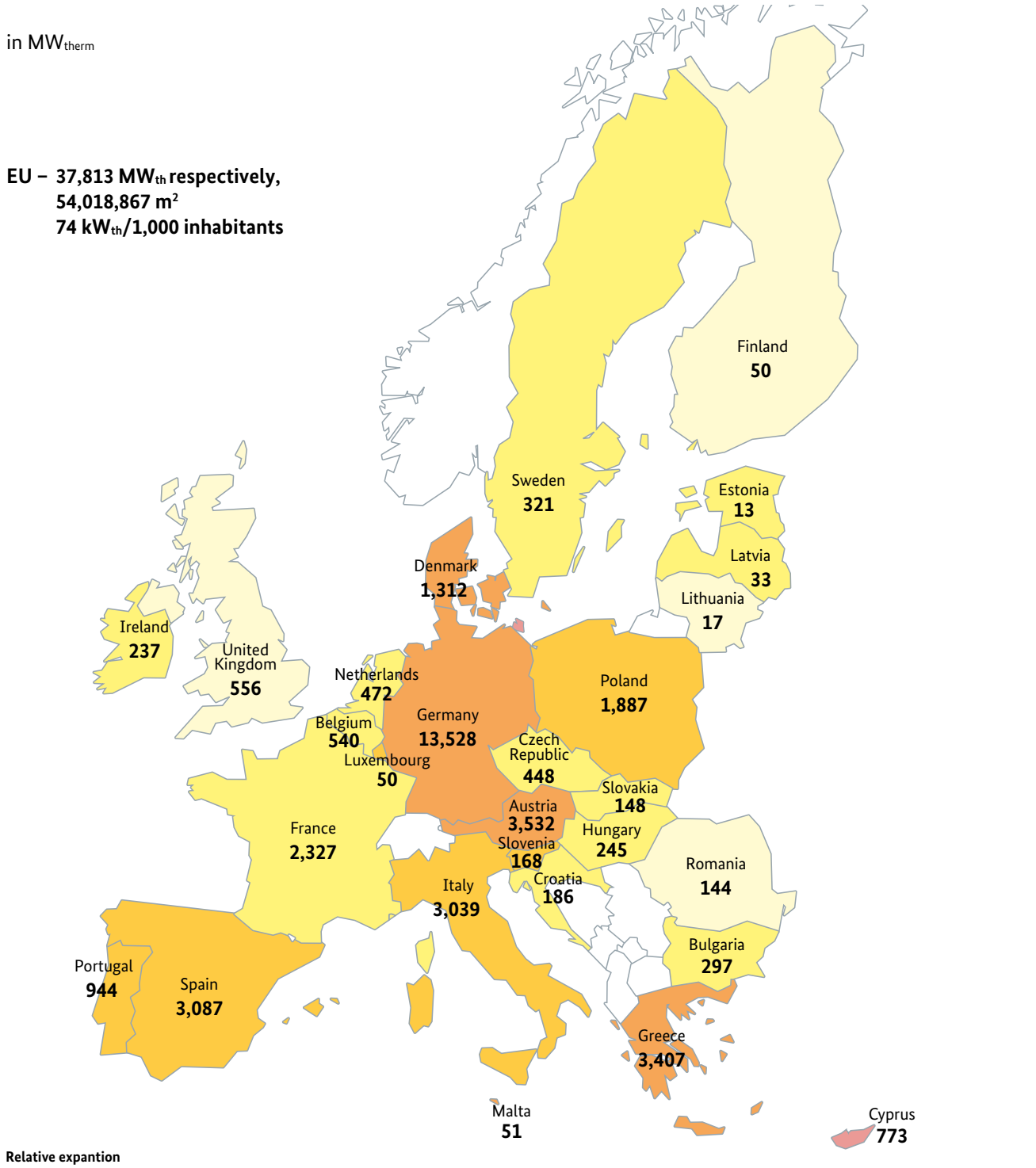
This means that, at the end of 2019, almost 130.7 gigawatts of photovoltaic capacity were installed in the EU-28. As before, the largest share of this – 37.5% – was located in Germany. It was followed by Italy (16%), the United Kingdom (10%), France (8%) and Spain (7%). Going by installed capacity per 1,000 inhabitants, the EU figure stood at over 255 kilowatts. Once again, Germany was in the lead, with 592 kilowatts. It was followed by the Netherlands with 403 kilowatts, with Belgium closely behind at 397 kilowatts.

The newbuild of capacity also resulted in a year-on-year rise in electricity generation from pho-

tovoltaic installations in the EU-28 of more than 7% to 131.8 billion kilowatt-hours (2018: 122.9 billion kilowatt-hours).

Solar thermal power installations are also used in the EU to generate electricity using solar energy. However, they are only viable in southern European regions with high numbers of hours of sunshine. At times, the funding available in Spain for such power stations was particularly attractive. As a result, the country became a leader in solar thermal electricity generation, not only in the

Figure 56: Total installed solar thermal capacity in the EU, 2019



Source: EurObserv'ER "Solar Thermal Barometer" [52]

EU, but worldwide. As a result, almost all of solar thermal capacity installed in the EU – amounting to roughly 2,300 megawatts – is located in Spain. At roughly 5 billion kilowatt-hours of electricity, these installations cover around 2% of Spanish electricity consumption each year [48]. No further newbuild has taken place since 2013 due to a lack of funding.

Solar energy use – heat supply

According to the EurObserv'ER Solar Thermal Barometer [52], the pan-EU solar thermal market followed almost ten years of decline with a clear expansion in 2018, and was just able to maintain this development in 2019. 2.28 million square meters of new solar collector surface area was installed in the EU, corresponding to a thermal capacity of nearly 1.6 gigawatts; this was 1.5% more than in 2018 (2.24 million square meters). At the end of 2019, the EU-28 had a total installed collector surface area of just under 54 million square meters, corresponding to a thermal capacity of 37.8 gigawatts.

Even though, in contrast to the EU-wide trend, the solar thermal market shrank further in Germany, with 511,000 square meters of new glazed collector surface area, Germany continued to be the biggest market in Europe. Greece made significant progress in second place, with 361,500 square metres. As in the preceding year, Poland came third with newly installed collectors covering an area of 263,000 square metres in 2019. It was followed by Spain with just over 204,000 square metres, and Denmark in fifth place, where 2.7 times more – more than 194,000 square metres – was installed than in the preceding year. This made the Danish market the largest driving force behind the upward trend in the European solar thermal market in 2019.

Taking the total installed collector surface area at the end of 2019, by far the largest collector surface area was installed in Germany (19.3 million square meters), followed a long way behind by Austria (5.0 million), Greece (4.9 million), Spain (4.4 million) and Italy (4.3 million). In terms of per-capita installed solar thermal capacity (see Figure 56), Cyprus continues to top the ranking, with 893 watts, ahead of Austria (399) and Greece (318).

Renewable energy sources in the transport sector

EU Directive 2009/28/EC sets a binding target for the transport sector, namely that the share of final energy consumption from renewable sources in each EU Member State must be at least 10% by 2020, taking multiple-counting options into consideration. Further to this, Directive 2018/2001 states that renewables must account for 14% of energy consumption in the transport sector by 2030. At that time, conventional biofuels may not contribute more than 7%, and "modern biofuels", produced for example from waste material, are to have attained a share of at least 3.5%. In the calculation of the share, the latter can be imputed at twice the amount of their energy content; the use of renewables-based electricity can be imputed at four times the amount.

Following a period of decline in the use of biofuels, related particularly to questions about sustainability aspects, their sales have been rising again in the EU since 2017. This trend continued in 2019: at close to 22.5 million tonnes, more than 4% more biofuels were sold than in the preceding year (2018: 21.6 million tonnes); there were roughly equal rises in both biodiesel and bioethanol (see also Figure 57).

Regional sales of electric vehicles (including plug-in hybrids) rose by around 70% in 2019 in Europe, to roughly 550,000 vehicles. The largest number of new registrations of electric vehicles was seen in Germany (around 108,630), followed by Norway (around 81,500) and the United Kingdom (around 72,500). France ranked fourth, with around 69,500, and the Netherlands was not far behind at around 68,000 vehicles. Sales in the EU amount to around 7% of the global market for electric vehicles [53].

Figure 57 shows the consumption of biofuels in the EU in 2018 and 2019 (provisional figures from Eurostat).

Further information about biofuels in Europe can be found on the EurObserv'ER website [54] at www.eurobserv-er.org/category/all-biofuels-barometers/.

Figure 57: Consumption of biofuels in the EU Member States in 2018 and 2019

	2018				2019[1]			
	Bioethanol	Biodiesel	Other biofuels	Total	Bioethanol	Biodiesel	Other biofuels	Total
	kilotons (kt)				kilotons (kt)			
Austria	101.5	249.5	0.7	351.6	103.7	273.6	0.3	377.6
Belgium	160.2	410.7	20.8	591.7	182.5	396.5	21.5	600.5
Bulgaria	44.3	156.8	-	201.1	49.3	169.6	-	219.0
Croatia	-	27.8	-	27.8	0.6	26.1	-	26.6
Cyprus	-	3.5	-	3.5	-	3.8	-	3.8
Czech Republic	121.1	229.4	-	350.5	141.2	238.7	-	379.9
Denmark	69.1	193.0	6.3	268.3	51.0	267.6	7.0	325.6
Estonia	-	-	-	-	-	-	-	-
Finland	135.4	275.8	45.5	456.6	141.9	331.2	40.7	513.8
France	856.5	3,117.4	8.5	3,982.4	972.6	3,087.9	8.5	4,069.0
Germany	1,205.0	2,404.0	192.0	3,801.0	1,143.0	2,439.0	185.0	3,767.0
Greece	-	196.5	-	196.5	41.0	200.0	-	241.0
Hungary	73.0	128.0	-	201.0	73.0	131.0	-	204.0
Ireland	27.3	49.1	-	76.4	26.5	87.5	-	113.9
Italy	38.2	1,380.1	954.1	2,372.5	35.4	1,412.2	987.1	2,434.7
Latvia	13.2	33.3	-	46.5	11.4	27.4	-	38.8
Lithuania	20.6	91.5	-	112.1	23.6	89.4	-	113.0
Luxembourg	-	-	0.02	0.02	-	-	0.02	0.02
Malta	-	10.4	-	10.4	-	10.8	-	10.8
Netherlands	272.5	685.8	61.0	1,019.3	344.8	655.3	56.7	1,056.7
Poland	243.3	792.2	2.2	1,037.7	257.9	895.7	2.3	1,155.9
Portugal	7.0	300.8	-	307.8	6.4	303.0	-	309.4
Romania	141.3	235.1	-	376.4	142.0	235.0	-	377.0
Slovakia	58.0	153.0	-	211.0	56.0	152.0	-	208.0
Slovenia	-	75.9	-	75.9	-	75.0	-	75.0
Spain	240.7	1,725.1	3.3	1,969.0	203.5	1,701.7	3.4	1,908.7
Sweden	284.0	1,535.0	90.0	1,909.0	313.0	1,537.0	63.0	1,913.0
United Kingdom	594.3	1,013.7	-	1,608.0	598.1	1,422.3	-	2,020.4
Region EU-28	**4,706.4**	**15,473.4**	**1,384.3**	**21,564.1**	**4,918.5**	**16,169.2**	**1,375.4**	**22,463.1**

1 preliminary data

Source: Eurostat Energy Balances "Early estimates 2019" [55]

Part III: Global use of renewable energy sources

The contribution made by renewable energy to the world's energy supply is growing. However, global demand for energy is also rising, and if this is to be covered in a sustainable manner and the targets agreed in the Paris climate accord are to be achieved, the pace at which renewable energy is being developed and used must be substantially stepped up around the world.

For example, at the beginning of 2019 the International Renewable Energy Agency (IRENA) sketched out in its latest roadmap (up to 2050) [56] that a renewables-based expansion of electrification can rapidly and substantially reduce energy-related carbon emissions. In this way, the significance of electricity as a deliverer of energy is increasing significantly. In the IRENA scenario, it increases its share of global final energy consumption from 20% today to nearly 50% in 2050. This would represent a doubling of total electricity consumption, but 86% of it could be covered by renewable energy. For this to take place, however, there needs to be a significant expansion in capacity: in the case of power generation from wind energy, there would need to be a rise from 650 gigawatts to more than 6,000 gigawatts by 2050, with a rise to 8,500 gigawatts in the case of photovoltaics (up from approximately 630 gigawatts today).

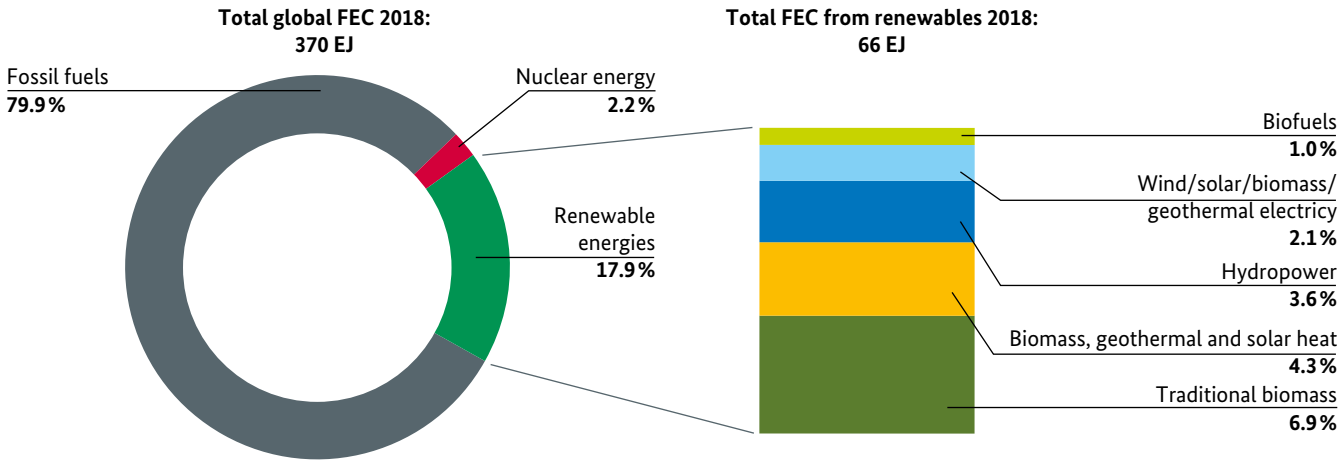
Still almost a billion people in developing countries still lack access to electricity. Renewable energy technologies, being decentralised by nature, can provide a basic electricity supply in many cases; the options range from off-grid photovoltaic systems for individual households to renewable energy installations that supply entire villages with electric power. In this way, renewable energy can improve people's standards of living. According to estimates by the IEA, around 2.7 billion people still rely on traditional biomass use for cooking, i.e. they mostly use open fires. This often leads to irreversible deforestation and entails serious health risks for the users [57].

The following data on the global deployment of renewable energy were used based on their availability at the time this document was drafted, and therefore do not yet fully reflect all developments in 2019.

According to estimates by REN21 [58], the share of renewable energy in global final energy consumption stood at 17.9% in 2018, just below the preceding year's level of 18.1%. This shows that the expansion of renewable energy is finding it difficult to keep pace with the increasing global demand for energy. Rather, there is a need for clear global increases in the rate of expansion in order to attain the necessary improvements in the share of global energy consumption covered by renewables.

In 2018, fossil energy sources covered a 79.9% share of global energy consumption, and nuclear energy covered 2.2%. It is true that there have been encouraging rates of growth in the use of modern forms of renewable energy for years, but the 17.9% still includes 6.9% (2017: 7.5%) based on traditional biomass use, which cannot be deemed sustainable. Of the 11% of final energy provided from modern renewable energy technologies, 4.3% is accounted for by biomass, geo-

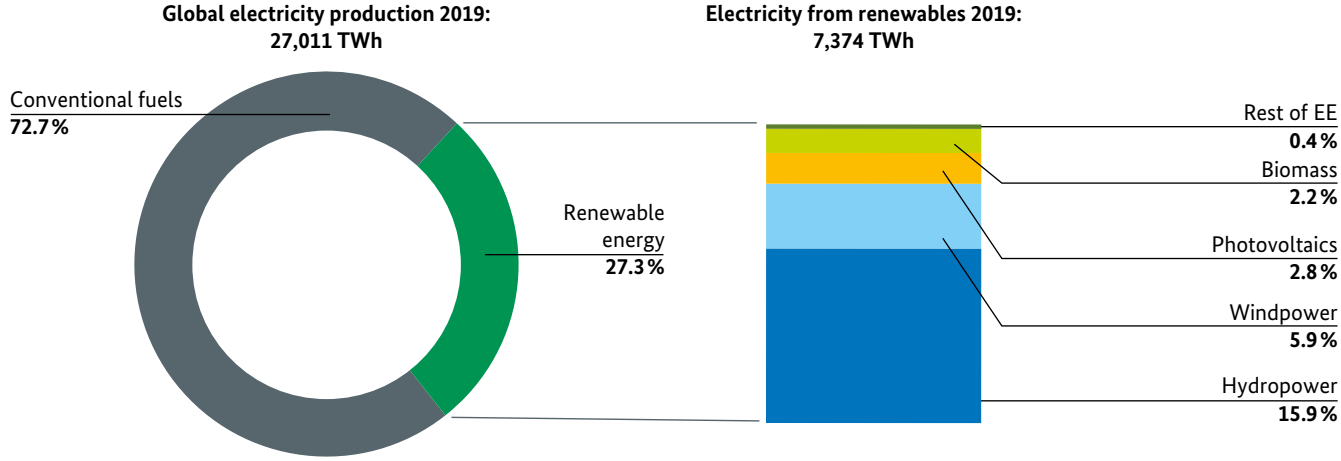
Figure 58: Distribution of global final energy consumption (FEC), 2018



1 EJ (exajoule) = 1,000 PJ (petajoules), see also the conversion factors in the Annex

Source: REN21: Renewables 2020 Global Status Report; REN21 Secretariat, Paris, 2020 [58]

Figure 59: Distribution of global electricity generation, 2019



Source: REN21: Renewables 2020 Global Status Report; REN21 Secretariat, Paris, 2020 [58]

thermal and solar heat, 3.6% by hydropower, 2.1% by electricity from wind, solar, biomass and geothermal energy, and 1% by biofuels in transport.

Electricity generation from renewable energy sources

As in Germany and across the EU, the main growth in renewable energy worldwide is taking place in the electricity sector. According to REN21 [58], 7,374 terawatt-hours of electricity from the sun, wind, water, biomass and geothermal heat were generated in 2019, more than 5% up on the previous year's level. Also, the rate of increase was more than one percentage point higher than in 2018. According to REN21, the share of renewables in total global electricity generation rose to 27.3% (2018: 26.2%).

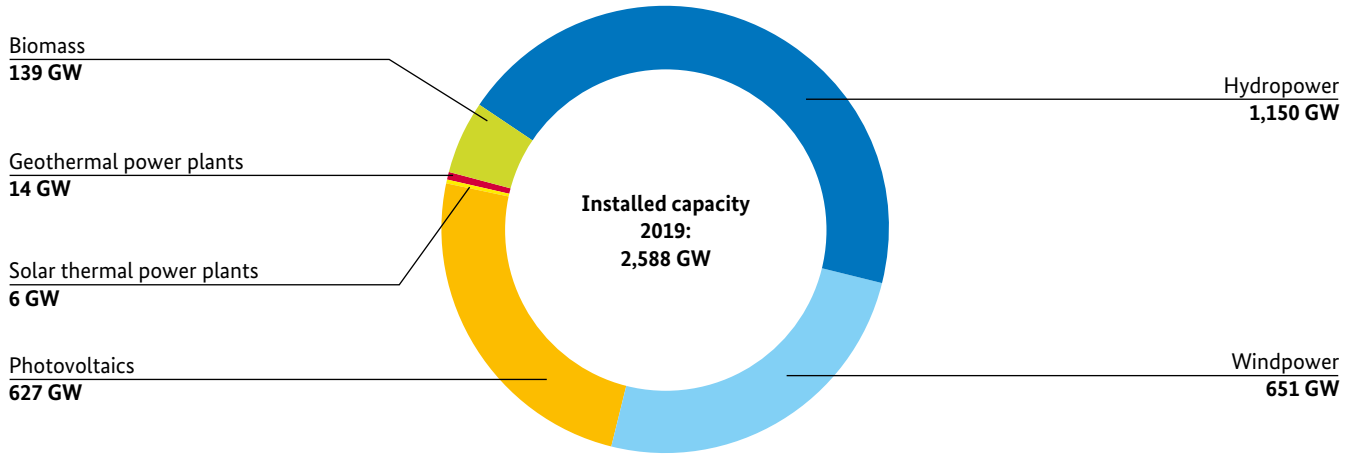
The current growth in electricity generation from renewables around the world is also based mainly on an increase in the shares of wind energy and PV, with the share of wind energy rising to 5.9% (2018: 5.5%) and that of photovoltaics increasing to 2.8% (2018: 2.4%). In contrast, the share of hydropower, which a few years ago accounted for the bulk of electricity from renewable energy, stood at 15.9%, virtually unchanged from the preceding year's level (2018: 15.8%).

A look at the global amount of newly installed capacity in the electricity sector highlights the trend towards renewable energy. A total of 201 gigawatts of power generation capacity from renewables was added around the world in 2019, 11% more than in the preceding year (2018: 181 gigawatts). Of the total new capacity in the electricity sector, 75% took the form of solar, wind, etc., compared with 64% in the preceding year. Here, photovoltaics led the way, accounting for 57%, followed by wind energy (30%). Hydropower only contributed 8% of newly installed power generation capacity based on renewables.

At the end of 2019, 651 gigawatts of wind energy capacity, 627 gigawatts of PV capacity and 139 gigawatts of biomass-based electricity generation were connected to the grid worldwide. On a smaller scale, geothermal energy contributed 13.9 gigawatts, and solar thermal power plants 6.2 gigawatts.

Including hydropower, the world's power generation capacity based on renewables therefore totalled 2,588 gigawatts at the end of 2019. According to REN21, China was well ahead of the rest of the field, with 789 gigawatts of cumulated capacity. It was followed by USA (282 gigawatts), Brazil (144 gigawatts), India (137 gigawatts) and, in fifth place, Germany with 124 gigawatts [58]. With 67 gigawatts, China also headed the rankings of the

Figure 60: Total installed power generation capacity based on renewables at the end of 2019



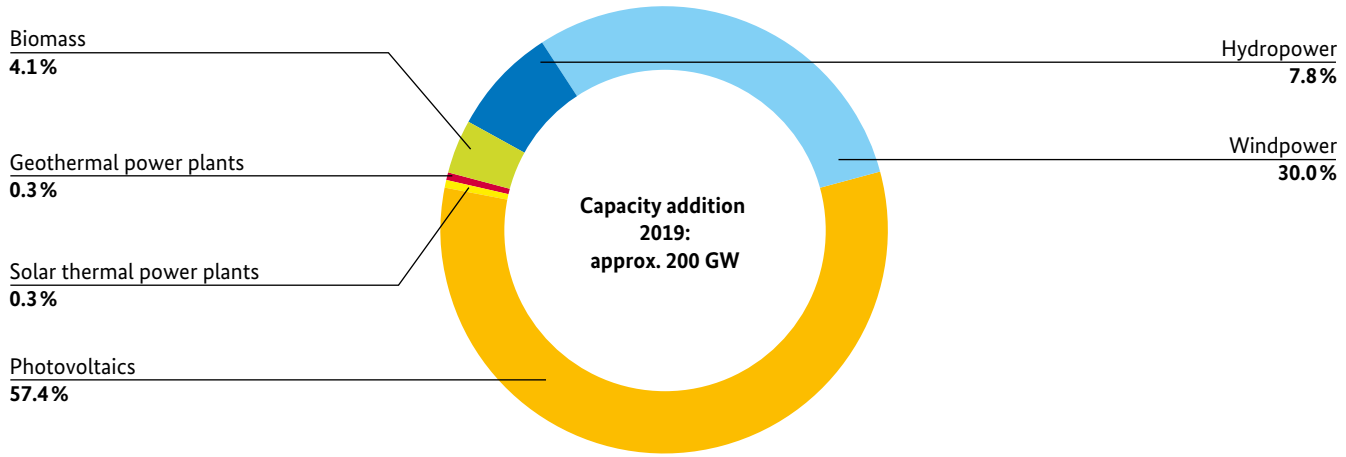
Source: REN21: Renewables 2020 Global Status Report; REN21 Secretariat, Paris, 2020 [58]

newly built installations in 2019. This was followed by newbuild in the USA (22 gigawatts), India (13 gigawatts) and Brazil and Japan (8 gigawatts each).

Standing at around 60 gigawatts (54 gigawatts onshore and 6 gigawatts offshore), the rate of expansion in the use of **wind energy** in 2019 was roughly 18% up on that of the preceding year (51 gigawatts). 26.8 gigawatts of new capacity was installed in China alone, followed by the United States with 9.1 gigawatts. A long way behind, the United Kingdom and India came next with 2.4 gigawatts each, and then Spain with 2.3 gigawatts. Of the total of 651 gigawatts of wind energy capacity installed around the world at the end of 2019, 236 gigawatts, or 36%, was located in China.

Global newbuild of **photovoltaics** rose by 12% from the preceding year's level, to 115 gigawatts in 2019. Even though the rate of expansion in China fell for the second year in succession, China was still the world leader in terms of newbuild, adding more than 30 gigawatts. The United States ranked second, with 13.3 gigawatts, followed by India with 9.9 gigawatts, Japan with 7.0 gigawatts and Vietnam with 4.8 gigawatts. Of the installed 627 gigawatts of photovoltaic capacity, nearly 205 gigawatts were located in China, 76 gigawatts in the United States, 63 in Japan, 49 in Germany and 43 in India.

Figure 61: Expansion of power generation capacity based on renewables, 2019



Source: REN21: Renewables 2020 Global Status Report; REN21 Secretariat, Paris, 2020 [58]

In 2019, total installed power generation capacity from **biomass** increased by about 8%, rising to 139 gigawatts worldwide. The majority of this capacity was added in China, the United States and Brazil. Electricity generation from **geothermal energy** rose by around 0.7 gigawatts to 13.9 gigawatts. Here, the United States and Indonesia led the field, and Turkey was the front-runner in terms of newbuild.

Renewable energy sources in the other sectors

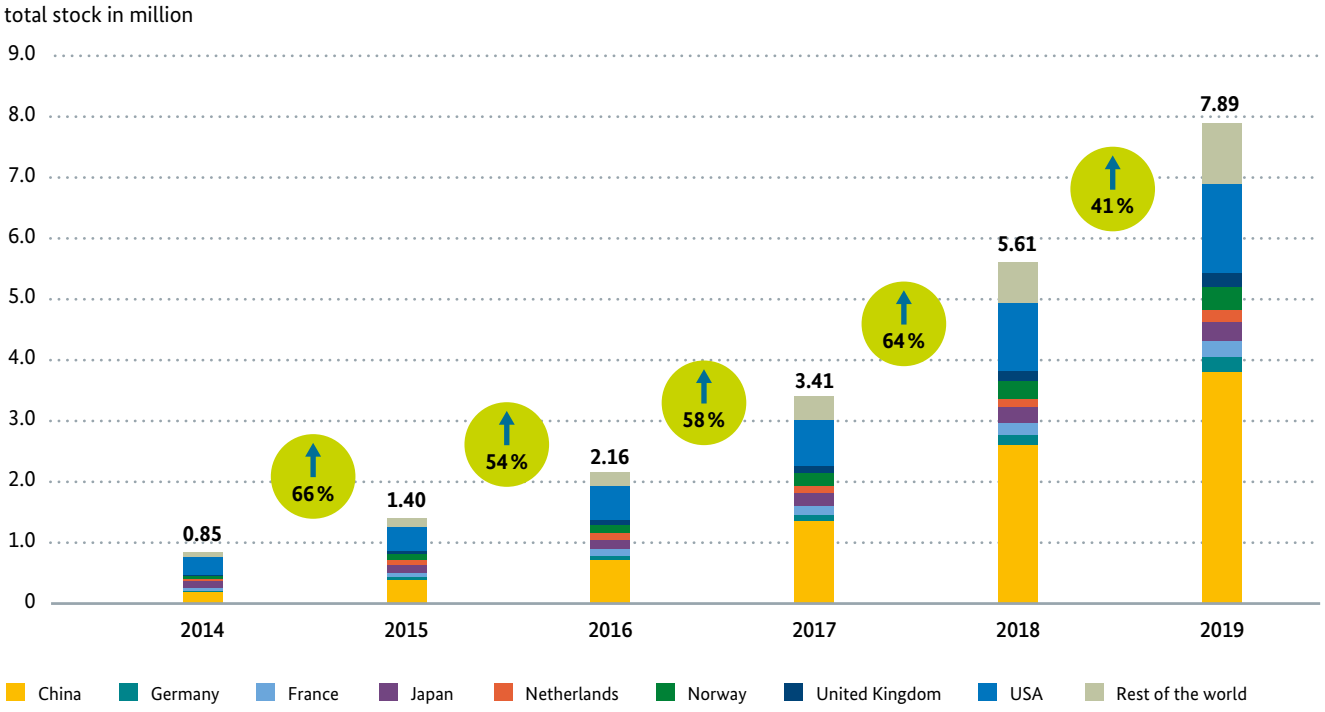
As in Germany and Europe, the rise in the proportion of renewable energy in the field of heating and refrigeration, which is responsible for over half of global energy consumption, is also much slower around the world than that seen in the electricity sector. For example, the share of modern renewable energy technologies used in the heating and cooling of buildings increased only from 8.0% to 10.1% between 2010 and 2018. In the industrial sector, renewable energy covers only 14.5% of energy requirements at present [58].

In the transport sector, which accounts for 32% of global final energy consumption, the share of renewable energy was a mere 3.3% in 2019. At 3.0%, the bulk of this took the form of biofuels, with electric mobility contributing 0.3% [58]. Electric mobility is however deemed to offer the greatest potential for future increases. The global fleet of electric vehicles rose by 41% in 2019 to 7.89 million. With 1.2 million new vehicles – a share of nearly 50% – China was the clear driving force here, followed by the United States with 330,000 new vehicles. In terms of the total fleet of electric vehicles, China (3.81 million) was also clearly ahead of the United States (1.45 million) [53].

Investments and jobs

For many years, investments in installations to use renewable energy have also been a significant economic factor worldwide. Whilst the previous year saw a clear downward trend, global investment in 2019 registered a slight increase to nearly USD 302 billion (2018: USD 296 billion). The fact

Figure 62: Global fleet of electric vehicles



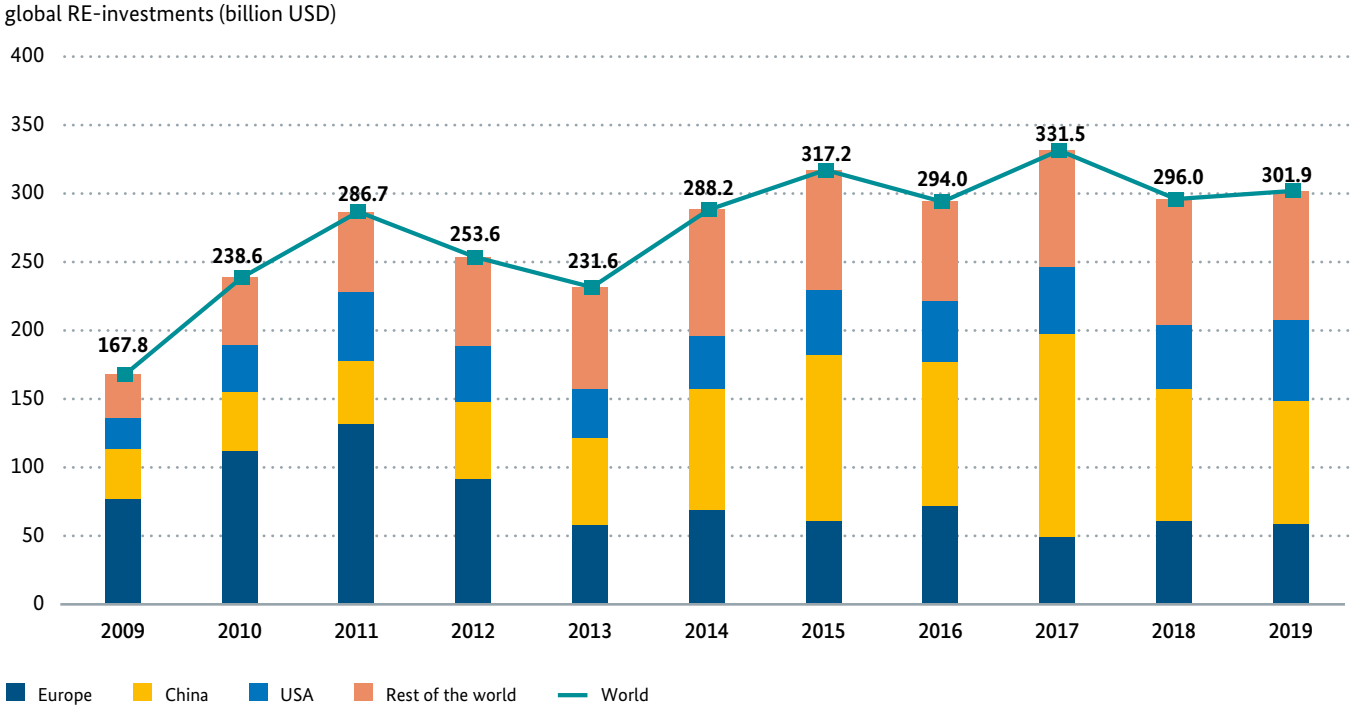
The figures cover passenger cars and light commercial vehicles with only battery-electric engines or with range extenders and plug-in hybrids.

Source: ZSW [53]

that investments rose by less than the volume of newbuild reflects significantly falling prices. Most of the investments in renewable energy took place in China (USD 90.1 billion), followed by the United States (USD 59 billion) [58].

At USD 142.7 billion, the largest proportion of the investments was made in wind energy, but photovoltaics were not far behind, at USD 141 billion. Here, wind energy registered a year-on-year increase of 8%, whilst photovoltaics saw a 2% decline, illustrating the substantial potential for cost reductions still offered by that technology. These two technologies combined accounted for some 94% of total investments in renewable energy (excluding large-scale hydropower).

Figure 63: Investments in renewable energy sources by region



Source: REN21: Renewables 2020 Global Status Report; REN21 Secretariat, Paris, 2020 [58]

Figure 64: Worldwide investments in 2018 and 2019 disaggregated by renewable energy sector

Sektor	2018	2019	Growth rate 2018/2019
	RE-investments (billion USD)		(%)
Wind energy	132.7	142.7	8
Solar energy	143.5	141.0	-2
Biofuels	3.3	3.0	-9
Biomass[1]	11.5	11.2	-3
Hydropower[2]	2.3	2.5	9
Geothermal power	2.5	1.2	-52
Ocean energy	0.2	0.2	0
Total	**296**	**302**	**2**

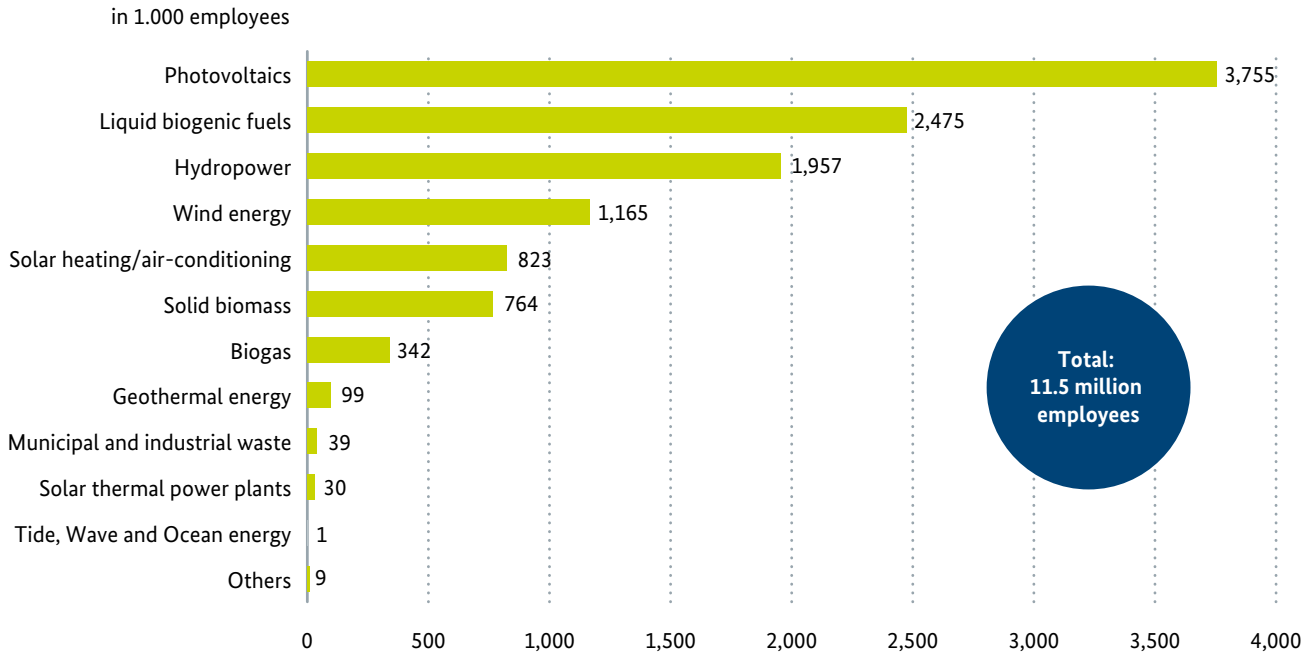
1 Including waste

2 Only hydropower plants < 10 MW

Source: REN21: Renewables 2020 Global Status Report; REN21 Secretariat, Paris, 2020 [58]

According to IRENA [59], the number of people employed in the renewables sector increased by nearly half a million people worldwide in 2019, so that almost 11.5 million people now have a job in the sector. At around 3.8 million, a good third of them worked in the photovoltaic sector, followed by the biofuels industry with just over 2.5 million. On the third and fourth place was hydropower with 2 million and wind energy with almost 1.2 million jobs.

Figure 65: Persons employed in the renewable energy sectors, 2019



Source: IRENA – Renewable Energy and Jobs – Annual Review [59]

Annex

International networks for renewable energy sources

International Renewable Energy Agency – IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation dedicated to the worldwide promotion of the growth of renewable energy. IRENA now has 161 members, with 22 states currently in the accession process. IRENA is headquartered in Abu Dhabi, United Arab Emirates. The IRENA Innovation and Technology Centre (IITC), one of its three core divisions, is based in Bonn. Since April 2019, Francesco La Camera of Italy has been the Director-General in charge of the IRENA Secretariat. IRENA currently employs around 200 people.

IRENA is the global voice of renewable energy in international debates. It is also a platform for countries to share knowledge on successful approaches to renewable energy growth, effective policies, capacity expansion, financing mechanisms and energy efficiency measures related to renewable energy. As a knowledge repository, it provides access to information on renewable energy ranging from technological expertise to economic data, opportunities, and development scenarios for renewable energy. It is also tasked with advising industrialised, developing and emerging economies on driving growth in renewable energy. IRENA is thus a centre of excellence for renewable energy.

Cooperation with other players

As an international organisation with global reach, IRENA seeks to support all relevant players in their efforts to bring about the large-scale use of renewable energy technologies around the world. Vital partners include governments, national and international institutions, non-government organisations and the private sector.

Work programme and budget

The current programme of work for 2020/2021 is based on the following four strategic objectives:

1. empower effective policy and decision-making by providing authoritative knowledge and analysis on renewables-based energy transformation at global, national and sectoral levels;

2. shape the global discourse on energy transformation by providing relevant timely, high-quality information and access to data on renewable energy;

3. provide an inclusive platform for all stakeholders to foster action, convergence of efforts and knowledge sharing for impact on the ground;

4. support country-level decision-making to accelerate the renewables-based transformation of their energy systems, advance strategies to decrease global emissions and achieve sustainable development.

IRENA's work to implement these strategic targets is broken down into six thematic programme areas:

1. Centre of Excellence for Energy Transformation

2. Global Voice of Renewables

3. Network Hub

4. Source of Advice and Support

5. International Cooperation and Strategic Engagement

6. Efficient, Transparent and Innovative Management

An annual budget of around USD 22 million is available for these areas. Voluntary contributions are also made by the Member States.

In recent years, IRENA has particularly gained a reputation for its analysis and development of measures to implement the UN's Sustainability for All initiative. This initiative aims to substantially increase the global share of renewable energy by 2030, and to double the rate of improvements in energy efficiency. Further to this, in 2017 IRENA developed perspectives for 2050, which map out the global transition of the energy sector in line with the Paris climate goals, estimate the investment framework this requires, and assess the labour market development going hand in hand with the energy transition. The modelling analysis comes to the conclusion that a global energy transition is technically feasible and can be achieved at reasonable cost [59]. IRENA updates this study every year as an input for the debate at the Berlin Energy Transition Dialogue.

More information on IRENA publications can be found on the organisation's website www.irena.org/publications.

Other focal areas of IRENA's work include issues surrounding the financing of renewable energy, analyses of resource potential, investment conditions and the socioeconomic, employment and environmental impact of renewable energy technologies. Key projects include studies on the potential for reducing the costs of renewables and the global macroeconomic impacts of expanding renewable energy.

Furthermore, IRENA helps countries and regions accelerate the introduction and expansion of renewable energy, and conducts Renewable Readiness Assessments in individual developing countries to this end. These projects identify priority areas for action in individual countries and guide policymakers in driving renewable energy growth in their respective country.

Main bodies and structure

IRENA is composed of three main governing bodies. The Assembly is IRENA's ultimate decision-making authority. It consists of all the countries who have ratified the statute.

The Council, which is made up of 21 members, reviews reports and documents, particularly the IRENA work programme and budget, and submits them to the Assembly for decision. The 10th Assembly was held in Abu Dhabi, United Arab Emirates, in January 2020.

The Secretariat implements the IRENA work programme and assists the Assembly, Council and other subordinate bodies in performing their functions. The Secretariat is overseen by IRENA's Director-General and consists of three divisions. Two are located in Abu Dhabi and one in Bonn.

Further information at: www.irena.org

The International Energy Agency (IEA)

The International Energy Agency (IEA) is one of the world's central energy organisations. An autonomous institution within the OECD, it acts as a voice for the energy-consuming industrialised countries, and currently consists of 30 OECD member countries. The accession of Chile and Lithuania to the IEA is being prepared. Given the strong growth in energy demand outside the OECD, the IEA is also expanding its cooperation with countries that are not members of the OECD and therefore cannot become members of the IEA according to the current rules. Since the end of 2015, the IEA has concluded association agreements in this regard with Brazil, China, India, Indonesia, Morocco, Singapore, South Africa and Thailand.

The IEA was founded in 1974 in response to the first oil crisis, with a view to ensuring that the supply of oil would not be subject to disruptions. In order to achieve this goal, its member coun-

tries agreed to hold at least 90 days' worth of emergency oil stocks.

In addition, the IEA has developed into a central platform for sharing experience and advising policymakers on virtually all aspects of energy policy. A key part of this is discussing how renewable energy can be developed and integrated into the various energy systems. The IEA toolkit includes regular country reviews setting out policy recommendations, as well as the annual World Energy Outlook (WEO), a comprehensive international reference publication on energy policy with forecasts currently reaching up to 2040. These are the most influential publications released by the IEA and serve as key reference material in the designing of national energy policies right around the world.

The IEA issues numerous publications on renewable energy, most recently the Renewable Energy Market Report with a forecast extending through to 2024. The IEA's World Energy Outlook 2019 contains an in-depth section on offshore wind energy and underlines the importance of renewable energy for the development of the global and regional energy footprints up to 2040.

The Federal Ministry for Economic Affairs and Energy is also represented in the IEA Renewable Energy Working Party (REWP).

Since 2011, the Renewable Industry Advisory Board (RIAB), a committee consisting of companies in the renewable energy industry, has held regular workshops to discuss market and industry trends and has provided information to support the REWP and the IEA secretariat in their activities. The RIAB includes German companies as well.

More information on IEA publications can be found on the organisation's website www.iea.org.

Energy cooperation in the G20

Since 2008, the 'Group of 20' (G20) has hosted annual meetings of Heads of State and Government of 19 countries and of the European Union. It is the central forum for international cooperation on financial and economic issues. Within the talks that take place, energy policy issues have become increasingly important. Since 2013, they have been discussed within a dedicated working group, which was expanded under the 2017 German G20 presidency to become a working group for energy and climate change which is jointly coordinated by the Federal Ministry for Economic Affairs and Energy and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The working group has focused more sharply on the central role of the energy sector in the implementation of the Paris Climate Agreement and on the 2030 Agenda on Sustainable Development and has adopted a Climate and Energy Action Plan for Global Growth. The action plan can be viewed here: www.g20germany.de/Content/DE/_Anlagen/G7_G20/2017-g20-climate-and-energy-en_nn=2186554.html.

In 2018 and 2019, the dialogue on energy policy was continued in specific working groups under the Argentinian and Japanese G20 presidencies. Energy policy issues are continuing to play an important role under the current presidency of Saudi Arabia, particularly reflecting the impact of the global COVID-19 pandemic on the energy markets.

Renewable Energy Policy Network for the 21st Century – REN21

The first International Renewable Energy Conference – renewables2004, which was initiated by the Federal Government and held in Bonn, put renewable energy on the global agenda. This conference provided crucial momentum: the more than 100 participating countries agreed that renewable energy would play a central role in an

energy system of the future and committed to national or regional targets and actions. To maintain this momentum, the Renewable Energy Policy Network for the 21st Century (REN21) was then founded. REN21 publishes the Global Status Report each year, a publication which informs policy debate on renewable energy [58].

The Renewable Energy Policy Network for the 21st Century (REN21) is a global policy network that was largely co-founded on the initiative of Germany after the renewables2004 conference. The network, which has been extensively funded by Germany, has developed into the most important global multi-stakeholder network dedicated to promoting policy measures aimed at accelerating the expansion of renewable energy. It plays a key role in the provision of strategic and organisational support to the countries hosting International Renewable Energy Conferences (IRECs). REN21 comprises representatives from government, international organisations, civil society, the scientific community and private-sector stakeholders from the fields of energy, the environment and development. The Secretariat of REN21 is located in Paris.

Every year, REN21 publishes the Renewables Global Status Report (GSR), which tracks the yearly growth of renewables around the world and has emerged as the standard reference for renewable energy expansion and investment. The report presents the worldwide situation and geographical distribution of installed renewable capacity, growth targets, policy instruments and global investment in renewable energy [58].

In addition to the Global Status Report, REN21 also publishes Regional Status Reports that examine in greater depth the development of renewables in individual regions around the world.

2017 saw the second edition of the Global Futures Report. This publication contains an overview of possible directions and expectations for the future growth of renewable energy. Based on scenarios and interviews with experts, the report describes the expectations of various players for the future of renewables, key issues and important policy options.

Further information at: www.ren21.net

International Renewable Energy Conferences (IRECs)

The great success of renewables2004 has been continued in other countries through the launching of the International Renewable Energy Conferences (IRECs). The individual conferences have generated strong political impetus for accelerating the expansion of renewable energy worldwide. In addition, the IRECs have often had a significant impact in the respective host country. Since 2004, follow-up conferences have taken place for example in China, the United States, India, the United Arab Emirates, Mexico and most recently in Korea in October 2019.

The various IRECs have covered a wide range of topics and priorities. For example, discussions have focused on use of renewable energy sources in developing countries as well as the expansion of renewable energy in industrial nations.

Debates on regional conditions in the host country also form part of the agenda of the IRECs. At MEXIREC in Mexico City, for example, numerous ministers and high-level participants from the field of energy policy and the business community discussed aspects like the policy framework and factors that are key to the successful expansion of renewable energy in Central and South America, whilst the SAIREC event in Cape Town, South Africa, looked into the development of renewable energy in Africa, and particularly in sub-Saharan Africa.

The Delhi International Renewable Energy Conference (DIREC 2010) took place in October 2010. DIREC led to the signing of a joint political declaration reaffirming the intention of all the conference participants to promote the faster expan-

sion of renewable energy worldwide, and to support the initiative for the UN's International Year of Sustainable Energy For All.

KIREC, held in Seoul in 2019, was the first IREC to be organised jointly by a national and a municipal government. This underlines the importance of urban areas for the use of renewable energy and for the implementation of environmental policy at local level. The city of Seoul presented its ambitions and funding for renewable energy at the conference, as well as its efforts to create a more efficient, more sustainable and safer urban environment.

The decision on the holding of the next IREC in 2021 or 2022 is to be taken by the end of 2020 in the light of available information about the future course of the COVID-19 pandemic.

Berlin Energy Transition Dialogue – BETD

Since 2015, the Federal Government has held an international energy conference, the Berlin Energy Transition Dialogue, every spring. This two-day conference is aimed at intensifying international exchange of experiences, challenges and opportunities associated with the global energy transition. The event is jointly hosted by the Federal Ministry for Economic Affairs and Energy and the Federal Foreign Office.

In 2019, the event was attended by more than 2,000 domestic and foreign decision-makers from the political sphere, from business, science and academia, civil society, and world-leading energy experts from almost 90 countries. This also included 50 foreign and energy ministers, as well as more than 100 high-ranking delegations from all over the world. Against the backdrop of the Paris climate agreements, the aim of the conference was to continue international dialogue on a secure, environmentally compatible and affordable global energy transition. Parallel to the event, attendees were also offered an extensive side programme, including excursions to experience the German energy transition at first hand.

The 6th Berlin Energy Transition Dialogue, which had been scheduled for spring 2020, unfortunately had to be cancelled due to the COVID-19 pandemic. In order nonetheless to continue the international debate on the BETD issues until a physical BETD is possible again, the online campaign "BETD – The Dialogue goes on" was held in mid-May 2020 via a wide range of digital formats.

Further information at:
www.energydialogue.berlin

Clean Energy Ministerial (CEM)

Launched in 2010, the Clean Energy Ministerial (CEM) is a global forum that was set up to promote sustainable energy generation right around the world. It is attended by some 26 industrial countries and emerging economies, as well as by representatives for the European Union [60].

Cooperation at the CEM takes place across a variety of working groups in which Member States usually focus on specific individual technologies. There are also short-term 'campaigns' which often include players from the private sector and civil society. This cooperation goes back to ten technology action plans on a range of low-carbon technologies that were jointly developed in 2009 by a group of industrial countries, in preparation for the COP 15 climate conference in Copenhagen.

The Federal Government, represented by the Federal Ministry for Economic Affairs and Energy, co-leads the multilateral campaign for long-term scenarios for the energy transition, and to increase the flexibility of electricity grids, together with Denmark. The various ministers involved meet on an annual basis to decide on what the key areas of focus should be when it comes to the work carried out as part of the initi-

atives. The last meeting took place in Riyadh in February 2020, hosted by Saudi Arabia.

Further information at:
www.cleanenergyministerial.org

Mission Innovation – MI

Mission Innovation is a global initiative of 24 countries and the European Union which is working to promote innovative technologies for renewable energy and bring them to market maturity.

MI was established at the UN Climate Conference in Paris in 2015 by the heads of state and government assembled there in order to bolster the fight against global warming.

In the launch declaration, the MI members set themselves the goal of doubling their public investment in research, development and demonstration projects for renewable energy over a five-year period. The private sector is to be involved in this process.

In the context of MI, Germany, represented by the Federal Ministry for Economic Affairs and Energy, has joined forces with the European Union and Australia to form a "challenge" (a working group) to make carbon-neutral hydrogen. In addition, Germany and the EU are leading a "challenge" to make use of solar energy. Germany has already attained its goal of doubling investment in innovation programmes over the last five years.

The annual MI conferences generally take place following the CEM assemblies at the site of those meetings. At the last general assembly in Riyadh in February, the MI members decided to set up a further five-year MI programme of work. The next CEM and MI conferences may be held in Vina del Mar, Chile, in early 2021.

SEforALL – The Sustainable Energy for All initiative

Launched by former UN Secretary General Ban Ki-moon in 2011, the Sustainable Energy for All initiative aims to ensure that all people around the world can access sustainable energy by 2030. Besides ensuring universal access to modern energy services, the initiative seeks to raise the annual improvement in energy efficiency rates from 1.2% to 2.4% and to double the share of renewables in the global energy mix. These targets are to be attained by 2030.

Today, some 789 million people worldwide still have no access to electricity. Further to this, roughly 2.8 billion people have no access to renewable and zero-emission energy sources for their daily cooking. This figure is forecast to remain essentially unchanged through to 2030 if no additional efforts are undertaken.

A high-ranking group of 46 advisors from business, government and civil society has drawn up an agenda for action in order to implement the SEforAll targets. The measures to attain the goals aim to combine the efforts made by both the public and private sectors and civil society in order to increase the overall impact. At the United Nations Conference on Sustainable Development in Rio (Rio+20), 50 countries from Africa, Asia, Latin America and the group of the Small Island Developing States, plus a large number of companies, local governments and various groups from civil society, presented their own commitments towards implementing the Action Agenda. The initiative thus succeeded in harnessing the political momentum from the Rio+20 negotiations to mobilise support.

The intention is for SEforAll to also provide the G20 members with an annual report on the improvements made in universal access to renewable energy.

Further information at: www.se4all.org

Information on methodology

Some of the figures published in this report are provisional. Where the final data are published, they may differ from earlier publications. Discrepancies between the figures in the tables and the respective column or row totals are due to rounding. The terminology commonly used in energy statistics includes the term (primary) energy consumption. This is not strictly correct from a physical point of view, however, because energy cannot be created or consumed, but merely converted from one form to another (e.g. heat, electricity, mechanical energy). This process is not entirely reversible, however, meaning that a proportion of the energy's exergy is lost.

For more information on the German terminology used in energy statistics, please refer to the website of the Federal Ministry for Economic Affairs and Energy www.bmwi.de/Navigation/DE/Service/Glossar-Energiewende/glossar.html.

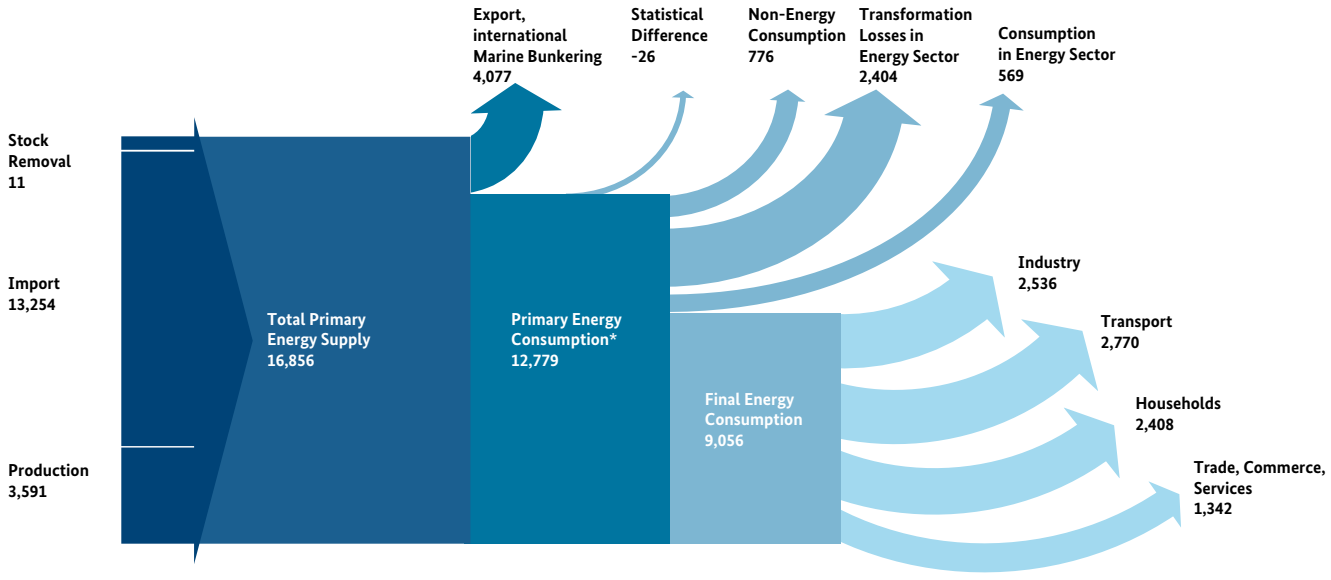
The amounts of energy (gross electricity consumption, final energy consumption from renewables for heating, cooling and transport) presented in this brochure cannot be added to produce an aggregate value because they are determined on the basis of specific conventions which differ in each case. Consequently it is not possible to calculate shares of total final energy consumption on this basis.

Methodological changes

AGEE-Stat is constantly working to improve the methodology of the renewable energy statistics. The Working Group engages in a dialogue with experts on specific forms of renewable energy to constantly update knowledge in order to improve the data basis for electricity generation and heat production from renewable energy sources. The resulting methodological changes aim to ensure that renewable energy statistics can be updated over the long term, while also providing a uniform and consistent data base to meet national and international reporting obligations. An overview of the methodological changes is provided below:

Figure 66: Energy Flow Chart for Germany, 2019

in Petajoule (PJ)



* Data preliminary
29.3 Petajoule (PJ) ≙ 1 Mio. t SKE

Source: Working Group on Energy Balances (AG Energiebilanzen) 09/2020

Installed electrical output of waste incineration plants

For quite some time, generation of electricity and heat from waste incineration plants has been allocated half to renewable energy sources and half to non-renewable energy sources due to the biogenic part of municipal waste. In order to achieve consistency with the published findings of the statistical offices of the Federation and the Länder, and with the monitoring by the Federal Network Agency under the Energy Industry Act, AGEE-Stat will in future also designate 50% of the electrical output of waste incinerators as being renewable.

Installed electrical capacity to generate electricity and heat from sewage sludge and sewage gas

Following the revision of the Energy Statistics Act in 2017, new official capacity and generation data for the installations in municipal sewage works using sewage gas or sewage sludge to generate electricity and/or heat became available. The capacity time series for sewage gas and solid biogenic fuels (including sewage sludge) were supplemented on this basis from 2018.

Final energy consumption of solid biomass used for the generation of heat in private households

In the context of the research project entitled "Systematic Resource Monitoring of Wood" funded by the Federal Ministry of Food and Agriculture (BMEL) via the Fachagentur Nachwachsende Rohstoffe e.V. (FNR) (www.fnr.de/index.php?id=11150&fkz=22005918) a new empirical survey (study entitled „Energieholzverwendung in privaten Haushalten 2018 – Marktvolumen und verwendete Sortimente" – www.fnr.de/fileadmin/heizenmitholz/HH_2018_Teilbericht.pdf) in German) determined the consumption of wood as a fuel by private households in 2018. On the basis of the findings of the study, the corresponding regression model by the Thünen Institute was adjusted. This has led to changes in the wood consumption data for 2015–2019 and for earlier non-surveyed years.

Calculation of share in accordance with EU Directive 2009/28/EC

EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources contains detailed requirements with regard to calculating the achievement of targets. In addition to the overall share of renewable energy in gross final energy consumption, it also defines specific shares for electricity, heating and transport. Calculations of the contributions made by wind energy and hydropower take account of the effects of climatic variation on electricity yield. As a result of this "normalisation" to produce an average year, the figure for wind and hydropower no longer corresponds to the actual yield for the year in question, but provides a better picture of capacity expansion. Bioliquids and biofuels must fulfil specific sustainability criteria to be able to count towards the overall target and the target in the transport sector. In the transport sector, a factor of 2.5 is applied to the contribution made by electricity that is generated from renewable energy sources and used in electric rail transport, while a factor of 5 applies to the contribution made by electricity that is generated from renewable energy sources and used in road vehicles with an electric drive. Furthermore, biofuels made from feedstock as defined in Annex IX of Directive 2009/28/EC (particularly used cooking oil) are double-counted towards the decarbonisation goal.

Gross final consumption of energy is defined as follows in Article 2 (f) of Directive 2009/28/EC: *"'Gross final consumption of energy' means the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission."*

Thus, it is of limited value to compare data determined in accordance with the rules set out in the EU Directive with statistics from other sources, such as national statistics or data relating to the Renewable Energy Sources Act.

Calculating the share without applying the calculation method set out in the EU Directive

The Federal Government's Energy Concept of 2010 also lays down the target for renewable energy sources to account for 18% of gross final energy consumption by 2020. In order to track progress, Germany uses a different method to the one set out in the EU Directive, one which also factors in real generation of electricity from wind and hydropower and the actual consumption of biofuels in transport.

Economic stimulus from the use of renewable energy

The rapid expansion of renewables seen in Germany in recent years has resulted in a massive increase in the importance of the renewable energy sector for the economy as a whole. Firstly, the construction of RES installations is fostering the use of electricity and heat. And as the number of plants grows, the operation of these plants is becoming an increasingly important factor in the economy as well.

Investment in renewable energy facilities is calculated based on newly installed capacity or the number of additional installations. This number is then combined with the specific investment costs (EUR/kW) or average cost per installation (EUR/installation) to determine the total investment per segment in the year under review. In the case of installations whose construction takes place over a period of several years, investments are assigned to the appropriate period. This particularly concerns offshore wind installations, installations that use deep geothermal energy, large hydropower plants, and large biomass CHP plants and biogas plants. This approach prevents the investment from being solely assigned to the year the plant was completed or went into operation.

The economic stimuli arising from plant operation include not only the costs of operation and maintenance, especially personnel costs, but also the provision of renewable fuels and biofuels.

The costs of operating and maintaining installations are determined on the basis of values specific to each type of technology. They were determined using cost calculations from various scientific studies. These particularly include the research projects relating to the Renewable Energy Sources Act (including the research reports on the Renewable Energy Sources Act Progress Report, for example [6] and the final report on the monitoring of power generation from biomass [10]), the evaluations of the Market Incentive Programme [40], and the evaluations of KfW funding for renewable energy sources [62].

The calculation of the costs arising from supplying fuel for heat and power generation also includes the costs of solid and liquid fuels and of the substrates used to produce biogas. The relevant solid biomass fuels include waste wood, residual wood from forestry and industry, wood pellets, wood chips, wood briquettes, and commercially traded firewood. The main components of substrates for biogas production are maize silage, grass silage, whole-crop silage and inferior grain. In total, the economic stimulus from the supply of biogenic fuels for heat and power is estimated at €4.6 billion.

Conversion factors

Metric prefixes							
Megawatt hour:	1 MWh = 1,000 kWh	Kilo	k	10^{3*}	Tera	T	10^{12}
Gigawatt hour:	1 GWh = 1 million kWh	Mega	M	10^{6}	Peta	P	10^{15}
Terawatt hour:	1 TWh = 1 billion kWh	Giga	G	10^{9}	Exa	E	10^{18}

Units of energy and output	
Joule J	for energy, work, heat quantity
Watt W	for power, energy flux, heat flux
1 Joule (J) = 1 Newton metre (Nm) = 1 Watt second (Ws)	

Legally binding units in Germany since 1978. The colorle and derived units such as coal equivalent and oil equivalent are still used as alternatives.

Conversion factors					
		PJ	TWh	Mzce	Mtoe
1 Petajoule	PJ	1	0.2778	0.0341	0,0239
1 Terawatt hour	TWh	3.6	1	0.123	0,0861
1 million tonnes coal equivalent	Mtce	29.308	8.14	1	0,7
1 million tonnes crude oil equivalent	Mtoe	41.869	11.63	1.429	1

The figures refer to the heat calorific value.

Grenhose gases	
CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
SF_6	Sulphur hexafluoride
H-FKW	Hydrofluorocarbons
FKW	Perfluorocarbons

Other air pollutants	
SO_2	Sulphur dioxide
NO_X	Nitrogen oxides
HCI	Hydrogen chloride (Hydrochloric acid)
HF	Hydrogen fluoride (Hydrofluoric acid)
CO	Carbon monoxide
NMVOC	Non-methane volatile organic compounds

* 10^2 = 100, 10^3 = 1,000, 10^4 = 10,000, 10^5 = 100,000, 10^6 = 1,000,000 etc.

List of abbreviations

AGEB	Arbeitsgemeinschaft Energiebilanzen e. V. (Working Group on Energy Balances)
AGEE-Stat	Arbeitsgruppe Erneuerbare Energien-Statistik (Working Group on Renewable Energy Statistics)
AGQM	Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e.V. (Working Group on Biodiesel Quality Management)
BAFA	Federal Office for Economic Affairs and Export Control
KfW	Kreditanstalt für Wiederaufbau
GFEC	Gross final energy consumption
BDEW	Bundesverband der Energie- und Wasserwirtschaft (German Association of Energy and Water Industries)
BDH	Bundesverband der Deutschen Heizungsindustrie (Federation of German Heating Industry)
Biokraft-NachV	Sustainability Ordinance (Biokraftstoff-Nachhaltigkeitsverordnung)
BioSt-NachV	Biomass Electricity Sustainability Ordinance (Biomassestrom-Nachhaltigkeitsverordnung)
BMEL	Federal Ministry of Food and Agriculture
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMWi	Federal Ministry for Economic Affairs and Energy
BNetzA	Bundesnetzagentur (Federal Network Agency)
BSW	Bundesverband Solarwirtschaft (Federal Solar Industry Association)
BWP	Bundesverband Wärmepumpe e.V. (German Heat Pumps Association)
CHP	Combined heat and power plant
COP-15	15th Conference of the Parties
DBFZ	Deutsches Biomasseforschungszentrum (German Biomass Research Centre Leipzig)
DEPV	Deutscher Energieholz- und Pellet-Verband e.V. (German Wood and Pellet Fuel Association)
dena	German Energy Agency
ECN	Energy Research Centre of the Netherlands
RE/RES	Renewable energy (sources)
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EnSAG	Omnibus Energy Act (Energiesammelgesetz)
EU	European Union
Eurostat	Statistical Office of the European Union
FEC	Final energy consumption
Fh-ISE	Fraunhofer Institute for Solar Energy Systems (Fraunhofer-Institut für Solare Energiesysteme)
R&D	Research and development

FNR	Fachagentur Nachwachsende Rohstoffe e. V. (Agency for Renewable Resources)
EWEA	European Wind Energy Association
TCS	Trade, commerce and service sector
GSR	Global Status Report
GWP	Global warming potential
HIC	Hamburg Institute
HH	Households
HP	Heating plant
HVO	Hydrotreated vegetable oil
IE Leipzig	Leipzig Institute for Energy (Leipziger Institut für Energie)
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
N/A	Not available
PP	Power plant
KWKG	Combined Heat and Power Act (Kraft-Wärme-Kopplungsgesetz)
MaStRV	Core Energy Market Data Register Ordinance (Marktstammdaten-registerverordnung)
MAP	Market Incentive Programme (Marktanreizprogramm)
NQ	Not quantified
NECP	National Energy and Climate Plan
NREAP	National Renewable Energy Action Plan
NUTS 2	Definition of regions for regional policy measures
UBA	Federal Environment Agency (Umweltbundesamt)
UFOP	Union for the Promotion of Oil and Protein Plants (Union zur Förderung von Oel- und Protein-pflanzen e.V.)
PV	Photovoltaics
PEC	Primary energy consumption
ptj	Projektträger Jülich (project management agency)
REN21	Renewable Energy Policy Network for the 21st Century
SMARD	Electricity market data: information platform of the Federal Network Agency
StBA	Federal Statistical Office (Statistisches Bundesamt)
StromEinspG	Act on the Sale of Electricity to the Grid (Stromeinspeisungs-gesetz)
SystEEm	Integration of renewable energy sources and regenerative energy supply systems (Integration erneuerbarer Energien und regenerative Energieversorgungs-systeme)
GHG	Greenhouse gas
TSO	Transmission system operator
UL	UL International GmbH
USD	United States dollars

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For more information on renewable energy, please visit the following websites operated by the Federal Ministry for Economic Affairs and Energy www.bmwi.de **and** www.erneuerbare-energien.de