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Energiewende
Switch to the Future

Renewable Energy Sources in Figures

National and International Development, 2016

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Introduction

Dear Reader,

In the new edition of Renewable Energy Sources in Figures – National and International Development, the Federal Ministry for Economic Affairs and Energy reports in detail on the way in which renewable energy developed in Germany in 2016.

When it comes to the areas of electricity, heat and transport, the publication shows the following:

- The share of renewables in total electricity consumption rose from 31.5% in 2015 to 31.7% in 2016.
- Renewables accounted for 13.0% of gross final energy consumption for heating, remaining stable year-on-year.
- In the area of transport, renewable energy sources accounted for 5.2% of total final energy consumption, down slightly on the previous year (5.3%).

Overall, the development of renewable energy in 2016 was moderate compared to previous years.

The use of renewable energy sources has positive ecological effects and also has a positive impact on the economy:

- In 2016, emissions of 160 million tonnes of CO_2 equivalent were avoided, with the electricity sector alone accounting for 119 million tonnes of this figure.
- A total of €15.1 billion was invested in the construction of renewable energy installations last year.
- The operation of renewable energy installations provided an economic stimulus of €15.6 billion.

The data used here are taken from the findings of the Working Group on Renewable Energy – Statistics (AGEE-Stat), which prepared the “balance sheet” for renewable energy sources in Germany on behalf of the Federal Ministry for Economic Affairs and Energy.

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

Not only does it document the latest information for Germany, it also reports on the development made in the use of renewable energy sources in the European Union, which has also set ambitious goals for itself. The publication is rounded off with data on the use of renewables worldwide.

The information for 2016 presented in this publication reflects the situation as of the editorial deadline for this brochure (August 2017), meaning certain figures are provisional.

Alongside this brochure, the website of the Federal Ministry for Economic Affairs and Energy offers current timelines showing the development of renewable energy sources in Germany since 1990, plus a variety of diagrams. These timelines and diagrams will be updated at the end of 2017/start of 2018.

For more information about renewable energy and the transformation of Germany’s energy system, please visit the Ministry’s websites at www.bmwi.de and www.erneuerbare-energien.de.

Yours sincerely,

The Federal Ministry for Economic Affairs and Energy

Berlin, September 2017

Working Group on Renewable Energy Statistics

Since February 2004, the Working Group on Renewable Energy (AGEE-Stat) has generated statistics and compiled data on renewable energy sources and incorporated them into a comprehensive, up-to-date and coordinated system. AGEE-Stat works on behalf of the Federal Ministry for Economic Affairs and Energy.

AGEE-Stat's findings are incorporated into this publication.

AGEE-Stat is an independent expert body. Its members include experts from the

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

At the beginning of 2016, the Federal Environment Agency took over the office and management of the Working Group from the Centre for Solar Energy and Hydrogen Research Baden-Württemberg, which had previously run the Working Group since its launch. Michael Memmler of the Federal Environment Agency is now the director.

AGEE-Stat's activities focus on developing and maintaining comprehensive statistics on the use of renewable energy sources. The Working Group also has the task of

- creating a basis for meeting the German government's various national, EU and international reporting obligations on renewable energy and
- providing 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 can be found on the website of the Federal Ministry for Economic Affairs and Energy at www.erneuerbareenergien.de

Part I: Renewable energy in Germany

The energy transition is Germany's avenue into a secure, environmentally friendly, and economically successful future. The central element of this transition is the restructuring of our energy supply towards the use of renewable energy. We have already come a long way: almost one-third of our electricity derives from the wind, sun and co. This means that renewables have become our number-one source of electricity. In the recent years, there has also been an increase in the level of use in the heat sector, although the pace of developments has been much slower than in the electricity sector. In the transport sector, the share of renewables has been slightly falling since 2008.

Future expansion of renewable energy

The Renewable Energy Sources Act, which entered into force in 2000 and has since been revised several times, aimed to facilitate market access for young technologies like wind energy and photovoltaics by guaranteeing their purchase at fixed rates. It thus built a platform for the expansion of renewables in the electricity sector, enabling them to emerge from being a niche to become the mainstay of Germany's power supply. With a share of 31.7% of Germany's gross electricity consumption in 2016, renewables have advanced to become the most important source of energy in Germany's electricity supply.

The German government's 2014 Renewable Energy Sources Act aimed not least to ensure the ongoing expansion of renewable energy by defining deployment corridors for each of the various RES technologies – to achieve shares of 40% to 45% of gross electricity consumption in 2025 and 55% to 60% in 2035. Also, the 2014 Renewable Energy Sources Act stated that the rates of remuneration should be determined via competitive auctions from 2017 at the latest. To this end, pilot auctions have successfully been held for ground-mounted photovoltaics installations since 2015. These have proved their worth, generating competition and leading to falling costs.

Under the 2017 recast of Renewable Energy Sources Act, which entered into force on 1 January 2017, the auctions are now to be extended to cover other technologies, particularly wind energy. The only exemption is for installations with an output of below 750 kilowatts, i.e. mainly small photovoltaics installations.

The 2017 reform of the Renewable Energy Sources Act is a key element in the final stages of Germany's implementation of EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources, which requires the country to generate 18% of its gross final energy consumption from renewable energy sources by 2020. This is because the electricity sector makes up a massive part of this.

A further major instrument for heating/cooling is the Renewable Energies Heat Act, alongside which the Market Incentive Programme also provides an additional source of funding for these areas. Finally, the use of renewable energy in the transport sector is largely determined by the Biofuel Quota Act. When it comes to the use of green electricity in transport, mention should also be made of the Electric Mobility Strategy and, from 2016, the purchase premium for electric vehicles.

By 2020, renewables are to account for 14% of final energy consumption for heating and cooling in accordance with the Renewable Energies Heat Act, and for 10% of the final energy consumption in transport in keeping with the requirements of EU Directive 2009/28/EC. These targets will help to achieve a reduction of at least 40% in greenhouse gas emissions in Germany by 2020 (compared to 1990) and a reduction of at least 80% to 95% by 2050. In order to achieve this, total electricity consumption is to be reduced by 10% by 2020 and 25% by 2050, and primary energy consumption by 20% by 2020 and 50% by 2050.

Monitoring the energy transition

The German government's Energy for the Future monitoring process is used to regularly review the progress made in the transformation of Germany's energy system. The monitoring process primarily involves analysing and consolidating the many available energy statistics and putting them into an easy-to-understand form – thus providing an overview of the current status of the transformation of the energy market in an annual monitoring report. As part of this process, the German government issued its fifth Monitoring Report on the energy transition in December 2016. A panel of four experts monitors and scientifically evaluates the monitoring process.

The figures presented in this brochure provide the fundamental data pool for tracking the development of renewable energy. The data also serve as a basis for the monitoring and progress reports and the meeting of many other national and international reporting obligations.

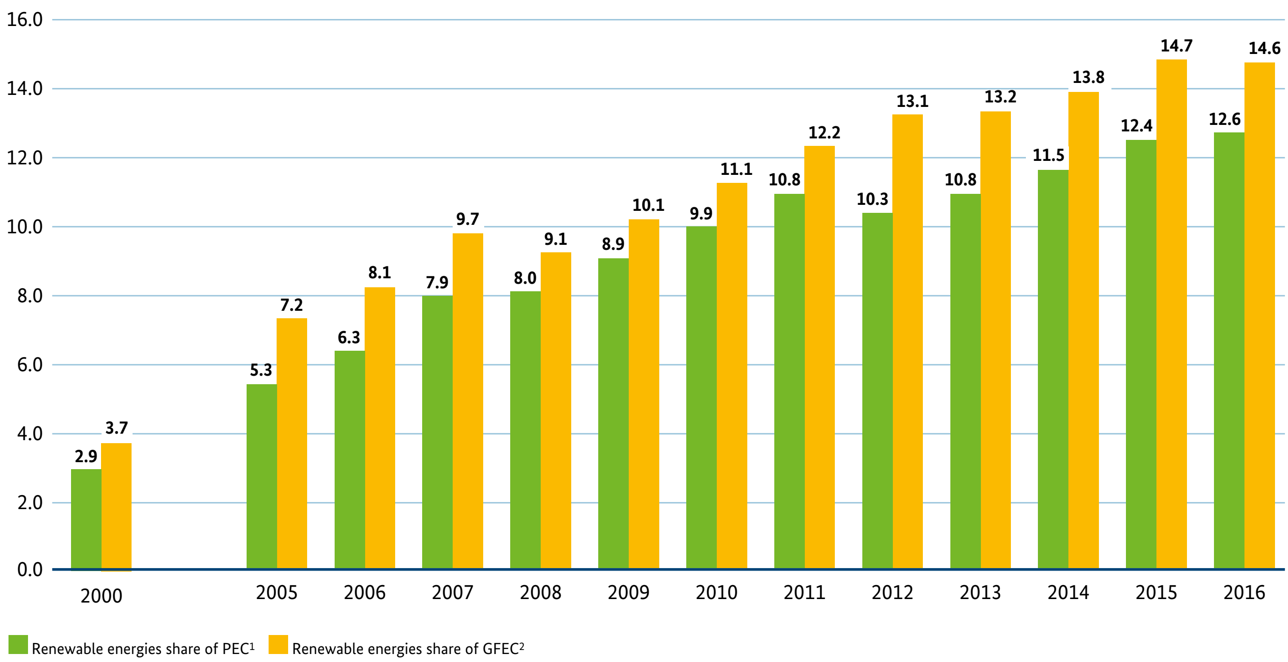
Figure 1: Renewable energy in Germany: Status quo

Categories	2016	2015
Renewable energy share		
of gross final energy consumption	14.6	14.7
of gross electricity consumption	31.7	31.5
of final energy consumption in heating /cooling	13.0	13.0
of final energy consumption in transport	5.2	5.3
of primary energy consumption	12.6	12.4
Avoidance of greenhouse gas emissions through the use of renewable energy sources		
Total greenhouse gas avoidance	160 million t	158 million t
of which through electricity with remuneration under the EEG	100.0 million t	100.2 million t
Economic impetus through the use of renewable energy sources		
Investment in the construction of renewable energy plants	15.1 billion €	14.0 billion €
Costs/Revenues from the operation of renewable energy plants	15.6 billion €	14.9 billion €

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources; see figure 2 and 6, provisional figures

Figure 2: Shares of renewable energy sources in gross final energy consumption and primary energy consumption

in percent



1 Decline of renewables' share in primary energy consumption based on change in methodology from 2012, preceding years not yet revised.

2 Method for calculating share of renewable energy in gross energy consumption does not take account of special calculation rules set out in EU Directive 2009/28/EC. For more details on calculation method, see Information on methodology.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; EEFA; AGEB [1], [2]; Eurostat [3] and other sources, see figure 6, some figures provisional

Electricity

Electricity generation from renewable energy sources stable

In 2016, just over 188 billion kilowatt hours of electricity were generated from renewable energy sources – only slightly more than in the preceding year (2015: 187 billion kilowatt hours). This means that renewables cemented their position as the number-one energy source in the electricity sector, ahead of lignite, but were unable to continue the rapid growth seen over the past years. Thus, the share of renewables in gross electricity consumption rose only slightly, edging up to 31.7% (2015: 31.5%). The reason for this restrained growth was the decline in electricity generation from onshore wind and from photovoltaics due to unfavourable weather conditions, whilst total installed capacity of each of the two technologies continued to increase.

Strong growth in onshore wind capacity

In 2016, onshore wind energy continued to be heavily expanded, with some 4,443 megawatts newly installed, marking an increase over the previous year. After the dismantling of old installations (277 megawatts), net expansion in 2016 amounted to 4,166 megawatts. This is the second highest expansion figure since 2014 (4,651 megawatts). At the end of the year, a total of 45,412 megawatts of installed onshore wind capacity was linked up to the grid. However, the high level of expansion did not have a direct effect on the amount of electricity generated from wind turbines as there was comparatively little wind in 2016. This meant that the amount of electricity produced by onshore wind installations declined by nearly 7% over the previous year, falling to 66,3 billion kilowatt hours (2015: 70.9 billion kilowatt hours).

Rising importance of offshore wind energy

Following record expansion in the use of offshore wind energy in 2015, which was largely the result of pent-up demand finally being absorbed as existing installations were connected to the grid, the total capacity newly connected to the grid in 2016 was much lower than in the preceding year (849 megawatts in 2016 compared to 2,290 megawatts in 2015). The fact that offshore wind energy is nevertheless assuming an ever more important role in our energy supply is reflected in the figures, with generation in 2016 up by almost 50% over the preceding year (12.3 billion kilowatt hours in 2016 compared to 8.3 billion kilowatt hours in 2015).

Overall, wind energy generated approx. 78.6 billion kilowatt hours in 2016, covering 13.3% of total German electricity consumption – the same as in the preceding year (2015: 13.3%).

Figure 3: Renewables-based electricity generation in 2015 and 2016

	Renewable energy sources 2016		Renewable energy sources 2015	
	Gross electricity generation (GWh)[5]	Share of gross electricity consumption (%)[6]	Gross electricity generation (GWh)[5]	Share of gross electricity consumption (%)[6]
Hydropower[1]	20,546	3.5	18,977	3.2
Onshore wind energy	66,324	11.2	70,922	11.9
Offshore wind energy	12,274	2.1	8,284	1.4
Photovoltaics	38,095	6.4	38,726	6.5
Biogenic solid fuels[2]	10,950	1.8	11,033	1.9
Biogenic liquid fuels	411	0.1	447	0.1
Biogas[3]	31,750	5.3	31,288	5.3
Sewage gas	1,432	0.2	1,389	0.2
Landfill gas	360	0.1	396	0.1
Biogenic fraction of waste[4]	5,912	1.0	5,768	1.0
Geothermal energy	162	0.03	134	0.02
Total	**188,216**	**31.7**	**187,364**	**31.5**

1 For pumped-storage power plants, only electricity generation from natural inflow
2 Incl. sewage sludge
3 Incl. biomethane
4 Biogenic share of waste in waste incineration plants estimated at 50%
5 1 GWh = 1 million kWh
6 Based on gross electricity consumption, 2016: 594.6 billion kWh; 2015: 595.1 billion kWh, AGEB [4]

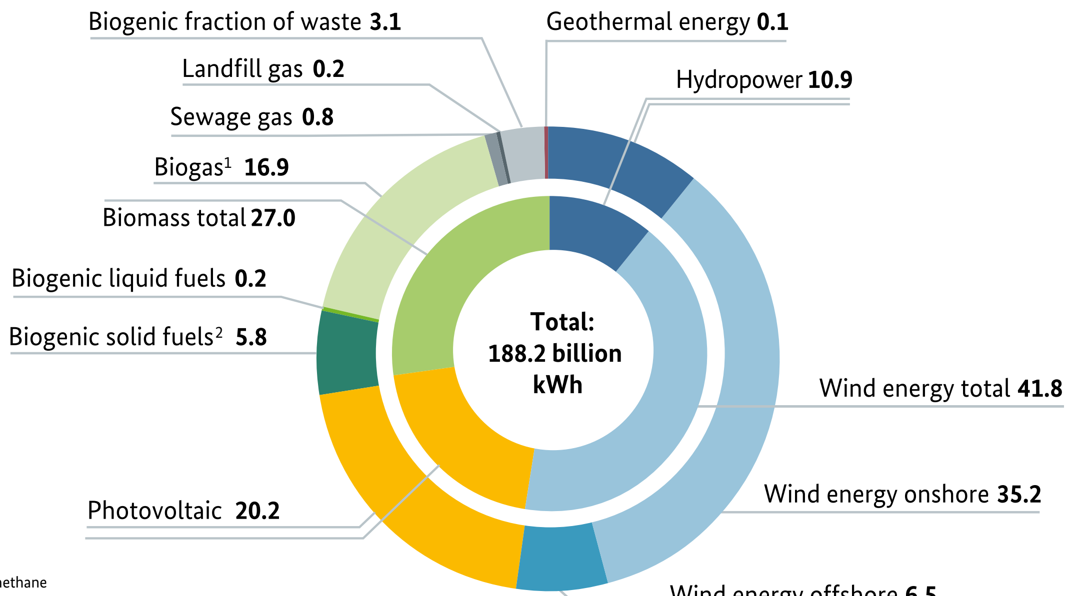
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 6, provisional figures

Downwards trend in the expansion of photovoltaics capacity halted

Following a three-year decline in the expansion of photovoltaics, 2016 saw this trend reversed. In this year, 1,524 megawatts of capacity was newly installed, up just slightly on the preceding year (2015: 1,450 megawatts). This did, however, lie considerably below the target corridor of 2,400 to 2,600 megawatts. This meant that by the end of 2016, photovoltaics installations across Germany had a combined total capacity of 40,874 megawatts. Despite the increase in capacity, the amount of electricity generated by these

Figure 4: Renewables-based electricity generation in 2016

share in percent



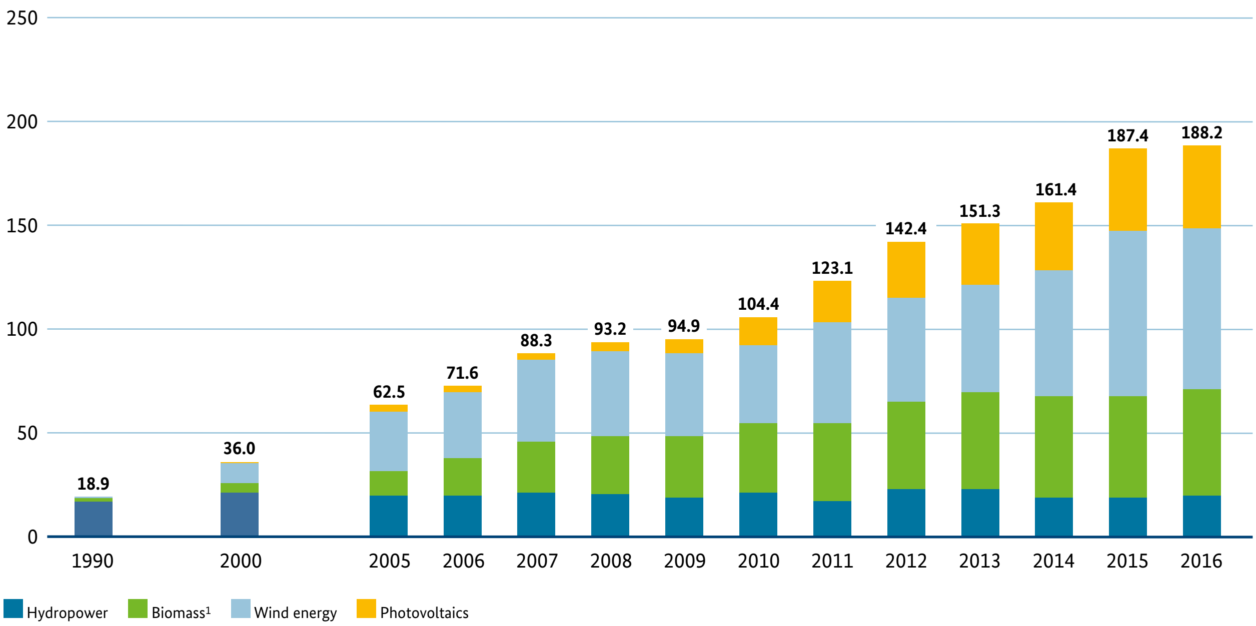
1 Incl. biomethane

2 Incl. sewage sludge

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

Figure 5: Electricity generation from renewable energy sources

in billion kWh



1 Incl. solid and liquid biomass, biogas incl. biomethane, sewage gas and landfill gas incl. sewage sludge and the biogenic share of waste

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 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	71	–	1,435	1	–	**18,933**	**3.4**
2000	21,732	9,513	–	4,731	60	–	**36,036**	**6.2**
2005	19,638	27,229	–	14,354	1,282	0.2	**62,503**	**10.2**
2006	20,008	30,710	–	18,700	2,220	0.4	**71,638**	**11.6**
2007	21,170	39,713	–	24,363	3,075	0.4	**88,321**	**14.2**
2008	20,443	40,574	–	27,792	4,420	18	**93,247**	**15.1**
2009	19,031	38,610	38	30,631	6,583	19	**94,912**	**16.3**
2010	20,953	37,619	176	33,925	11,729	28	**104,430**	**17.0**
2011	17,671	48,314	577	36,891	19,599	19	**123,071**	**20.3**
2012	22,091	49,949	732	43,216	26,380	25	**142,393**	**23.5**
2013	22,998	50,803	918	45,527	31,010	80	**151,336**	**25.1**
2014	19,587	55,908	1,471	48,301	36,056	98	**161,421**	**27.3**
2015	18,977	70,922	8,284	50,321	38,726	134	**187,364**	**31.5**
2016	20,546	66,324	12,274	50,815	38,095	162	**188,216**	**31.7**

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

2 Incl. solid and liquid biomass, biogas incl- biomethane, sewage gas and landfill gas and the biogenic share of waste (biogenic share of waste in waste incineration plants estimated at 50%); also including sewage sludge as of 2010

3 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy (BMWi) based on data from AGEE-Stat; ZSW; AGEB [1], [2], [4], [5]; BDEW; BMWi; BNetzA [6]; StBA; DBFZ; ÜNB [7]; ITAD, UBA [21], some figures provisional

installations fell slightly in 2016 due to fewer hours of sunshine, dropping to 38.1 billion kiolowatt hours (2015: 38.7 billion kilowatt hours). This meant that photovoltaics accounted for a 6.4% share of gross electricity consumption.

Greater expansion of biogas for flexibilisation of supply

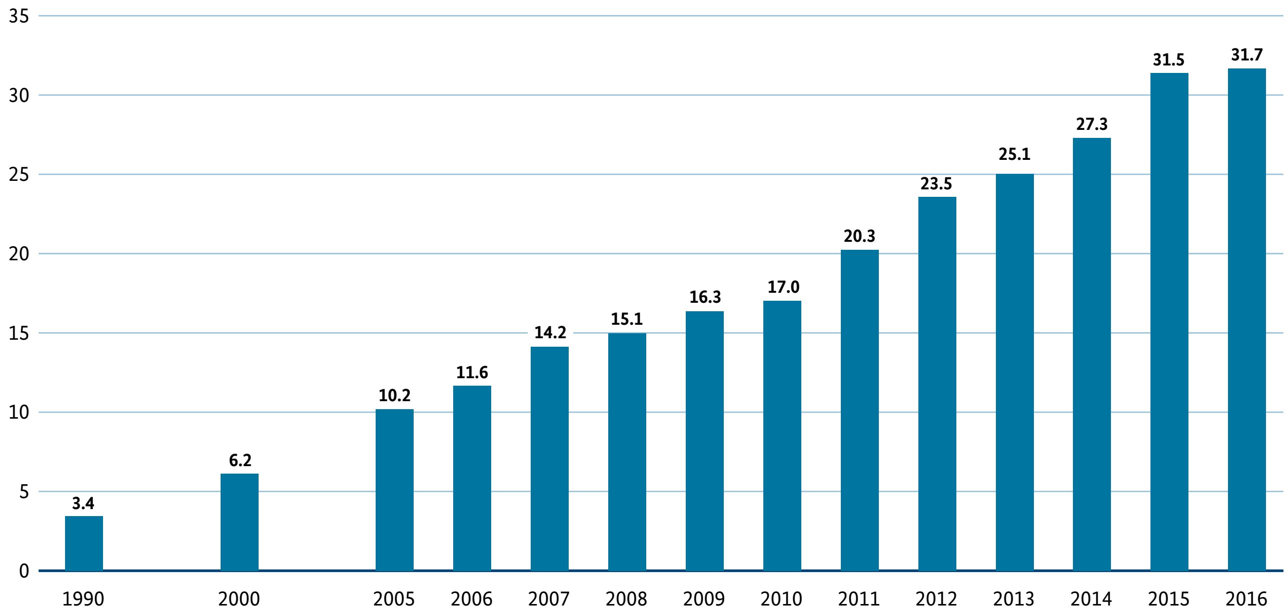
In 2016, some 214 megawatts of gross generation capacity were created based on biomass installations. This was twice as much compared to the preceding year, with 199 megawatts deriving from biogas facilities. The vast majority of this additional capacity was created through the regeneration of existing facilities in order to flexibilise supply. As a result, electricity generation from biogas rose slightly, climbing to 31.8 billion kilowatt hours (2015: 31.3 billion kilowatt hours). A total of 50.8 billion kilowatt hours of electricity was generated from solid, liquid and gaseous biomass, including landfill gas, sewage gas and biogenic waste (2015: 50.3 billion kilowatt hours), or 8.5% of total gross electricity consumption.

Hydroelectric and geothermal energy

As a result of higher rainfall, the level of power generation from hydroelectric installations in 2016 was considerably higher than in the preceding year (20.5 billion kilowatt hours in 2016 compared with 19.0 billion kilowatt hours in 2015) and accounted for 3.5% of gross electricity consumption. The volume of electricity generated from geothermal energy remained low, though climbing to 162 million kilowatt hours (2015: 134 million kilowatt hours).

Figure 7: Share of renewables-based electricity generation in gross electricity consumption

in percent

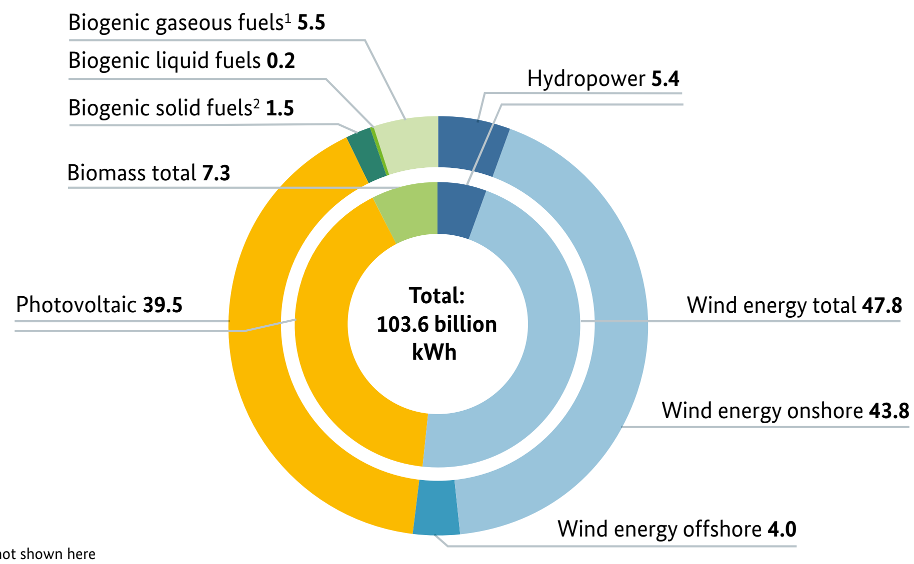


Under the 2017 Renewable Energy Sources Act (EEG), renewable energy must make up 40 to 45 percent of gross electricity consumption by 2025

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

Figure 8: Installed power generation capacity based on renewables in 2016 according to energy source

in percent



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

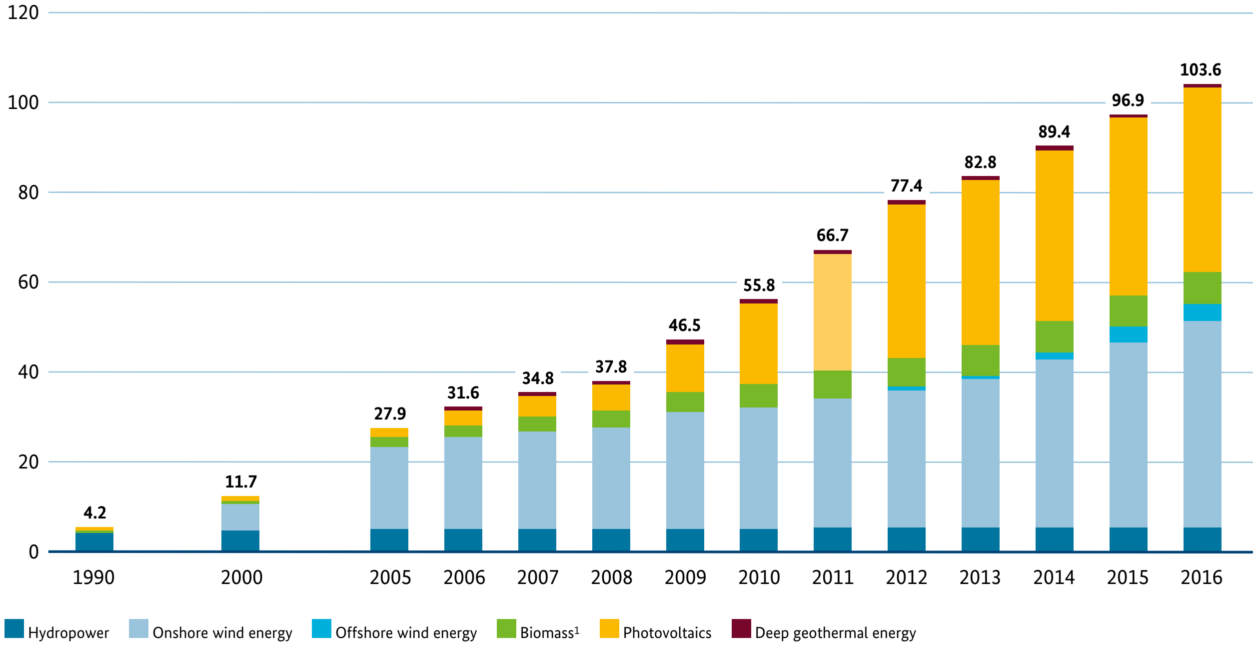
1 Biogas incl. biomethane, sewage gas and landfill gas

2 Excl. biogenic share of waste

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

Figure 9: Installed power generation capacity based on renewables

Gigawatt [GW]



1 Incl. solid and liquid biomass, biogas incl. biomethane, sewage gas and landfill gas, excl. biogenic share of waste

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 10, some figures 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	–	129	2	–	**4,168**
						–	
2000	4,831	6,097	–	703	114	–	**11,745**
						–	
2005	5,210	18,248	–	2,352	2,056	0.2	**27,866**
2006	5,193	20,474	–	3,010	2,899	0.2	**31,576**
2007	5,137	22,116	–	3,392	4,170	3	**34,818**
2008	5,164	22,794	–	3,681	6,120	3	**37,762**
2009	5,340	25,697	35	4,871	10,566	8	**46,517**
2010	5,407	26,823	80	5,463	18,006	8	**55,787**
2011	5,625	28,524	188	6,424	25,916	8	**66,685**
2012	5,607	30,711	268	6,753	34,077	19	**77,435**
2013	5,590	32,969	508	7,036	36,710	30	**82,843**
2014	5,580	37,620	994	7,260	37,900	33	**89,387**
2015	5,589	41,246	3,284	7,356	39,350	33	**96,858**
2016	5,598	45,412	4,133	7,562	40,874	39	**103,618**

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 Incl. solid and liquid biomass, biogas incl. biomethane, sewage gas and landfill gas, excl. biogenic share of waste

3 1 MW = 0.001 GW

Sources: Federal Ministry for Economic Affairs and Energy (BMWi) based on data from AGEE-Stat; ZSW; BDEW; BMWi; BNetzA [6]; StBA; DBFZ; DEWI [8]; GeotIS [9]; BSW; GtV; ITAD; some figures provisional

Heat

Share of renewables in heat consumption remains stable

The use of renewables for heat generation rose in 2016, partly due to the colder weather. The consumption of wood by private households (including wood pellets) went up 10% compared with the previous year, jumping to 68 billion kilowatt hours (2015: 61.9 billion kilowatt hours). The use of wood for generating heat thus also increased in the commerce/trade/services sector.

An increasing amount of geothermal energy and ambient heat was also used in combination with heat pumps. In 2016, some 66,500 new installations were set up – more than in any other year before. This meant that in 2016, some 11.3 billion kiowatt hours of heat was generated through the use of heat pumps, nearly 9% more than in the preceding year.

In 2016, the total area of solar collectors newly installed amounted to 744,000 sq. m, again 8% down on the previous year. During the same period, however, the old installations that came to the end of their operating lives and the fewer hours of sunshine over the preceding year meant that the production of heat from solar thermal energy remained at the same level as 2015 (7.8 billion kilowatt hours). The renewable energy used in the heat sector is mostly biomass, particularly the use of firewood. In addition to this, there were also 31,400 wood-pellet combustion systems newly installed in the year 2016.

As a result, the overall consumption of heat generated from renewable energy sources rose by 4.6% to over 162.4 billion kilowatt hours (2015: 155.2 billion kilowatt hours). Total final energy consumption for heat generation rose in 2016 as a result of weather conditions, climbing by 4.4%. Thus the share of renewable energy in final energy consumption for heating and cooling therefore remained stable, at 13.0% (2015: 13.0%).

Figure 11: Heat consumption based on renewable energy sources in 2015 and 2016

	Renewable energy sources 2016		Renewable energy sources 2015	
	Final energy consumption heat (GWh)[9]	Share (%) of final energy consumption for heat[10]	Final energy consumption heat (GWh)[9]	Share (%) of final energy consumption for heat[10]
Biogenic solid fuels (households)[1]	67,986	5.4	61,900	5.2
Biogenic solid fuels (TCS sector)[2]	9,722	0.8	10,368	0.9
Biogenic solid fuels (industry)[3]	25,108	2.0	25,108	2.1
Biogenic solid fuels (HP/CHP)[4]	6,312	0.5	5,957	0.5
Biogenic liquid fuels[5]	2,052	0.2	2,089	0.2
Biogas[6]	16,932	1.4	16,711	1.4
Sewage gas	2,078	0.2	2,022	0.2
Landfill gas	128	0.01	129	0.01
Biogenic fraction of waste[7]	11,933	1.0	11,807	1.0
Solar thermal energy	7,801	0.6	7,806	0.7
Deep geothermal energy	1,044	0.1	969	0.1
Near-surface geoth. Energy, ambient heat[8]	11,304	0.9	10,351	0.9
Total	**162,400**	**13.0**	**155,217**	**13.0**

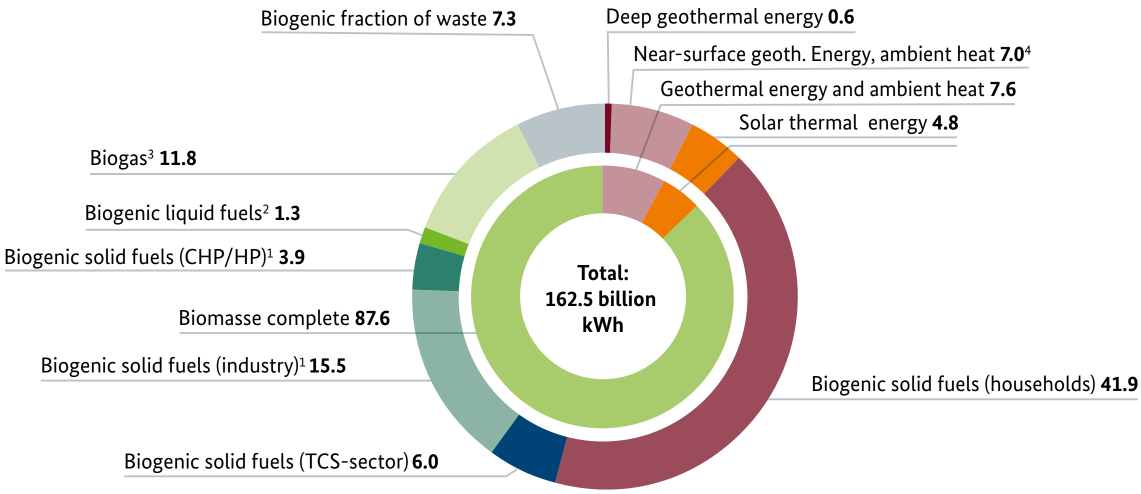
1 Mostly wood, incl. wood pellets
2 Data for TCS available from 2015; TCS = trade, commerce and service sector
3 In accordance with Section 8 Energy Statistics Act, incl. sewage sludge;
4 In accordance with Section 3 and 5 Energy Statistics Act, incl. sewage sludge; HP = heating plants, CHP plant = combined heat and power plant
5 Incl. consumption of biodiesel in agriculture
6 Incl. biomethane
7 Biogenic share of waste in waste incineration plants estimated at 50%
8 Renewable heat from heat pumps (air/water, water/water, brine/water, process water and gas heat pumps)
9 1 GWh = 1 million kWh
10 Relates to final energy consumption for ambient heat, hot water, process heat, air conditioning and process cooling, 2016: 1,251.0 billion kWh; 2015: 1,197.4 billion kWh according to data from AGEB [2]

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

Note:
'Final energy consumption for heat generation' also includes energy consumption from renewable energy sources used for cooling.

Figure 12: Heat consumption from renewable energy sources in 2016

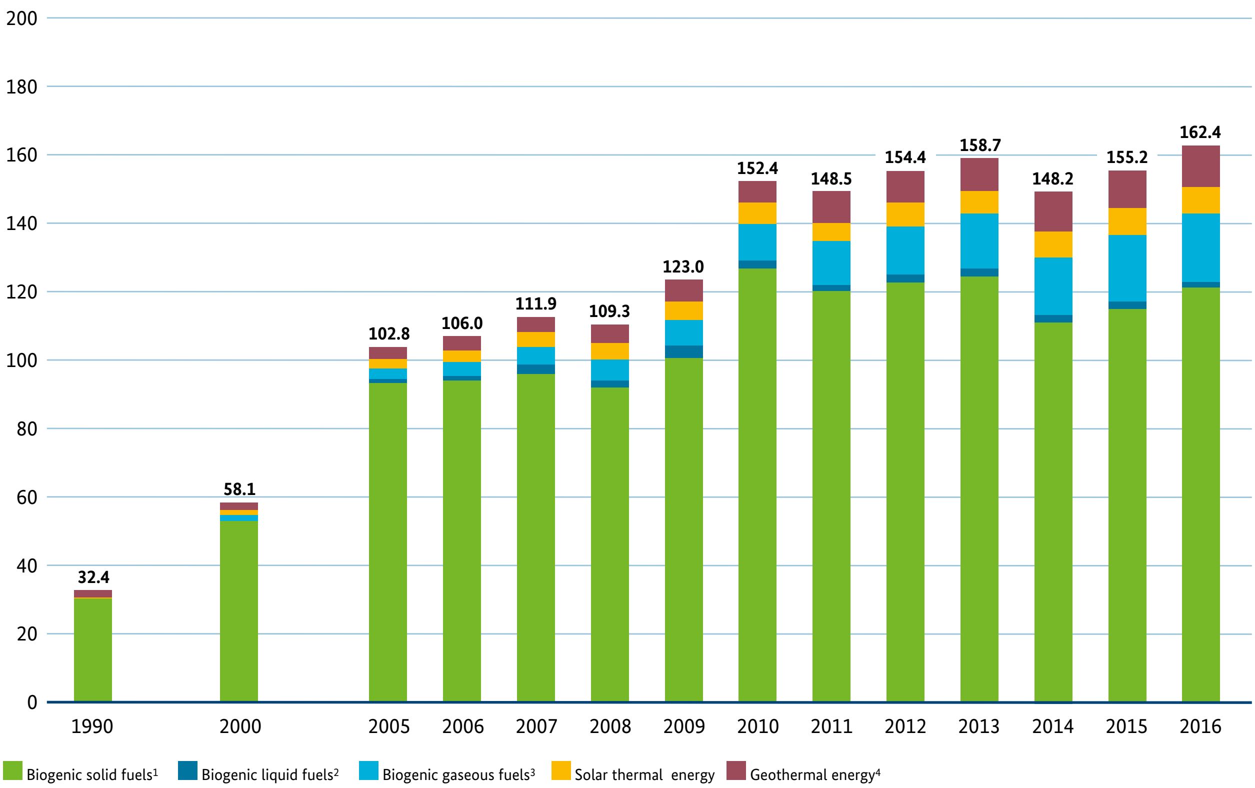
in percent



1 Incl. sewage sludge
2 Incl. consumption of biodiesel in agriculture
3 Biogas, biomethane, sewage and landfill gas
4 Including heat from deep geothermal energy and renewable heat from heat pumps (air/water, water/water, brine/water, service water and gas heat pumps)
Data for trade, commerce and service sector (TCS) available from 2015 onwards.
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 14, provisional figures

Figure 13: Heat consumption from renewable energy sources

in billion kWh



1 Incl. biogenic share of waste; also incl. sewage sludge from 2010; data for trade, commerce and service sector (TCS) only available from 2003 onwards
2 Incl. consumption of biodiesel in agriculture
3 Biogas incl. biomethane, sewage and landfill gas
4 Including heat from deep geothermal energy and renewable heat from heat pumps (air/water, water/water, brine/water, service water and gas heat pumps)
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 14, some figures provisional

Figure 14: Heat consumption from renewable energy sources

	Solid Biomas[1]	Liquid Biomass[2]	Gaseous Biomass[3]	Solarthermal energy	Near-surface geoth. Energy, ambient heat[4]	Total FEC heat	E share of FEC of heat
			(GWh)[5]			(GWh)[5]	(%)
1990	30,573	–	–	130	1,677	**32,380**	**2.1**
2000	53,604	8	1,355	1,290	1,808	**58,065**	**4.4**
2005	93,296	709	2,974	3,031	2,759	**102,769**	**8.0**
2006	94,567	1,275	3,293	3,554	3,268	**105,957**	**8.0**
2007	96,492	1,872	5,581	3,945	3,968	**111,858**	**9.5**
2008	91,999	2,645	5,422	4,490	4,763	**109,319**	**8.5**
2009	101,041	3,251	7,517	5,276	5,883	**122,968**	**10.4**
2010	126,546	3,151	10,175	5,633	6,852	**152,357**	**11.5**
2011	119,712	2,429	12,077	6,442	7,846	**148,506**	**12.2**
2012	122,931	2,015	14,074	6,696	8,715	**154,431**	**12.6**
2013	124,364	2,053	15,947	6,767	9,539	**158,670**	**12.4**
2014	110,752	2,217	17,258	7,287	10,655	**148,169**	**12.9**
2015	115,140	2,089	18,862	7,806	11,320	**155,217**	**13.0**
2016	121,061	2,052	19,138	7,801	12,348	**162,400**	**13.0**

1 Incl. biogenic share of waster (in waste incineration plants estimated at 50%); The decrease in heat consumption in 2008 compared with the preceding year is due to a change in data collection methods which does not permit any conclusions about the actual increase in use; incl. sewage sludge from 2010 onwards; data for TCS sector (trade, commerce and service) only available from 2003 onwards

2 Incl. consumption of biodiesel in agriculture

3 Biogas incl. biomethane, sewage and landfill gas

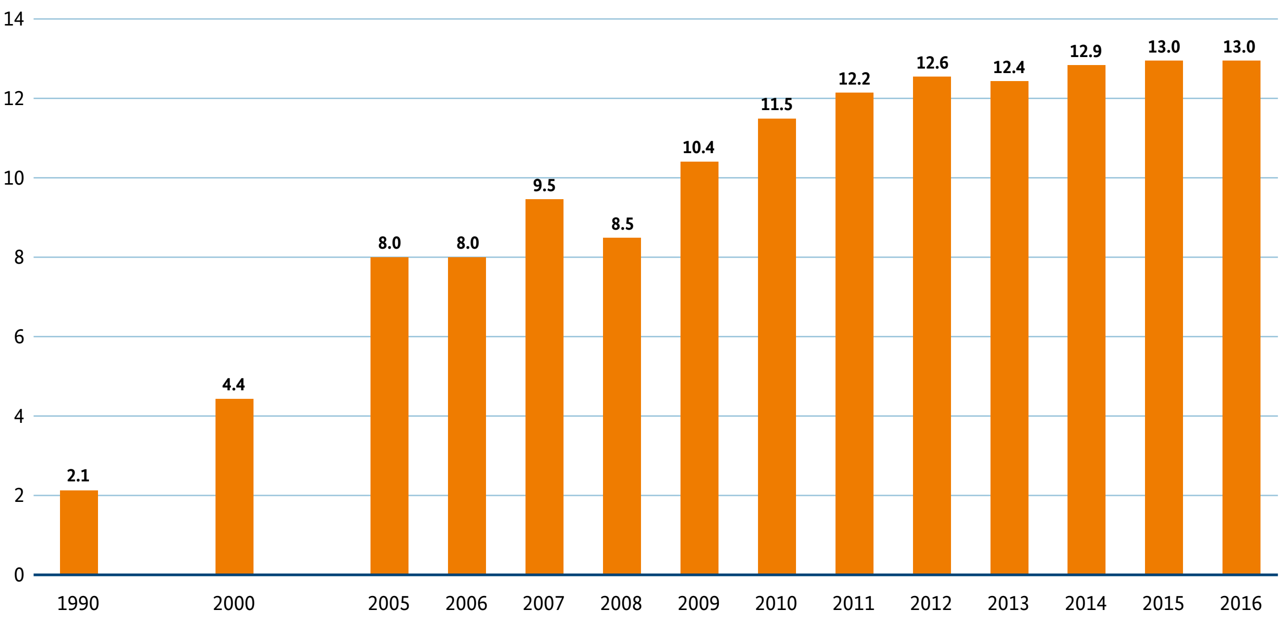
4 Including heat from deep geothermal energy and renewable heat from heat pumps (air/water, water/water, brine/water, service water and gas heat pumps)

5 1 GWh = 1 billion kW

Sources: Federal Ministry for Economic Affairs and Energy (BMWi) based on data from AGEE-Stat; ZSW; AGEB [1], [5], [10]; BMWi; StBA; DBFZ; GeotIS [9]; GZB [11]; RWI; BDH; BSW; DEPV; BWP; IEA/ESTIF [12], some figures provisional

Figure 15: Share of renewables in heat consumption

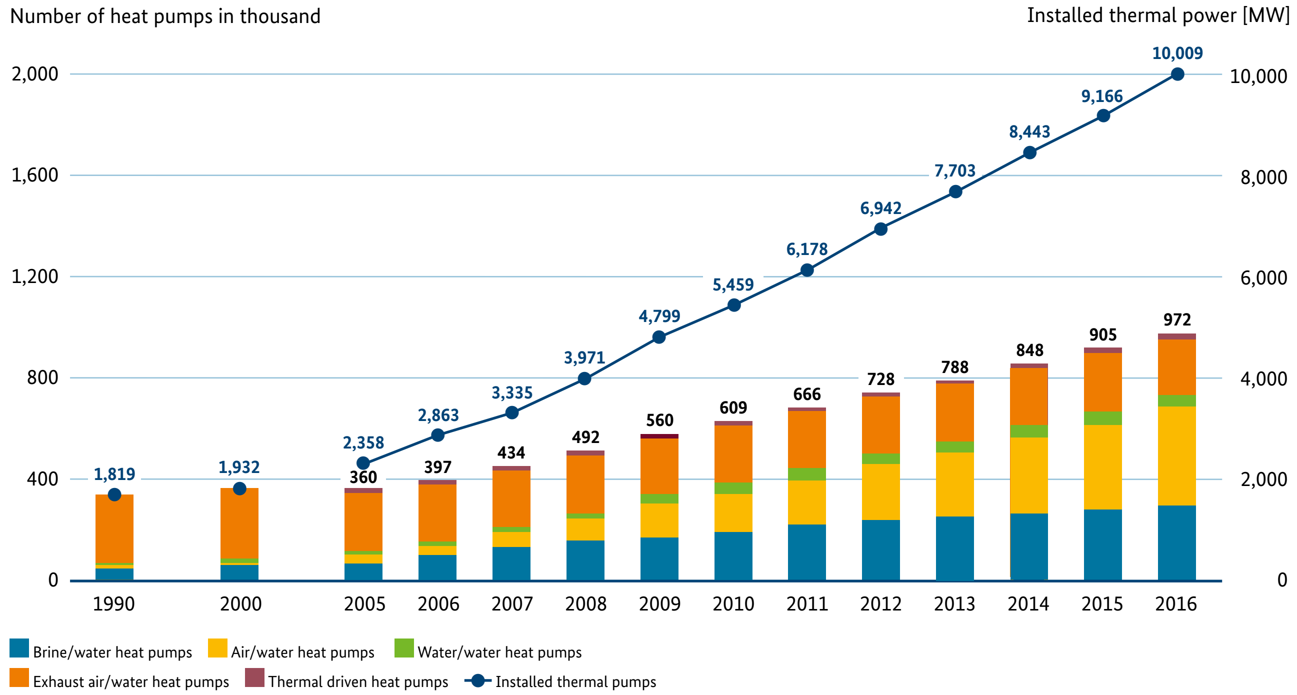
in percent



Under the 2012 Renewable Energy Heat Act (EEWärmeG), renewable energy must make up 14% of final energy consumption for heating and cooling by 2020.

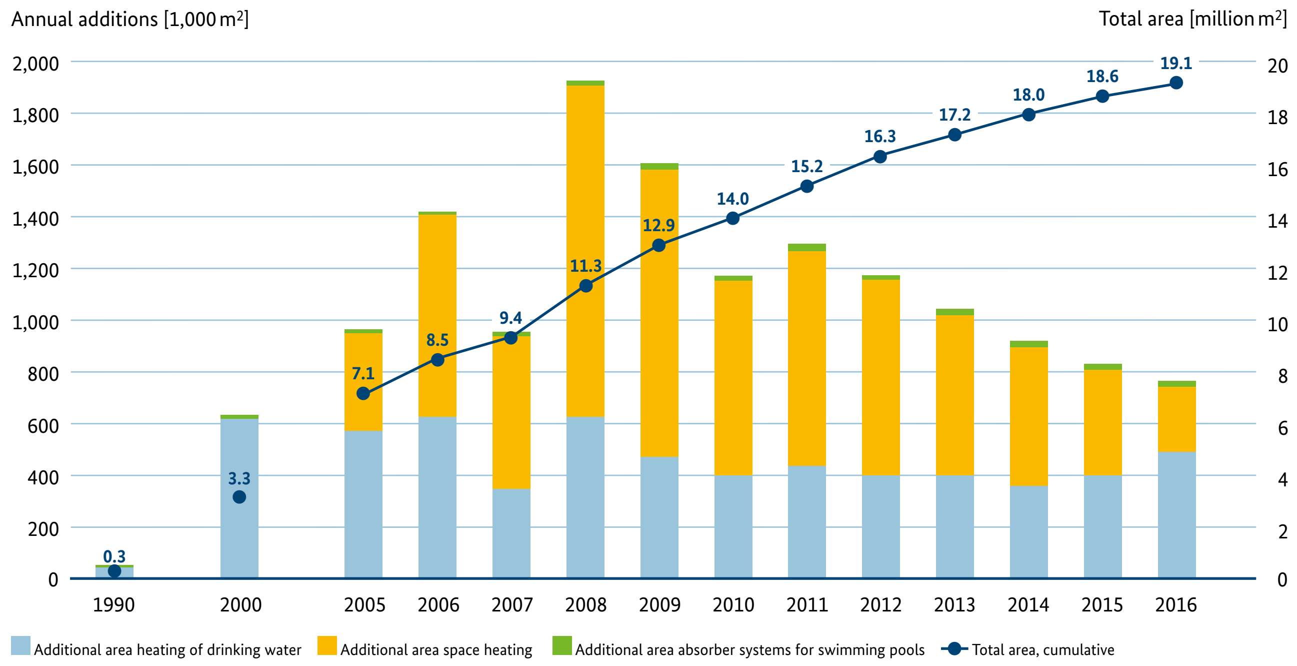
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 14, some figures provisional

Figure 16: Development of heat pump stock



Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat, ZSW; GZB [11]; BWP

Figure 17: Additions to and capacity of solar collectors (solar heat)



Figures account for 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 18: Solar-based heat: area and heat generation capacity of solar collectors in Germany

		1990	2000	2005	2006	2008	2010	2011	2012	2013	2014	2015	2016
Cumulative area	(1,000 m²)	348	3,251	7,099	8,501	11,330	14,044	15,234	16,309	17,222	17,987	18,625	19,122
Cumulative output	(MW)	243	2,312	5,058	6,049	8,063	10,006	10,909	11,728	12,456	13,100	13,681	14,217

Figures account for old installations taken out of service
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat, ZSW; BDH; BSW; IEA/ESTIF [12]

Transport

Sales of biofuels stable

In 2016, sales of biofuels totalled 3.2 million tonnes, remaining at the same level as the preceding year. Within this figure, sales of biodiesel and sales of bioethanol remained more or less constant. Sales of biomethane experienced a slight year-on-year increase, climbing to 27,000 tonnes.

This was due to a change in funding system in 2015 – from a system using an energy-based quota (6.25% in 2014) to one using a greenhouse gas quota. For 2015 and 2016, the greenhouse gas quota was set at 3.5%. This was reflected in the consumption of biofuels, which remained largely unchanged.

In 2016, the use of green electricity in the transport sector totalled 3.6 billion kilowatt hours – up just slightly over the preceding year. This largely corresponds with the very slight increase in the share of renewable energy in Germany's electricity mix that year. The share of renewable energy in total final energy consumption in transport (consumption of petrol and diesel fuels, liquefied gas, natural gas and electricity in rail and road transport plus aviation gasoline and jet fuel in Germany) thus fell in 2016 for the second year in succession, declining to 5.2% (2015: 5.3%).

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Figure 19: Consumption of renewable energy sources in the transport sector in 2015 and 2016

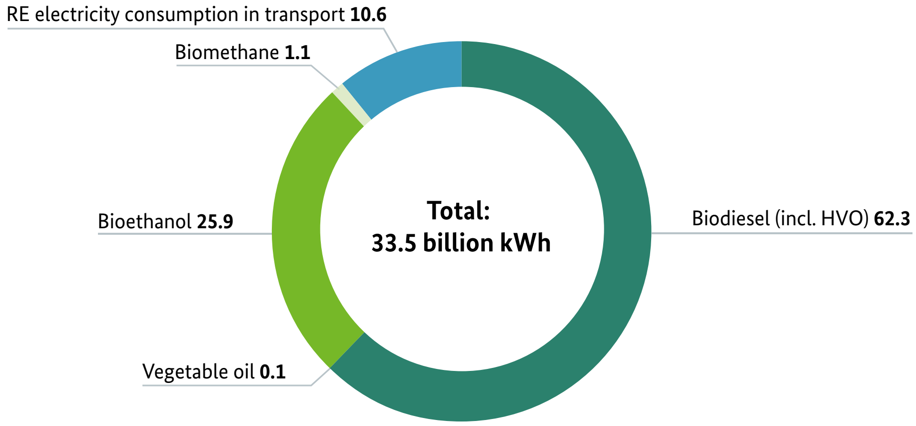
	Renewable energy sources 2016		Renewable energy sources 2015	
	Final energy consumption of transport (GWh)[3]	Share (%) of FEC of transport[4]	Final energy consumption of transport (GWh)[3]	Share (%) of FEC of transport[4]
Biodiesel[1]	20,873	3.2	20,840	3.3
Vegetable oil	42	0.01	21	0.003
Bioethanol	8,663	1.3	8,648	1.4
Biomethane	370	0.1	345	0.1
RE electricity consumption in transport[2]	3,566	0.5	3,553	0.6
Total	**33,514**	**5.2**	**33,407**	**5.3**

1 Consumption of biodiesel (incl. HVO) in the transport sector, excl. use in agriculture
2 For share of renewables in electricity in 2016, see Figure 6, ZSW as cited by AGEB [1], [2], [4], BDEW
3 1 GWh = 1 million kWh
4 Based on final energy consumption in transport, 2016: 649.7 billion kWh; 2015: 635.8 billion kWh, ZSW as cited by BAFA and AGEB [1], [2]

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 24, some figures provisional

Figure 20: Consumption of renewable energy sources in the transport sector in 2016

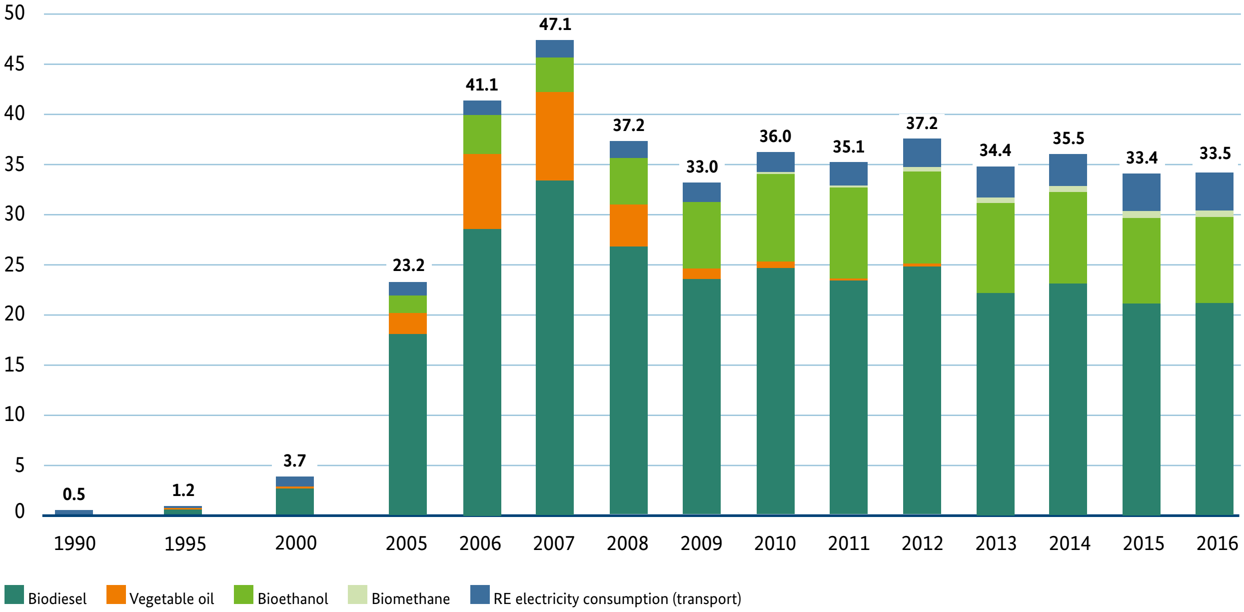
in percent



Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 23, provisional figures

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

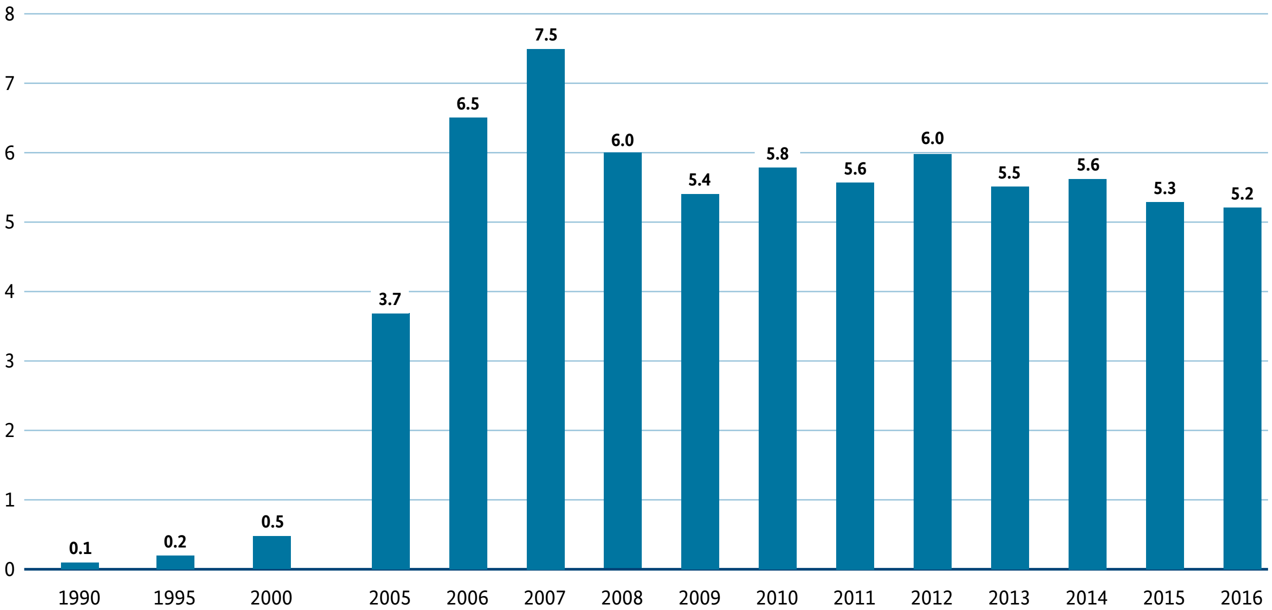
final energy consumption for transport in billion kWh



Source: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 23, some figures provisional

Figure 22: Share of renewable energy in final energy consumption in transport

share in percent



Under EU Directive 2009/28/EC, renewable energy must account for 10% of final energy consumption in the transport sector by 2020.
This chart does not count biofuel produced from waste or residues and electricity twice. The denominator also includes the domestic consumption of liquefied gas, natural gas, aviation gasoline and jet fuel as well as total electricity consumption in the transport sector.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; AGEB [1], [2]; BAFA; BMUB and other sources, see Figure 23, some figures provisional

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

	Biodiesel[1]	Vegetable oil	Bioethanol	Biomethane	RE electricity consumption	Final energy consumption of transport	Share of FEC of transport
			(GWh)[2]			(GWh)[2]	(%)
1990	–	–	–	–	465	**465**	**0.1**
			–	–			
2000	2,583	167	–	–	986	**3,736**	**0.5**
			–	–			
2005	18,046	2,047	1,780	–	1,343	**23,216**	**3.7**
2006	28,364	7,426	3,828	–	1,475	**41,093**	**6.5**
2007	33,182	8,752	3,439	–	1,743	**47,116**	**7.5**
2008	26,630	4,188	4,673	4	1,682	**37,177**	**6.0**
2009	23,411	1,044	6,669	13	1,896	**33,033**	**5.4**
2010	24,474	637	8,711	75	2,060	**35,957**	**5.8**
2011	23,244	209	9,090	92	2,467	**35,102**	**5.6**
2012	24,530	261	9,208	333	2,840	**37,172**	**6.0**
2013	21,998	10	8,891	483	3,008	**34,390**	**5.5**
2014	22,760	63	9,061	449	3,163	**35,496**	**5.6**
2015	20,840	21	8,648	345	3,553	**33,407**	**5.3**
2016	20,873	42	8,663	370	3,566	**33,514**	**5.2**

1 Consumption of biodiesel (incl. HVO) in the transport sector
2 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; BMF [13]; DIW [14]; Federal Government [15]; BAFA; BMUB; StBA [16]; DBFZ; AGQM; UFOP; Federal Government [17], [18], [19]; FNR; Office for Biofuel Quotas, some figures provisional

Figure 24: Consumption of renewables-based fuels in the transport sector

	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
							(1,000 Tonnen)						
Biodiesel[1]	250	1,749	2,749	3,216	2,581	2,269	2,372	2,263	2,314	2,064	2,156	1,999	2,003
Vegetable oil	16	196	711	838	401	100	61	20	25	1	6	2	4
Bioethanol	0	238	512	460	625	892	1,165	1,233	1,249	1,206	1,229	1,173	1,175
Biomethane[2]	0	0	0	0	0	1	6	7	25	36	33	25	27
Total	**266**	**2,183**	**3,972**	**4,514**	**3,607**	**3,262**	**3,604**	**3,523**	**3,613**	**3,307**	**3,424**	**3,199**	**3,209**

1 Consumption of biodiesel (incl, HVO) in the transport sector
2 Calculated using a calorific value of 50 MJ/kg in accordance with EU Directive 2009/28/EC

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources, see Figure 23, some figures provisional

Emissions avoided through the use of renewable energy sources

Renewable energy growth plays a significant role in meeting our climate targets. Emissions with a total global warming potential (GWP) of approximately 160 million tonnes of CO_2 equivalent were avoided in 2016. The power sector accounted for just under 119 million tonnes of these savings. Emissions of around 35 million tonnes were avoided in the heat sector and, through the use of biofuels in transport, some 6 million fewer tonnes of CO_2 equivalent were emitted (Figure 25).

The results for electricity and heat depend heavily on the specific fossil and nuclear fuels that the renewable energy sources replace. The current figures also take account of the difference in efficiency between renewables-based heating installations and those based on conventional energy sources. The emissions avoided through the use of renewables to generate heat are therefore accordingly lower.

In order to calculate the volume of greenhouse gas emissions that were avoided in the electricity sector, updated technology-specific substitution factors were used. For the first time, the calculation model employed also enables the geographical location to be identified where the emissions were avoided. This shows that roughly two-thirds of the greenhouse gas emissions that were avoided in gross electricity generation from renewables accrue to Germany, and around one-third are accounted for by a shift in generation in neighbouring countries [20].

The emissions balance for the use of biomass also depends on the nature and provenance of the raw materials [22]. 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. Due to a lack of data, it was not however possible to take account of indirect displacement effects.

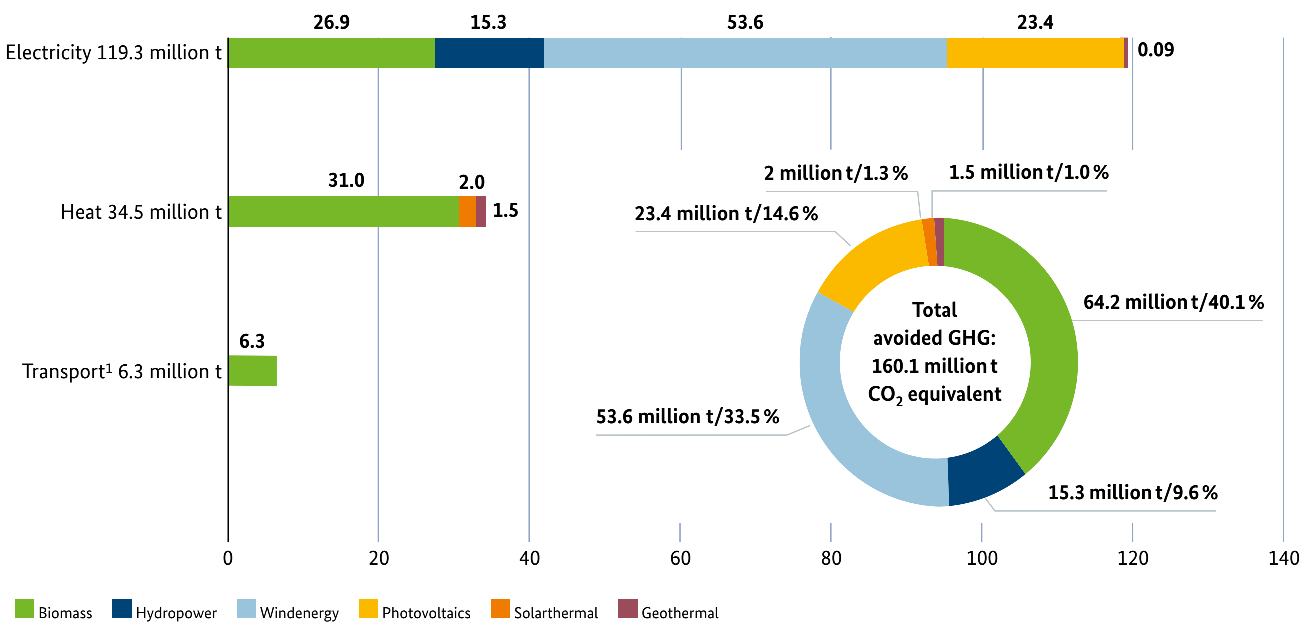
For the first time following the introduction of the greenhouse gas quota, the calculation of emissions from biofuels is based on self-assessment and estimates of the level of greenhouse gas emissions (incl. the raw materials base), as published by the Federal Office for Agriculture and Food in its annual Evaluation and Progress Report on the Biofuel/ Biomass Electricity Sustainability Ordinance [23]. 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, and also taking into account the findings of the research project 'BioEm' [22] and other expertise, as well as various assumptions and analogous conclusions.

Overall, it can be estimated that due to the general use of the regional NUTS2 values for biomass cultivation and the way in which the use of methanol in biodiesel production has been calculated thusfar, together with the requirements for substituting carbon dioxide emissions from fossils through those from biogenic fuels, the figures for the reduction in emissions based on the use of biofuels can be assumed to be optimistic.

The sharp increase in the use of energy crops in Germany went hand-in-hand with both direct and indirect changes in land use, which caused carbon dioxide emissions to rise. (Under the sustainability ordinances that have been put in place, direct changes in land use for the purposes of producing biofuels and bioliquids have been banned since

Figure 25: Net balance of the greenhouse gas emissions avoided through the use of renewable energy sources in 2016

in million t CO_2 equivalent



1 biofuels in the transport sector

Sources: Federal Environment Agency, [21] based on the sources quoted therein, provisional figures

Note:
For a detailed explanation of the basic methodology used to calculate the emission balances for renewable energy sources, please see the Federal Environment Agency publication Emissionsbilanz erneuerbarer Energieträger – Bestimmung der vermiedenen Emissionen 2016 (in German) [21].

2011.) However, it is difficult to quantify any indirect effects. As a consequence, these changes have not been taken into account in calculating emission balances to date. Model-based calculations indicate that indirect changes in land use in particular can cause significant greenhouse gas emissions and actually partially or fully cancel out greenhouse gas emissions savings generated, for instance, by individual biofuels. In future, fuel suppliers will also take into account such figures as the average preliminary estimates for emissions resulting from indirect changes in land use when they report greenhouse gas emissions per unit of energy and other similar statistics. In its latest Renewable Energy Progress Report, the European Commission also includes the average provisional estimates for indirect land-use changes in Annex VIII of Directive 2009/28/EC, in the context of its reporting on the level of greenhouse gas emissions that have been avoided [24]. As a result, savings in greenhouse gas emissions linked to biofuels reported by the Member States for 2015 decreased between 40% and 80% [25]. In November 2016, the Commission presented proposals for a gradual reduction in the share of biofuels produced from food crops after 2020, as part of its legislative initiatives on clean energy for all Europeans.

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 and nuclear energy sources having been replaced with renewables. All upstream process chains involved in the production and supply of the various energy sources and in plant construction and operation (but not dismantling) are also taken into account.

Figure 26 shows the balance for greenhouse gas emissions and air pollutants. Greenhouse gas abatement is particularly high in the electricity generation segment. The balances are negative for precursors of ground-level ozone. This is mainly due to the use of biogas. Emissions 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.

Figure 26: Net emissions balance for renewable energy sources used in electricity, heat and transport in 2016

		Renewables-based electricity generation total: 188,216 GWh		Renewables-based heat consumption total: 162,400 GWh		Renewables-based consumption for transport total: 29,948 GWh[5]		Total
	Greenhouse gas/ Air pollutant	Avoidance factor	Avoided Emissions	Avoidance factor	Avoided Emissions	Avoidance factor	Avoided Emissions	Avoided Emissions (total)
		(g/kWh)	(1,000 t)	(g/kWh)	(1,000 t)	(g/kWh)	(1,000 t)	(1,000 t)
Greenhouse-effect[1]	CO_2	613	115,455	158,234	35,590	240	7,189	158,234
	CH_4	1.13	212	189	-20	-0.10	-3	189
	N_2O	-0.03	-5	-10	-2	-0.09	-3	-10
	CO_2-equivalent	634	119,251	160,054	34,487	211	6,316	160,054
Acidification[2]	SO_2	0.14	27	40	13	0.01	0.4	40
	NO_X	0.07	12	-24	-30	-0.19	-6	-24
	SO_2-equivalent	0.19	35	23	-8	-0.12	-4	23
Ozone[3] Particles[4]	CO	-0.43	-81	-3.49	-563	-0.02	-0.5	-645
	NMVOC	0.00	-0.4	-0.19	-31	0.03	0.8	-31
	Particles	0.003	0.6	-0.13	-22	-0.01	-0.3	-21

1 Other greenhouse gases (SF_6, HFCs, partially HFCs) are not included
2 Other air pollutants (NH_3, HFCs, partially HFCs) 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 electricity consumption in the transport sector

Source: Federal Environment Agency (UBA) [21] based on the sources quoted therein

Reduction in the use of fossil fuels thanks to renewable energy

Figures 27 and 28 show the amount of fossil fuels saved by using renewable energy sources for electricity, heat and transport in 2016 and from 2007 to 2016. Total savings have risen continuously in recent years.

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

Being a country that is poor in resources, Germany still had to import 97% of its oil and just under 91% of its natural gas in 2016. Relying on energy imports can carry a certain level of risk, depending on the country of origin. This relates to the quantity of imports available (loss of producers due to disaster or war) and to price (unexpected rises in prices). Renewable energy sources can greatly reduce reliance on imports and improve energy security.

Figure 27: Primary energy savings due to the use of renewables in 2016

	Lignite	Hard coal	Natural gas	Petroleum/ heating oil	Diesel fuel	Petrol	Total
			Primary energy (billion kWh)				
Electricity		267.4	126.5				**393.9**
Heat	11.9	12.9	61.9	50.5	0.6		**137.7**
Transport			0.4		12.3	**7.4**	**20.1**
Total	**11.9**	**280.2**	**188.8**	**50.5**	**12.9**	**7.4**	**551.7**
			Primary energy (PJ)				
Total	**42.8**	**1,008.8**	**679.6**	**181.8**	**46.5**	**26.7**	**1,986.2**
Which corresponds to[1]:	3.6 million t[2]	37.3 million t[3]	19,316 million m^3	5,088 million litres	1,297 million litres	822 million litres	

The savings in fossil fuels are calculated using the same methodology as is used to calculate emission balances, see UBA [21].

1 Savings in primary energy savings were calculated using the net calorific values determined by AGEB [10].

2 Including approx. 2.7 million t hard coal, approx. 0.2 million t hard coal briquettes and approx. 0.6 million t pulverised coal

3 Including approx. 37.2 million t hard coal and approx. 0.1 million t coke from hard coal

Source: Federal Environment Agency (UBA) [21] based on the sources quoted therein

Figure 28: Fossil fuel savings resulting from the use of renewables

	Electricity	Heat	Transport	Total
		Primary energy (billion kWh)		
2007	193.2	91.8	24.3	**309.3**
2008	203.7	89.6	18.7	**312.0**
2009	198.9	102.4	16.1	**317.5**
2010	214.5	128.3	17.8	**360.6**
2011	261.6	126.6	18.7	**406.9**
2012	300.5	129.7	22.0	**452.2**
2013	319.2	133.7	21.0	**473.9**
2014	337.0	127.2	21.5	**485.8**
2015	391.7	132.4	20.0	**544.1**
2016	393.9	137.7	20.1	**551.7**

Source: Federal Environment Agency (UBA) [21] based on the sources quoted therein

Volumes of electricity pursuant to the Renewable Energy Sources Act (RES Act)

The Renewable Energy Sources Act was adopted on 1 April 2000. It is the central instrument for developing renewable energy for power generation. The RES Act is built upon the core elements of guaranteed feed-in tariffs for renewable electricity and priority for the feeding of green electricity into the electricity grid before all other types of electricity.

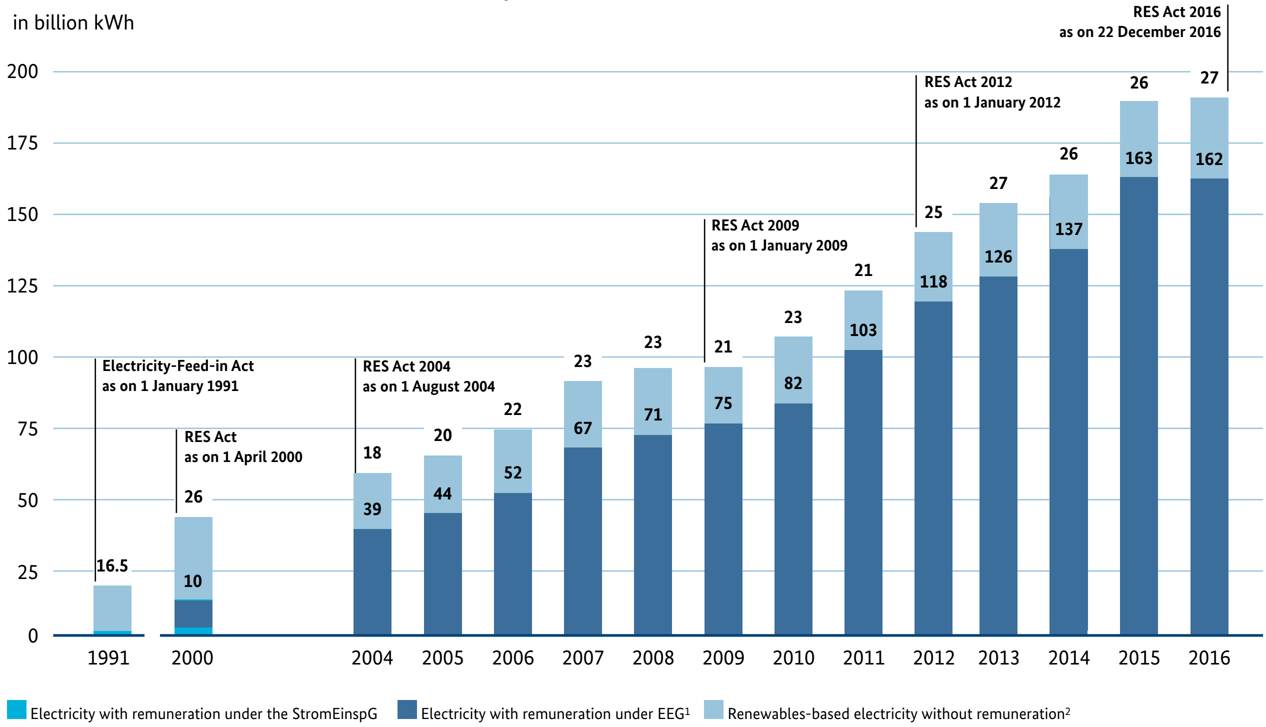
The Act has already been amended several times in order to take account of technological developments and to increasingly bring renewable energy onto the market. The shift towards the use of auctions under the 2017 amendment of the RES Act and the Offshore Wind Energy Act has recently come into effect. This means that feed-in tariffs for photovoltaics, onshore and offshore wind, and biomass installations that exceed a certain size are now determined based upon competition.

The RES Act has so far proven a most effective instrument in promoting greater use of renewable energy sources. Since the Act was first introduced back in 2000, the production of electricity from renewable energy sources has increased significantly, growing from 36 billion kilowatt hours to more than 188 billion kilowatt hours in 2016. This increase has been driven by onshore wind, photovoltaics, biomass, and in recent years, increasingly by offshore wind as well. Power generation based on photovoltaics, for example, has grown many times over, climbing from nearly 0.1 billion kilowatt hours in 2000 to over 38 billion kilowatt hours.

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 plants or 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 29. Since 2000, this electricity generation (for which a feed-in tariff is paid under the RES Act) has risen from around 10 billion kilowatt hours to 162 billion kilowatt hours in 2016.

More information is available on the website of the German Transmission Operators' information platform at www.netztransparenz.de and on the information platform operated by the Federal Ministry for Economic Affairs and Energy at www.erneuerbare-energien.de (see document EEG in Zahlen: Vergütungen, Differenzkosten und EEG-Umlage 2000 bis 2017 (in German only) under Recht und Politik>Erneuerbare-Energien-Gesetz (EEG)>EEG: Daten und Fakten).

Figure 29: 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 photovoltaics that is consumed on site, fed into the grid 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 transmission system operators (TSOs)

The renewable energy surcharge (EEG surcharge)

Operators of wind, solar, biomass and other installations entitled to remuneration under the RES Act generally market their own electricity or sell it via service providers. For the feed-in of this electricity, these operators receive a market premium from the grid operator. The market premium compensates for the difference between the feed-in tariff and the average trading price for electricity. Over the past few years, the market price for electricity has fallen by almost half, meaning that the market premium has increased significantly in order to offset this. The market premium is the main factor determining the level of financing needed for renewable energy and thus how high the EEG surcharge shall be.

Every 15 October, transmission system operators calculate the EEG surcharge for the coming year. The surcharge is based on forecasts made in accordance with the provisions of the Equalisation Scheme Ordinance (AusglMechV). 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).

Aggregate EEG surcharge = forcasted financing needs
in the following year
+ account settlement cost
(EEG account settled on 30 September)
+ liquidity reserve
(no more than 10 % of the funding costs)

The EEG surcharge rose in 2017 by 8% year-on-year. The main factor in this increase is the price of electricity on the spot market, which has fallen by almost 50% over the last 5 years. Market revenues for green electricity have therefore also sunk. In addition, remuneration costs have risen owing to the expansion of renewable energy, particularly offshore wind energy. The loss in market revenue and the higher remuneration resulted in a higher EEG surcharge.

As the RES Act guarantees remuneration for more than 20 years, there is a considerable cost burden linked to the EEG surcharge in the form of the remuneration payments be made on existing investments. A large proportion of existing installations was built between 2009 and 2012 and receive considerably higher rates of remuneration than those built since. This is because the cost of renewable energy has drastically fallen, meaning that new installations only need a fraction of the remuneration provided during that time. 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 RES Act. Under this system, the level of feed-in tariff for new renewables installations entitled to remuneration is determined via competitive auctions. The final feed-in tariffs determined in the first rounds of auctions for photovoltaics and onshore/offshore wind energy have therefore led remuneration rates to fall. These auctions also permit quantitative steering, ensuring that expansion targets are adhered to effectively. This has been done to make the continued expansion of renewable energy sources more predictable, reliable and, most importantly, more cost-effective.

In general the RES Act requires every electricity utility and self-consumer to pay the EEG surcharge. Electricity utilities routinely pass this cost on to the final consumer. However, it is beneficial to exempt some consumers from paying the EEG surcharge – namely, large energy-intensive companies that compete internationally, as well as railroad companies. The Special Equalisation Scheme was introduced in 2004 to minimise the impact of the EEG surcharge on the global competitiveness of large electro-intensive enterprises and the intermodal competitiveness of railroad companies [27].

In 2016, the scheme exempted a total of 2,162 companies that consume around 113 billion kilowatt hours of electricity from some of their EEG surcharges. This group accounts for roughly 24% 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; they have to pay a proportion of the EEG surcharge – 15% as a rule – and thus contribute to the funding provided under the RES Act.

All told, both privileged and non-privileged businesses in Germany together (those in the industrial sector as well as commerce, trade and services) pay just under half of the aggregate EEG surcharge in 2017 [28]. However, the exemptions still concentrate the aggregate EEG surcharge onto a smaller amount of electricity known as 'non-privileged final consumption'. For details, see Hintergrundinformationen zur Besonderen Ausgleichsregelung at the information platform www.erneuerbare-energien.de (in German only).

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. The forecast aggregate EEG surcharge for 2017 amounts to €24 billion and the (forecast) final consumption subject to the surcharge is 349 billion kilowatt hours. This produces a 2017 EEG surcharge of 6.88 cents per kilowatt hour.

$$\text{EEG surcharge} = \frac{\text{aggregate EEG surcharge}}{\text{non-privileged final consumption surcharge}}$$

The technologies that represent the largest share of the 2017 EEG surcharge are photovoltaics (38%), biomass (26%) and onshore wind energy (22%).

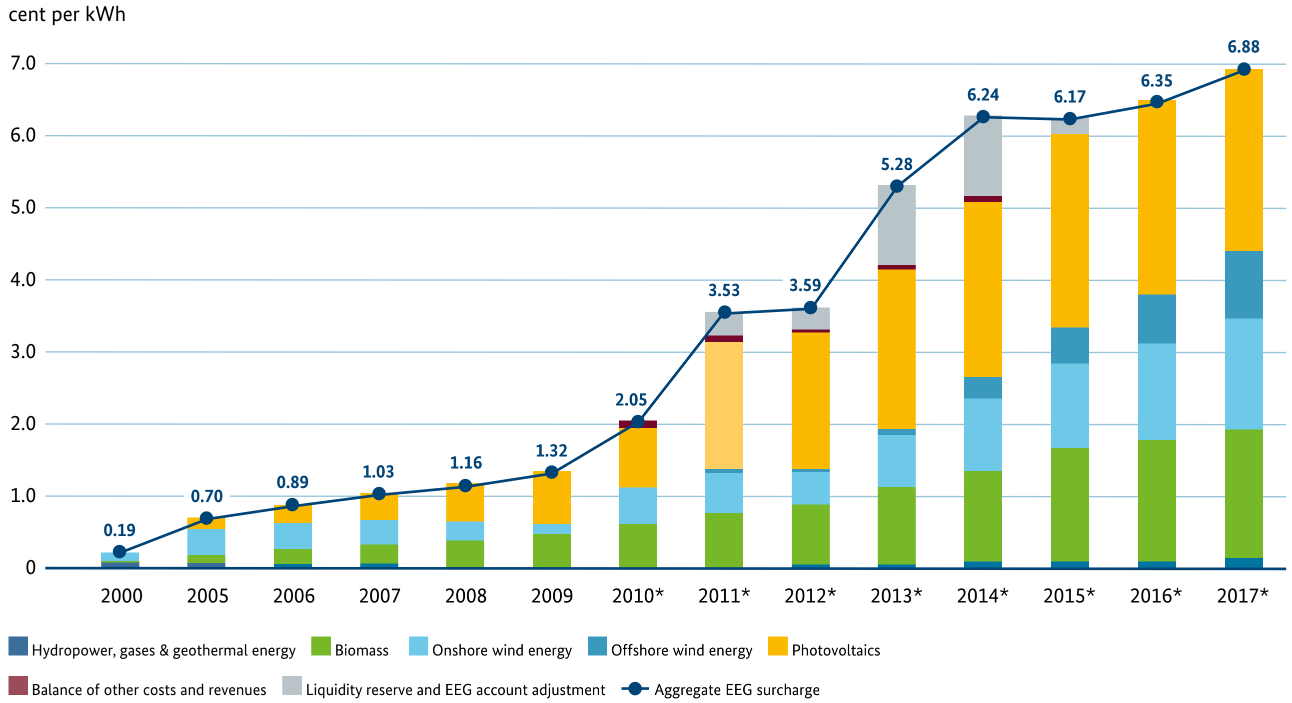
Economic impetus from the construction and operation of RE plants

Renewable energy as an economic factor

Investments in installations for the use of renewable energy are of considerable importance for Germany's economy, since a large part of the added value is generated in the country itself. From 2000, investment in renewable energy installations has risen steadily, peaking at just under €28 billion in 2010. By 2015, it had dropped back to €14.0 billion, but rose again in 2016, reaching €15.1 billion.

As in the preceding years, the segment with the greatest investment in 2016 was wind energy. At €10.1 billion, it accounted for two-thirds of total investment. Compared with the preceding year, investments in wind power (onshore and offshore) rose by around 11%. The growth in onshore wind installations more than offset the decline in offshore development. The sharp decline in total investment after 2010 was primarily due to the trend in photovoltaics which saw installation prices fall in 2011 and 2012 while new plants continued to be installed at an unchanged pace. Since 2013, however, prices have remained largely stable while the installation of new photovoltaics capacity has plummeted. Compared to the years 2007 to 2012 when investment in photovoltaics plants constituted between around 40% and 70% of total investment, this share fell

Figure 30: 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
* From 2010 onwards, transmission system operators' forecast of EEG surcharge in accordance with the Equalisation Scheme Regulation (AusglMechV), published on www.netztransparenz.de.
The item 'balance of other costs and revenues' includes the revenues from paying 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.
Source: Federal Ministry for Economic Affairs and Energy, based on data provided by the transmission system operators (TSOs); further information at http://www.erneuerbare-energien.de

right down to just under 11% by the year 2016. This corresponds to an investment volume of €1.6 billion.

Investment in the other fields (electricity and heat from biomass, hydropower, solar and geothermal heat) totalled €3.4 billion in 2016, or around 23% of total investment. Investments in installations based on the use of heat from biomass, solar thermal energy and hydropower fell slightly compared to the preceding year, while electricity generation from biomass and geothermal energy (incl. ambient heat) increased somewhat.

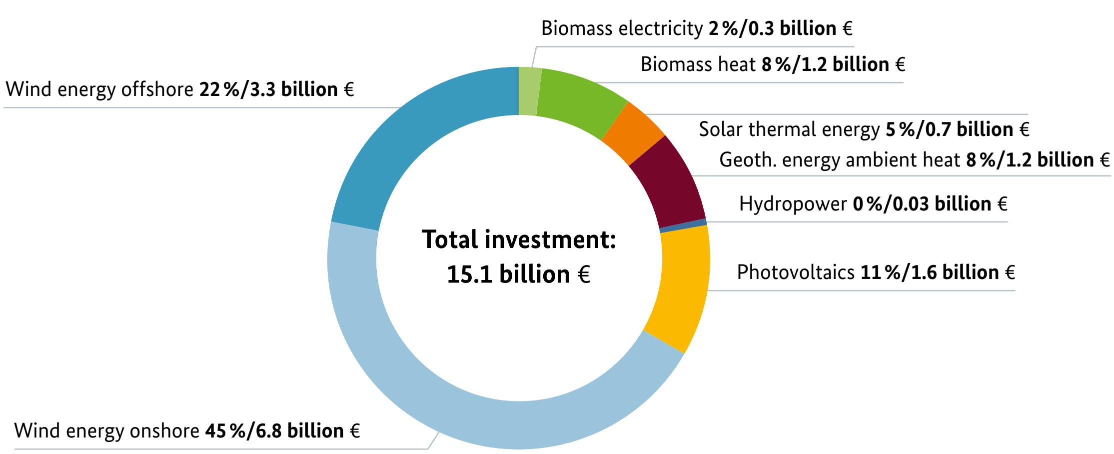
Price falls for renewable energy installations, especially photovoltaics installations, have meant that new installations generally cost less (in real terms) than in the preceding year. This means that the desired expansion has been attained at lower investment costs than in the past.

Figure 31: Investment in the building of renewable energy installations

	Hydropower	Wind energy onshore	Wind energy offshore	Photovoltaics	Solar thermal Energy	Geoth. energy, ambient heat	Biomass electricity	Biomass heat	Total
					(Billion €)				
2000	0.5	1.9	-	0.3	0.4	0.1	0.5	0.9	**4.7**
2005	0.2	2.5	-	4.8	0.6	0.4	1.9	1.5	**12.0**
2006	0.2	3.2	-	4.0	1.0	0.9	2.3	2.3	**14.0**
2007	0.3	2.5	0.03	5.3	0.8	0.9	2.3	1.5	**13.6**
2008	0.4	2.5	0.2	8.0	1.7	1.3	2.0	1.8	**17.7**
2009	0.5	2.8	0.5	13.6	1.5	1.2	2.0	1.6	**23.6**
2010	0.4	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	1.1	3.1	1.3	**26.2**
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	0.08	7.1	3.9	1.5	0.8	1.1	0.7	1.4	**16.4**
2015	0.06	5.4	3.7	1.6	0.8	1.0	0.2	1.3	**14.0**
2016	0.03	6.8	3.3	1.6	0.7	1.2	0.3	1.2	**15.1**

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

Figure 32: Investment in the building of renewable energy installations in 2016



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

Most – nearly 80 percent – of investment went towards electricity generation plants that qualify for payments under the RES Act. This portion rose by approx. 1.6 percentage points compared to the preceding year.

Stimulus from plant operation exceeds investment

In addition to construction, plant operation is a further economic factor. Due to the attendant need for personnel, electricity (ancillary energy), replacement parts and fuel, operating (and maintaining) plants sends economic impulses to other sectors as well. The operating expenses incurred by the operator lead to corresponding amounts of revenue for suppliers. The economic stimulus from plant operation has risen steadily in past years in tandem with the growing number of installations. For example, since 2000 revenues rose almost constantly, climbing from €2 billion to €15.6 billion in 2016. This means that the economic stimulus from plant operation again exceeded investment in installations as it did in the preceding year.

In contrast to the other renewable energy plants, biomass plants need fuel in order to generate electricity and heat. Because of these fuel costs, biomass plants account for the largest portion of the economic impulses resulting from plant operation. This is followed by the revenues generated by the sale of biofuels, and then the economic impulses from the operation of wind energy and photovoltaics installations, geothermal and ambient heat plants and hydropower and solar thermal installations. The economic impulses that are generated in the form of operating costs and/or revenues from the sale of biofuel provide a long-term boost to the economy because they are released continually over the entire life of the plants (usually 20 years) and increase with every additional plant that is installed.

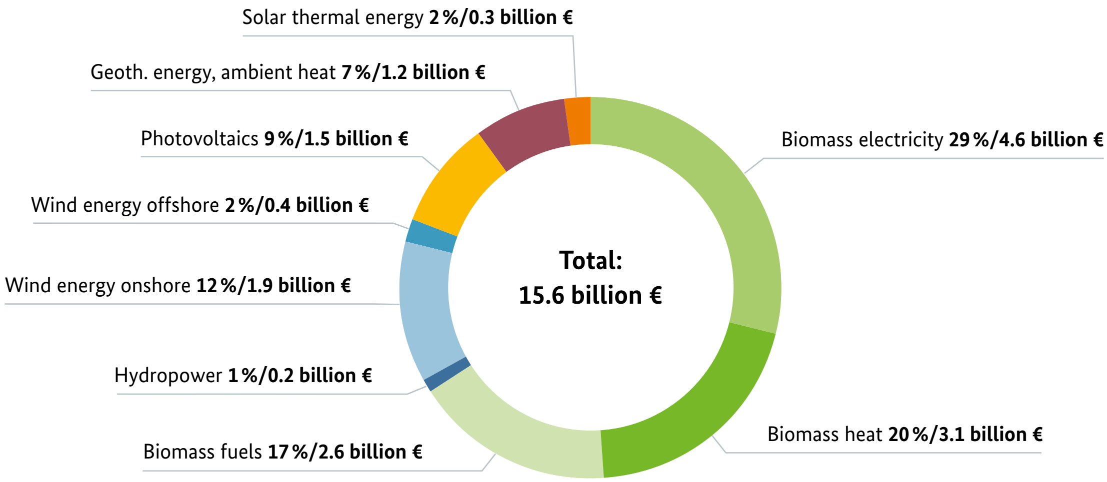
For more details on the method used in these calculations, see Information on methodology (Annex).

Figure 33: Economic impulses from the operation of renewable energy installations

	Hydropower	Wind energy onshore	Wind energy offshore	Photovoltaics	Solar thermal energy	Geoth. energy ambient heat	Biomass electricity	Biomass heat	Biomass fuels	Total
					(billion €)					
2000	0.1	0.2	–	0.01	0.00	0.2	0.2	1.2	0.2	**2.0**
2005	0.1	0.6	–	0.1	0.05	0.2	0.7	1.5	1.8	**5.0**
2006	0.1	0.6	–	0.2	0.07	0.3	1.1	1.7	3.2	**7.2**
2007	0.1	0.7	0.00	0.3	0.1	0.4	1.6	1.9	3.8	**8.8**
2008	0.2	0.8	0.00	0.4	0.1	0.4	1.9	2.0	3.5	**9.3**
2009	0.2	0.9	0.01	0.5	0.1	0.5	2.3	2.3	2.4	**9.3**
2010	0.2	1.0	0.02	0.8	0.2	0.6	2.8	2.7	2.9	**11.1**
2011	0.2	1.1	0.03	1.0	0.2	0.7	3.2	2.7	3.7	**12.8**
2012	0.2	1.2	0.06	1.3	0.2	0.8	3.9	2.9	3.7	**14.2**
2013	0.2	1.4	0.1	1.4	0.2	0.9	4.0	3.1	3.1	**14.4**
2014	0.2	1.6	0.2	1.4	0.2	1.0	4.3	2.8	2.7	**14.4**
2015	0.2	1.7	0.3	1.4	0.3	1.1	4.6	2.9	2.5	**14.9**
2016	0.2	1.9	0.4	1.5	0.3	1.2	4.6	3.1	2.6	**15.6**

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

Figure 34: Economic impulses from the operation of renewable energy installations in 2016



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

Promotion of renewable energy in the heating sector

Renewable Energies Heat Act

The purpose of this Act, which entered into force on 1 January 2009 and has since been repeatedly amended, is to enable the energy supply to develop in a sustainable manner, whilst still maintaining a reasonable economic approach and acting in the interest of mitigating climate change, conserving fossil resources and reducing dependency on energy imports, and to ensure that the technologies for generating electricity from renewable energy sources continue to be further developed. The Act is intended to help raise the share of renewable energy in energy consumption for heating and cooling to 14% by 2020.

The Renewable Energies Heat Act takes a two-fold approach: in Section 3, it addresses the obligation to use a certain proportion of renewable energy in the supply of heat to new buildings. Section 13, on the other hand, which provides for financial assistance (via the Market Incentive Programme) for measures to promote the use of renewable energy in the heat market, is mainly targeted at existing buildings.

In line with Section 18 of the Act, the Federal Government reports every four years on experience with the Act and submits proposals on its further development. The second Progress Report was published in November 2015. The developments so far show that the instruments of the Renewable Energies Heat Act are effective.

Energy saving requirements for buildings are not only set out in the Renewable Energies Heat Act (EEWärmeG), but also in the Energy Conservation Act (EnEV) and the Energy Savings Ordinance (EnEV). The Energy Conservation Act and the Renewable Energies Heat Act are to be brought together in a new act on energy in buildings, which is to put a uniform set of rules in place in which energy efficiency and the use of renewable energy in the building sector are integrated. These uniform rules will make it easier for energy saving requirements in buildings to be applied and implemented in practice. Under the EU Building Directive, a regulation setting out the nearly-zero energy standard is to be developed for new non-residential, public-sector buildings used by the authorities by the end of 2018 and for private new buildings by the end of 2020. This is to take into account the economic efficiency of effecting such requirements.

The Federal Ministry for Economic Affairs and Energy and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety have presented a draft Building Energy Act that embraces this new vision for energy saving law. Work on the bill is continuing [29].

The Market Incentive Programme

The Market Incentive Programme is intended to support the attainment of the goals of the Renewable Energies Heat Act by promoting sales of technologies which use renewable energy. The Programme is subject to ongoing evaluation by experts [30] in order to assess the impact of the funding. The Programme was revised in 2015, and the new 'Guidelines Promoting Measures for use of Renewable Energy in the Heating Market' [31] have been in force since 1 April 2015.

The Market Incentive Programme provides two kinds of support, depending on the type and size of the installation. For small installations, primarily in existing buildings, investment grants are made through the Federal Office for Economic Affairs and Export Control; such applications mainly come from private investors in the single-family or two-family homes segment. For larger installations, as well as for heat networks and storage, repayment grants are offered in the form of low-interest loans under the KfW Renewable Energies Programme ('premium' variant). Investments of this kind are mostly made in solutions for commercial or local government use.

From 2000 to 2016, the funding element of the investment grants (from the Federal Office for Economic Affairs and Export Control) amounted to approximately €1.42 billion of investment grants towards some 1.18 million solar thermal plants and approximately €781 million for some 411,000 small-scale biomass heating systems, e.g. pellet boilers. The resulting investment totalled about €10.48 billion in the solar segment and approximately €5.92 billion in the biomass segment.

Efficient heat-pump heating systems have been eligible for assistance since 2008. From 2008 to 2016, some 105,000 investment grants totalling roughly €281 million were disbursed. The resulting volume of investment totalled around €1.83 billion.

Under the second funding element of the Market Incentive Programme, the KfW Renewable Energy Premium programme, some 22,163 reduced-interest loans with repayment grants were approved between 2000 and 2016. The total volume of loans granted came to around €3.3 billion and the volume of repayment grants totalled some €814 million. This assistance was provided, for example, for solar thermal plants with large collector areas, biomass plants with relatively high outputs, deep geothermal plants, and for heating grids and heat storage facilities supplied with heat from renewable energy sources.

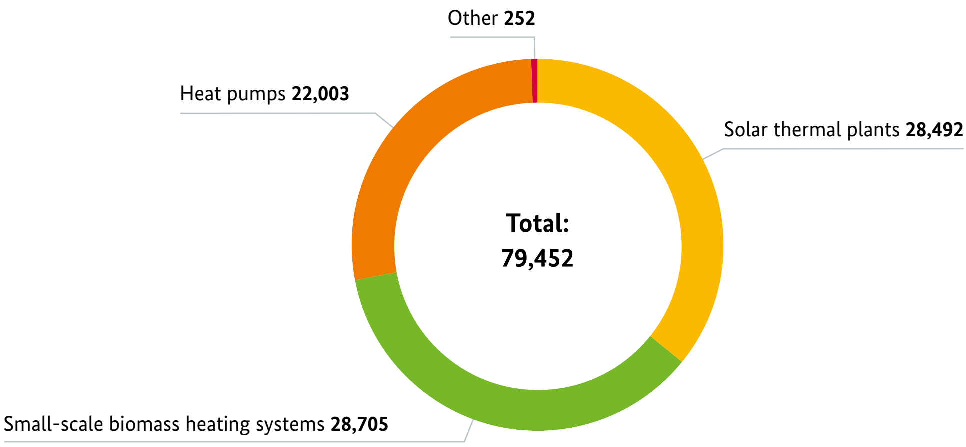
The number of approvals in 2016 for the two parts of the Market Incentive Programme (Federal Office for Economic Affairs and Export Control; KfW) are presented in figures 35 and 36.

More information on the Market Incentive Programme is available at the website operated by the Federal Ministry for Economic Affairs and Energy (BMWi) at www.bmwi.de and the Ministry's renewable energy information portal at www.erneuerbare-energien.de. Information on investment grants under the Market Incentive Programme is available from the Federal Office for Economic Affairs and Export Control (BAFA), www.bafa.de, and www.heizen-mit-erneuerbaren-energien.de.

Details on the KfW Renewable Energy Premium programme under the umbrella of the Market Incentive Programme are available on the KfW website at www.kfw.de.

Figure 35: Market Incentive Programme 2016 – Investment grants, share from Federal Office for Economic Affairs and Export Control (BAFA)

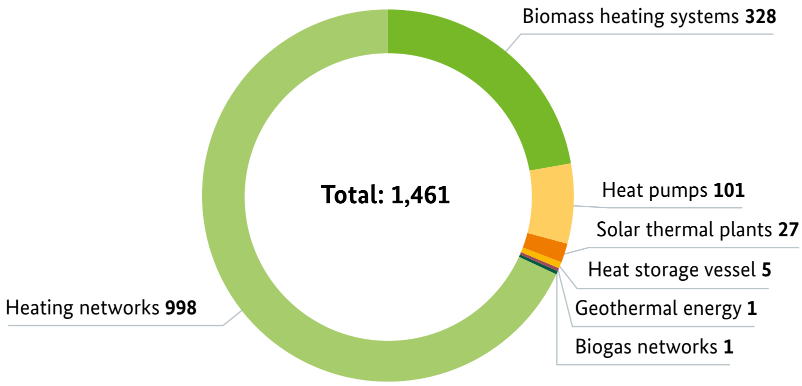
Number of approvals



Source: Federal Ministry for Economic Affairs and Energy

Figure 36: Market Incentive Programme 2016 – Repayment grants, share from KfW (KfW Renewable Energy Premium programme)

Number of approvals



Source: Federal Ministry for Economic Affairs and Energy

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 [32] found that considerable overfunding for biofuel had occurred in 2006 (the tax refund was much higher than the difference in production costs). For this reason, biofuel funding was shifted onto basis that would be viable and reliable in the long term by moving away from a purely tax-based to a purely regulatory support system [33] [34]. 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 to 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 marketed in Germany since the beginning of 2011 can only be (or were only able to be) subsidised via the biofuel quota or via taxes if they meet the requirements of the Biofuel Sustainability Ordinance (or if met these requirements by the end of 2015).

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 [25]. This is intended to ensure that the target for the use of biofuels and electric mobility of 10% in 2020, which applies equally to all EU Member States pursuant to Directive 2009/28/EC, will be attained.

The quantitative development in the various biofuels (see Figure 23) is closely related to the changes in funding arrangements since 2004. This can particularly be seen in the steady sales levels for biofuels in 2015 and 2016, which reflects the unchanged greenhouse gas reduction rate.

Electric mobility

Electric mobility is a central element of a climate-friendly transport policy. The Federal Government adopted a package of measures to promote electric mobility in 2016; the focus is on three measures with a financial impact: a temporary purchase grant for electric vehicles, the expansion of the charging infrastructure, and the purchase of electric vehicles by public authorities. The purchase grant is €4,000 for purely electric vehicles and €3,000 for plug-in hybrids; half of the funding comes from the Federal Government, and half from industry. It applies from 18 May 2016, and will continue until all the federal funding of €600 million has been disbursed; at the latest, it will expire in 2019.

The expansion of the charging infrastructure for electric vehicles is of key importance. The Federal Government has therefore approved a funding programme providing €200 million towards the construction of 5,000 additional quick-charge stations and €100 million for the construction of 10,000 new standard charging stations. Private investors, cities and municipalities can submit the appropriate grant applications from 1 March 2017 onwards.

Tax breaks are also being provided through the extension of the road tax exemption from 5 to 10 years for vehicles first registered between 1 January 2016 and 31 December 2020, as well as a tax exemption for the advantage gained where employers permit private electric vehicles to be charged up at work.

Promotion of renewable energy research and development

Providing funding for innovations in the renewables sector helps conserve scarce resources, reduce dependence on energy imports, and protect the environment and climate. Technical innovations improve plant reliability, reduce costs and ensure the security of energy supply as the share of green electricity in the German grid continues to grow.

Research and development projects on energy technology receive funding under the German government's Energy Research Programme. The Federal Ministry for Economic Affairs and Energy is responsible for providing the funding for applied research and development projects relating to renewable energy. Research and development also relates to site attractiveness and labour market conditions in order to strengthen both the competitiveness and the leading international position of German companies and research institutions.

The overarching aims of research funding are:

- to expand the use of renewable energy as part of the German government's sustainability, energy and climate policies,
- to significantly reduce the costs of heat and electricity generated from renewable sources,
- to make German companies and research institutions more competitive internationally and thereby create jobs with a future.

To achieve these aims, the Federal Ministry for Economic Affairs and Energy sets the following priorities:

- to optimise the German energy system to enable it to accomodate the growing share of renewable energy sources,
- to ensure the rapid transfer of know-how and technology from research to the marketplace,
- to ensure that renewable energy technologies are expanded in a way that is environmentally sound, e.g. by means of resource-conserving production methods (recycling-friendly plant design) and by supporting ecological research.

In 2016, the Federal Ministry for Economic Affairs and Energy approved a total of 442 new projects with an overall volume of nearly €301 million in the following fields: photovoltaics, geothermal energy, wind energy, SystEEm (integration of renewable energy sources and regenerative energy supply systems), low-temperature solar thermal energy, solar thermal power plants, marine energy, international cooperation and supporting ecological research (see Figure 37).

For more information, please see the Ministry's 2016 annual 'Innovation durch Forschung' (Innovation through Research) report. The website of Jülich (PtJ, www.ptj.de), the project management agency commissioned by the Federal Economic Affairs Ministry, includes information on funding and on applications for research funding programmes for renewable energy.

Figure 37: Newly approved projects for renewable energy technologies

	2013			2014			2015			2016		
	Number	1,000 €	Share in %	Number	1,000 €	Share in %	Number	1,000 €	Share in %	Number	1,000 €	Share in %
Photovoltaics	35	33,990	21.8	90	66,910	35.4	106	84,248	32.0	166	116,570	38.7
Wind energy	56	36,750	23.6	63	38,510	20.4	111	91,113	34.6	93	86,240	28.6
Geothermal energy	25	19,210	12.4	15	12,650	6.7	23	17,441	6.6	22	19,550	6.5
Low-temp. Solar thermal energy	25	9,945	6.4	15	6,500	3.4	21	9,675	3.7	24	12,900	4.3
Solar thermal power plants	14	8,650	5.6	22	7,440	3.9	17	3,845	1.5	13	8,900	2.9
SystEEm[1]	66	38,519	24.8	114	51,881	27.5	128	54,577	20.7	120	53,750	17.9
Cross-sectoral	16	4,101	2.6	12	2,673	1.4	0	0	0.0	0	0	0.0
Other	7	4,375	2.8	10	2,424	1.3	6	2,355	0.9	4	3,510	1.1
Total	**244**	**155,540**	**100.0**	**341**	**188,988**	**100.0**	**412**	**263,254**	**100.0**	**442**	**301,420**	**100.0**

1 SystEEm: Integration of renewable energy sources and regenerative energy supply systems

Source: Federal Ministry for Economic Affairs and Energy

Part II: Renewable energy in the European Union

The Directive 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, sets ambitious targets: by 2020, renewable sources are to account for 20% of gross final energy consumption and at least 10% of energy requirements in the transport sector.

Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources has been in force since 25 June 2009. It is 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 is to raise the renewables-based share of total gross final energy consumption in the EU from what was about 8.5% in 2005 to 20% in 2020.

To underpin the EU's 20% target, this Directive also lays down binding national targets for the 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, and therefore differ greatly. The national targets range from 10% for Malta to 49% for Sweden. Germany's national target is 18%. The calculation of the shares is based on certain rules: for example, power generation from hydroelectric and wind energy, which fluctuates across the year due to the weather, is standardised, i.e. calculated on the basis of average precipitation and wind conditions.

In addition, the Directive requires all Member States to use renewable sources to generate at least 10% of the energy consumed in transport. The calculation of the shares in the transport sector also follows certain rules, e.g. for the weighting of the various modes of transport. The arithmetic includes not only biofuels, but also other forms of renewable energy, such as renewables-based electricity consumed by electric vehicles or in rail transport.

When it comes to the development of national potential for achieving the respective target, the Directive primarily relies on the national funding schemes, and does not impose any further rules on the Member States with regard to their design. The Directive also introduced flexible cooperation mechanisms which give Member States the additional option of working together as needed in order to reach their targets. These cooperation mechanisms include the statistical transfer of renewable energy surpluses, joint projects to promote the use of renewable energy, and (partial) mergers of national incentive schemes of two or more Member States.

In addition, the Directive requires electricity generated from renewable sources to receive priority access to the grid. Also, it defines sustainability requirements for the use of biofuels and bioliquids for energy applications.

The Directive represents the first EU-wide regulation that covers all energy applications of renewable energy sources. As such, it provides a sound legal framework for making the necessary investments and thus a solid foundation for successfully expanding renewable energy capacity up to 2020.

As part of the 2030 Climate and Energy Framework, which was adopted in October 2014, the European Council laid down a binding EU target of achieving a minimum 27% share of renewable energy in 2030. This is to be implemented with the assistance of a revised European directive on the promotion of renewable energy for the period after 2020 and a regulation on governance of the energy union. The European Commission presented the respective proposals for this at the end of November 2016. Deliberations on these proposals in the EU Council of Ministers and in the European Parliament began in early 2017. The Federal Government is working to ensure that a robust legal framework is put in place which enables the common European target to be reliably achieved. The negotiations are not expected to be concluded before 2018.

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.

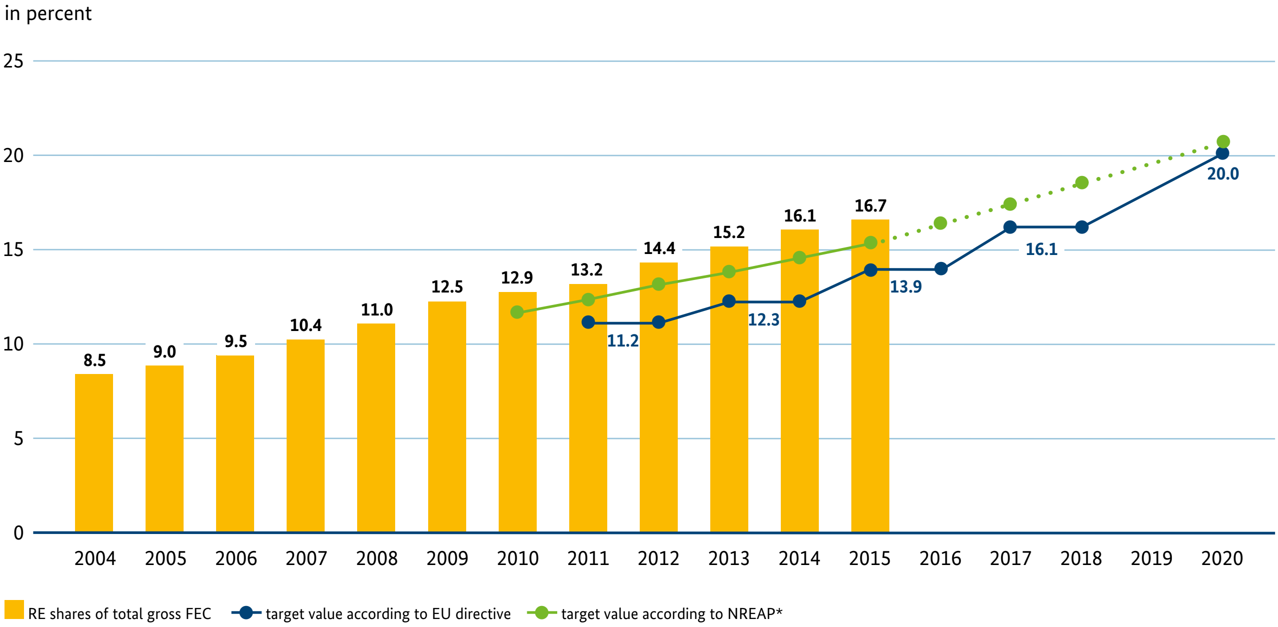
Progress reports pursuant to Directive 2009/28/EC

On the basis of the EU Directive on the promotion of the use of energy from renewable sources, Member States have adopted national action plans 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 published by the different Member States are available for download at https://ec.europa.eu/energy/node/70.

According to Eurostat [3], the share of renewable energy sources used in the European Union in 2015 was 16.7%. In 2004, this figure was just 8.5%. Since this year, the share of renewable energy in gross final energy consumption has therefore increased considerably across all Member States without exception. Of the 28 EU Member States, 11 Member States had reached their national targets for the year 2020 by 2015.

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 European Commission published its latest (fourth) progress report in February 2017 [25]. The report is available to download at https://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports.

Figure 38: Shares of renewable energy in gross final energy consumption in the EU in accordance with EU Directive 2009/28/EC



* The Energy Research Centre of 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) [3], ECN and Ökoinstitut [36]

Figure 39: Shares of renewable energy in total gross final energy consumption and gross final energy consumption of electricity

	RE shares of gross energy consumption (%)						RE shares of gross energy consumption for electricity[1] (%)				
	2005	2010	2013	2014	2015	Ziel	2005	2010	2013	2014	2015
Austria	23.9	30.4	32.3	32.8	33.0	**34**	62.0	65.7	68.0	70.1	70.3
Belgium	2.3	5.7	7.5	8.0	7.9	**13**	2.4	7.1	12.5	13.4	15.4
Bulgaria	9.4	14.1	19.0	18.0	18.2	**16**	9.3	12.7	18.9	18.9	19.1
Croatia	23.8	25.1	28.0	27.9	29.0	**20**	35.6	37.6	42.1	45.3	45.4
Cyprus	3.1	6.0	8.1	8.9	9.4	**13**	0.0	1.4	6.6	7.4	8.4
Czech Republic	7.1	10.5	13.8	15.1	15.1	**13**	3.7	7.5	12.8	13.9	14.1
Denmark	16.0	22.1	27.4	29.3	30.8	**30**	24.6	32.7	43.1	48.5	51.3
Estonia	17.5	24.6	25.6	26.3	28.6	**25**	1.1	10.4	13.0	14.1	15.1
Finland	28.8	32.4	36.7	38.7	39.3	**38**	26.9	27.7	30.9	31.4	32.5
France	9.5	12.5	14.1	14.7	15.2	**23**	13.7	14.8	16.9	18.3	18.8
Germany	6.7	10.5	12.4	13.8	14.6	**18**	10.5	18.1	25.3	28.2	30.7
Greece	7.0	9.8	15.0	15.3	15.4	**18**	8.2	12.3	21.2	21.9	22.1
Hungary	4.5	12.8	16.2	14.6	14.5	**13**	4.4	7.1	6.6	7.3	7.3
Ireland	2.9	5.6	7.7	8.7	9.2	**16**	7.2	14.6	21.0	22.9	25.2
Italy	7.5	13.0	16.7	17.1	17.5	**17**	16.3	20.1	31.3	33.4	33.5
Latvia	32.3	30.4	37.1	38.7	37.6	**40**	43.0	42.1	48.8	51.1	52.2
Lithuania	16.8	19.6	22.7	23.6	25.8	**23**	3.8	7.4	13.1	13.7	15.5
Luxembourg	1.4	2.9	3.5	4.5	5.0	**11**	3.2	3.8	5.3	5.9	6.2
Malta	0.2	1.0	3.7	4.7	5.0	**10**	0.0	0.0	1.6	3.3	4.2
Netherlands	2.5	3.9	4.8	5.5	5.8	**14**	6.3	9.6	10.0	10.0	11.1
Poland	6.9	9.3	11.4	11.5	11.8	**15**	2.7	6.6	10.7	12.4	13.4
Portugal	19.5	24.2	25.7	27.0	28.0	**31**	27.7	40.7	49.1	52.1	52.6
Romania	17.3	23.4	23.9	24.8	24.8	**24**	26.9	30.4	37.5	41.7	43.2
Slovakia	6.4	9.1	10.1	11.7	12.9	**14**	15.7	17.8	20.8	22.9	22.7
Slovenia	16.0	20.4	22.4	21.5	22.0	**25**	28.7	32.2	33.1	33.9	32.7
Spain	8.4	13.8	15.3	16.1	16.2	**20**	19.1	29.8	36.7	37.8	36.9
Sweden	40.6	47.2	52.0	52.5	53.9	**49**	50.9	56.0	61.8	63.2	65.8
United Kingdom	1.3	3.7	5.7	7.1	8.2	**15**	4.1	7.4	13.8	17.9	22.4
EU 28	**9.0**	**12.9**	**15.2**	**16.1**	**16.7**	**20**	**14.8**	**19.7**	**25.4**	**27.5**	**28.8**

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

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

Source: Eurostat [3]

Figure 40: Shares of renewable energy in gross final energy consumption for heat and cooling and in final energy consumption in transport

	RE shares of gross final energy consumption in the heating/cooling sector (%)					RE shares of gross FEC for transport (%)					
	2005	2010	2013	2014	2015	2005	2010	2013	2014	2015	targets
Austria	22.3	29.5	32.7	32.0	32.0	4.8	10.9	9.5	10.9	11.4	
Belgium	3.4	6.1	7.4	7.7	7.6	0.6	4.7	5.0	5.7	3.8	
Bulgaria	14.3	24.4	29.2	28.3	28.6	0.8	1.4	6.0	5.8	6.5	
Croatia	30.0	32.8	37.2	36.2	38.6	1.0	1.1	4.3	4.1	3.5	
Cyprus	10.0	18.2	21.6	21.6	22.5	0.0	2.0	1.1	2.7	2.5	
Czech Republic	10.9	14.1	17.6	19.6	19.8	0.9	5.1	6.3	6.9	6.5	
Denmark	22.8	31.0	34.9	37.9	39.6	0.4	1.1	6.6	6.7	6.7	
Estonia	32.2	43.3	43.2	45.2	49.6	0.2	0.4	0.4	0.4	0.4	
Finland	39.1	44.2	50.7	51.9	52.8	0.9	4.4	10.2	22.0	22.0	
France	12.2	15.8	17.9	18.8	19.8	2.1	6.5	7.7	8.4	8.5	
Germany	6.8	9.8	10.6	12.2	12.9	4.0	6.4	6.9	7.3	6.8	
Greece	12.8	17.9	26.5	26.9	25.9	0.1	1.9	1.0	1.3	1.4	
Hungary	6.0	18.1	23.7	21.2	21.3	0.9	6.0	6.2	6.9	6.2	
Ireland	3.5	4.5	5.4	6.6	6.4	0.1	2.4	5.7	5.8	6.5	
Italy	8.2	15.6	18.1	18.9	19.2	1.0	4.8	5.4	5.0	6.4	
Latvia	42.7	40.7	49.7	52.2	51.8	2.4	4.0	4.0	4.1	3.9	all countries 10 %
Lithuania	29.3	32.5	36.9	40.6	46.1	0.6	3.8	4.8	4.3	4.6	
Luxembourg	3.6	4.7	5.5	7.2	6.9	0.1	2.1	4.0	5.4	6.5	
Malta	2.2	7.8	15.7	14.5	14.1	0.0	0.0	3.4	4.6	4.7	
Netherlands	2.4	3.1	4.1	5.2	5.5	0.5	2.6	5.1	6.2	5.3	
Poland	10.2	11.7	14.1	14.0	14.3	1.6	6.6	6.6	6.2	6.4	
Portugal	32.1	33.9	34.6	34.0	33.4	0.5	5.6	0.9	3.7	7.4	
Romania	18.0	27.2	26.2	26.7	25.9	1.6	3.8	5.4	4.7	5.5	
Slovakia	5.0	7.9	7.9	8.9	10.8	1.6	5.3	6.0	7.6	8.5	
Slovenia	18.9	28.1	33.4	32.4	34.1	0.8	3.1	3.8	2.9	2.2	
Spain	9.4	12.6	14.1	15.7	16.8	1.3	5.0	0.8	0.8	1.7	
Sweden	51.9	60.9	67.1	68.0	68.6	6.2	9.2	19.2	21.1	24.0	
United Kingdom	0.8	2.7	4.0	4.7	5.5	0.5	3.3	4.7	5.3	4.4	
EU 28	**10.9**	**14.9**	**16.9**	**18.1**	**18.6**	**1.8**	**5.2**	**5.9**	**6.5**	**6.7**	**10.0**

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

Source: Eurostat [3]

Estimate of the shares of renewable energy in gross final energy consumption in Germany in 2016

Initial estimates and calculations indicate that renewable energy made up 14.7% of gross final energy consumption in 2016, based on the calculation method set out in the EU Directive.

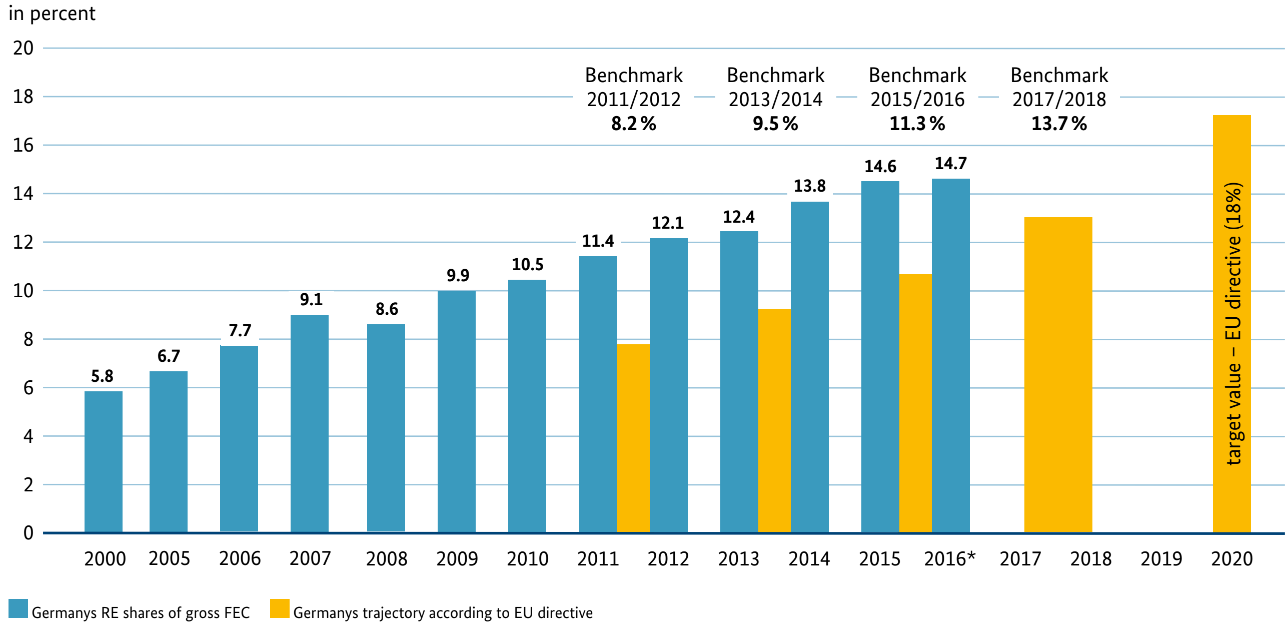
This means that the previous year's level (14.6%) was slightly exceeded. The level Germany reached in 2016 actually exceeded the national interim target laid down in EU Directive 2009/28/EC for 2017/2018 (13.7%).

Figure 41: Shares of renewable energy in total gross final energy consumption and in electricity, heat and transport in Germany

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	(in percent)											
RE shares in BEEV electricity	9.4	10.5	11.8	13.6	15.1	17.4	18.1	20.9	23.6	25.3	28.2	30.7
RE shares in BEEV heating/cooling	6.3	6.8	7.0	8.4	7.4	9.2	9.8	10.5	10.4	10.6	12.2	12.9
RE shares in BEEV transport	1.9	4.0	6.8	7.5	6.4	5.9	6.4	6.6	7.5	6.9	7.3	6.8

Quelle: EUROSTAT (SHARES) [3]

Figure 42: Shares of renewable energy in gross final energy consumption in Germany and target set out in the EU directive

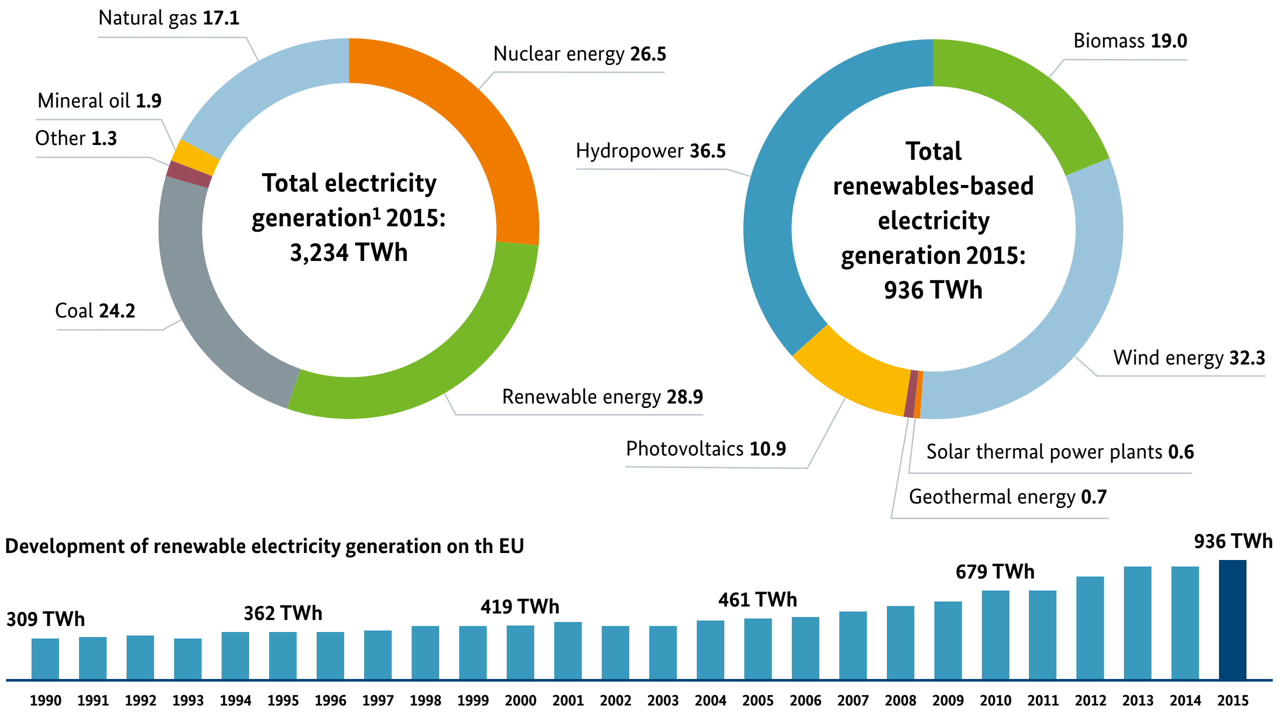


The directive contains detailed rules on how to calculate the share of renewable energy in gross final energy consumption. Due to the methodology set out in the EU directive, the data shown in this figure cannot be compared with data on national trends (see pages 8 et seq.). For more details on the calculation method in the EU Directive, see Information on methodology.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat, ZSW; data current as at August 2017 (*provisional)

Figure 43: Electricity generation in the EU in 2015

in percent



Other = 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

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat, ZSW; data current as at August 2017

Electricity generation from renewable energy sources

In 2005, the share of renewables in total EU electricity consumption was just under 14%, i.e. more than 86% of electricity consumption was covered by fossil fuels and nuclear energy. An analysis of the National Action Plans reveals that the target set in the Renewable Energy Directive 2009/28/EC of covering 20% of gross final energy consumption through the use of renewable energy by 2020 also includes an implicit target of achieving a clear increase in the share of gross electricity consumption covered by renewable energy. The overall set of Member State Action Plans produces a target exceeding 30%. In this way, the Directive – in tandem with the Electricity Directive (2001/77/EC), which entered into force in 2001 – has caused the share of the EU's gross electricity consumption covered by renewable energy to double to almost 29% within the space of 10 years (2005-2015).

Back in 2005, the bulk (more than two thirds) of green electricity came from hydropower. By 2015, the share of this technology had fallen to only just over 36%. In contrast, wind, biomass and solar energy have increased considerably, at 33%, 19% and 11% respectively.

At the end of 2015, total installed capacity in the EU for the generation of electricity from renewable energy amounted to around 401 gigawatts, or more than twice the level at the end of 2005. Wind energy accounted for approximately 141 gigawatts of this figure, ahead of hydropower (127 gigawatts) and photovoltaics (95 gigawatts).

In 2015, newly installed capacity totalled around 12.2 gigawatts (net), just less than in the preceding year, and meant that wind power again underwent the strongest growth among renewable technologies. In contrast, the expansion of photovoltaics declined considerably, falling to 6.4 gigawatts – its lowest level since 2009 (2015: 7.8 gigawatts).

Figure 44: Electricity generation from renewable energy sources in the EU (TWh)

	2005	2010	2011	2012	2013	2014	2015	2016
		(TWh)						
Biomass[1]	69.9	123.8	132.7	148.5	157.3	167.2	177.9	
Hydropower[2]	313.3	376.9	312.2	335.9	371.6	375.0	341.1	
Wind energy	70.5	149.4	179.7	206.0	235.8	253.1	301.9	302.7
Geothermal energy	5.4	5.6	5.9	5.8	5.9	6.2	6.5	
Photovoltaics	1.5	22.5	45.3	67.4	80.9	92.3	102.3	105.3
Solar thermal power plants	0.0	0.8	2.0	3.8	4.8	5.5	5.6	
Ocean energy	0.5	0.5	0.5	0.5	0.4	0.5	0.5	
EE total	461.0	679.4	678.2	767.7	856.8	899.8	935.8	
RE share of gross electrictiy consumption[3] (%)	**13.8**	**20.1**	**20.5**	**23.2**	**26.1**	**28.1**	**28.8**	
EU-gross final electricity generation	3,325.8	3,366.1	3,297.3	3,296.3	3,268.5	3,190.8	3,234.3	
Import	335.2	298.7	329.8	363.0	349.6	386.9	410.3	
Export	319.4	291.2	322.6	344.4	337.0	371.4	396.1	
Final consumption	2,784.7	2,838.7	2,785.1	2,791.8	2,767.7	2,702.8	2,743.5	

1 Including biogas [47], solid biomass, liquid biogenic fuel, 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
This overview is based on currently available statistics (up to 2015 EUROSTAT, 2016 EurObserv'ER – data available for wind energy and photovoltaics)

Sources: EUROSTAT (Supply, transformation and consumption of electricity – annual data [nrg_105a]) [36], EurObserv'ER [47]

Figure 45: Electricity generation from renewable energy sources in the EU in 2015

	Hydro-power	Wind energy	Biomass[1]	Biogas[2]	Liquid biogenic fuels	Photo-voltaics	Solar thermal power plants	Geoth. energy	Ocean energy	Total	RE share of gross elec. consumption[3]
					(TWh)						(%)
Austria	37.1	4.8	3.8	0.6	0.02	0.9	-	0.001	-	**47.3**	**62.7**
Belgium	0.3	5.6	4.5	1.0	0.2	3.1	-	-	-	**14.6**	**15.9**
Bulgaria	5.7	1.5	0.2	0.1	-	1.4	-	-	-	**8.8**	**22.7**
Croatia	6.4	0.8	0.1	0.2	-	0.06	-	-	-	**7.5**	**41.3**
Cyprus	-	0.2	-	0.1	-	0.1	-	-	-	**0.4**	**8.8**
Czech Republic	1.8	0.6	2.2	2.6	-	2.3	-	-	-	**9.4**	**13.2**
Denmark	0.02	14.1	3.8	0.5	-	0.6	-	-	-	**19.0**	**54.6**
Estonia	0.03	0.7	0.7	0.05	-	-	-	-	-	**1.5**	**15.8**
Finland	16.8	2.3	11.1	0.4	0.002	0.02	-	-	-	**30.5**	**35.9**
France	54.4	21.2	4.1	1.8	-	7.3	-	-	0.5	**89.4**	**17.7**
Germany	19.0	79.3	16.8	33.1	0.4	38.7	-	0.1	-	**187.5**	**31.3**
Greece	6.1	4.6	0.0	0.2	-	3.9	-	-	-	**14.9**	**24.2**
Hungary	0.2	0.7	1.9	0.3	-	0.1	-	-	-	**3.2**	**7.3**
Ireland	0.8	6.6	0.3	0.2	-	0.00	-	-	-	**7.9**	**27.0**
Italy	45.5	14.9	6.3	8.2	4.9	22.9	-	6.2	-	**108.9**	**33.1**
Latvia	1.9	0.1	0.4	0.4	0.001	-	-	-	-	**2.8**	**37.9**
Lithuania	0.3	0.8	0.4	0.1	-	0.1	-	-	-	**1.7**	**13.8**
Luxembourg	0.1	0.1	0.1	0.1	-	0.1	-	-	-	**0.4**	**5.2**
Malta	-	-	-	0.007	-	0.09	-	-	-	**0.1**	**4.2**

Continuation on page 40

Continuation from page 39

	Hydro-power	Wind energy	Biomass[1]	Biogas[2]	Liquid biogenic fuels	Photo-voltaics	Solar thermal power plants	Geoth. energy	Ocean energy	Total	RE share of gross elec. consumption[3]
					(TWh)						(%)
Netherlands	0.1	7.6	4.1	1.0	0.4	1.1	-	-	-	**14.3**	**12.1**
Poland	1.8	10.9	9.0	0.9	0.005	0.06	-	-	-	**22.7**	**13.8**
Portugal	8.7	11.6	2.8	0.3	-	0.8	-	0.2	-	**24.4**	**44.6**
Romania	16.6	7.1	0.5	0.1	-	2.0	-	-	-	**26.2**	**44.0**
Slovakia	3.9	0.01	1.1	0.6	-	0.5	-	-	-	**6.1**	**20.7**
Slovenia	3.8	0.006	0.1	0.1	0.004	0.3	-	-	-	**4.4**	**29.0**
Spain	28.1	49.3	4.8	1.0	-	8.3	5.6	-	-	**97.1**	**34.6**
Sweden	75.3	16.3	10.7	0.01	0.03	0.10	-	-	-	**102.4**	**73.5**
United Kingdom	6.3	40.3	22.2	7.2	-	7.6	-	-	0.002	**83.6**	**23.2**
EU 28	**341.1**	**301.9**	**111.5**	**60.9**	**5.5**	**102.3**	**5.6**	**6.5**	**0.5**	**935.8**	**28.8**

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

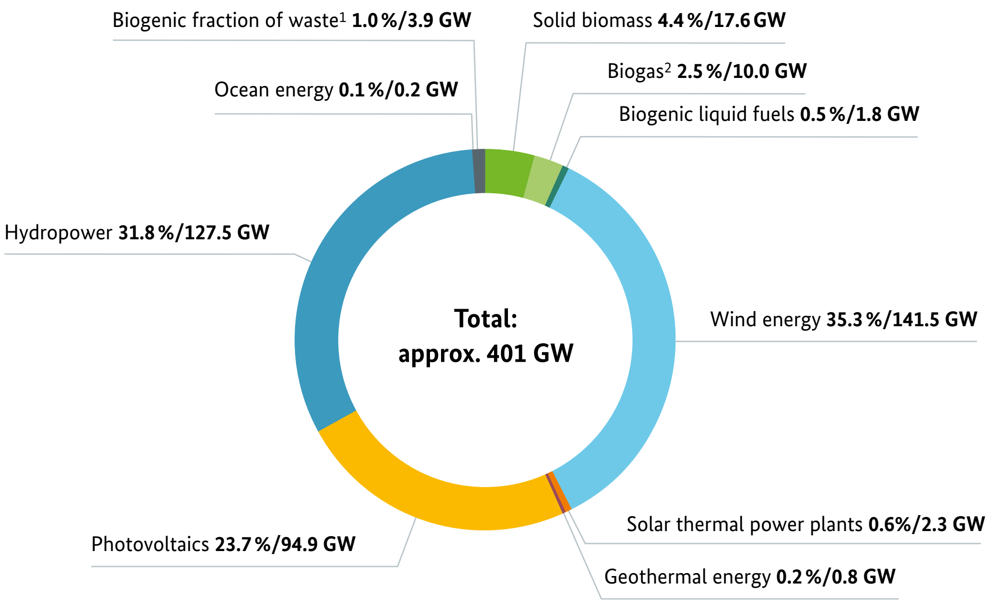
1 Incl. the biogenic share of municipal waste

2 Incl. sewage and landfill gas

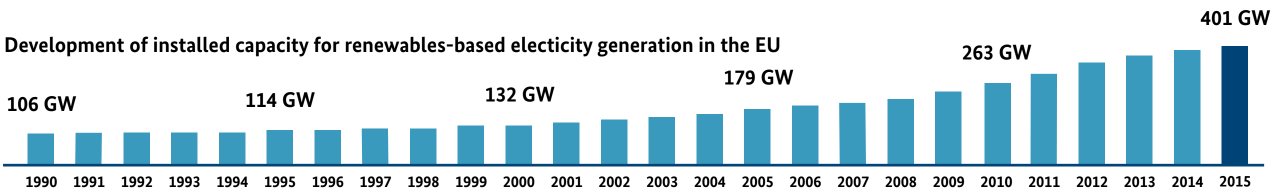
3 Gross electricity consumption = gross electricity generation plus imports minus exports; not calculated using rules in EU Directive

Source: EUROSTAT (Supply, transformation and consumption of electricity – annual data [nrg_105a]) [37]

Figure 46: Total installed renewables-based electricity generation capacity in the EU in 2015



Development of installed capacity for renewables-based electicity generation in the EU



Because of its very small share in power generation installations, marine energy is not shown.

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

2 Incl. landfill and sewage gas

Source: EUROSTAT (NRG_113a) [39]

Wind energy use

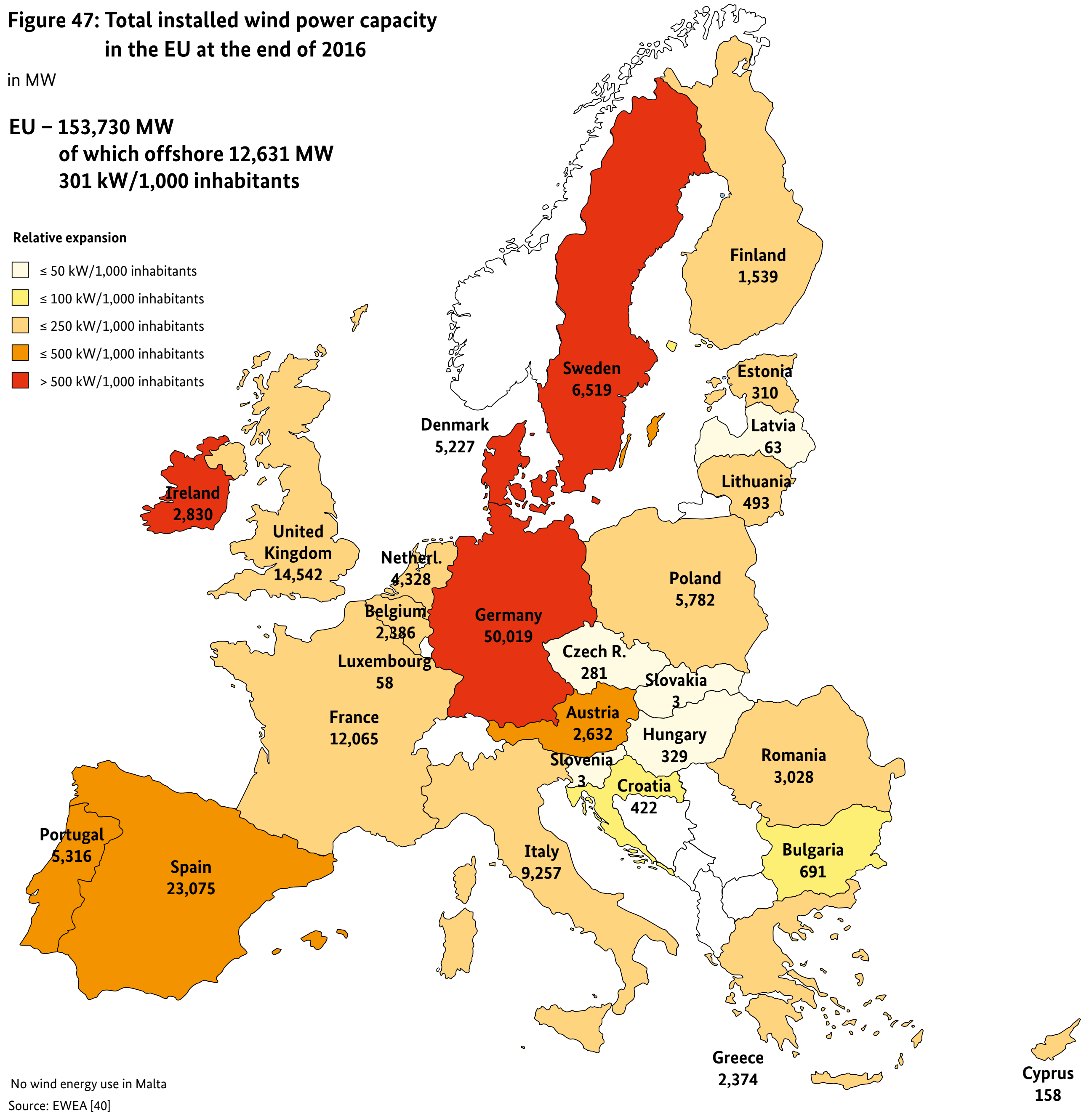
The rate of expansion in the use of wind energy across the EU remained at a high level in 2016. According to the European Wind Energy Association (EWEA) [40], at 12.2 gigwatts, net expansion of capacity was only just under the record level hit in the preceding year (12.5 gigawatts). Again, the bulk of this was installed in Germany (42%). After this came France (14%), the UK (8%) and the Netherlands (7%) by a considerable distance. According to the EWEA, this meant that by the end of 2016, wind energy installations across the EU had a combined total capacity of 153,730 megawatts. Here, Germany was able to maintain its leading position, accounting for just under 33%. After this come Spain (15%), the UK (just over 9%), France (just under 8%) and Italy (6%).

However, the picture is still different if the total installed capacity of the various Member States is considered in per-capita terms. On 31 December 2016, the EU average stood at just under 301 kilowatts per 1,000 inhabitants. This time, the country rankings were headed by Denmark with 916 kilowatts per 1,000 inhabitants, well ahead of Sweden (662 kW), Germany (609 kW) and Ireland (599 kW).

Considering installed offshore wind energy capacity on its own, the newbuild in 2016, which stood at over 1,600 megawatts, was just over half as high as in the preceding

Figure 47: Total installed wind power capacity in the EU at the end of 2016

in MW



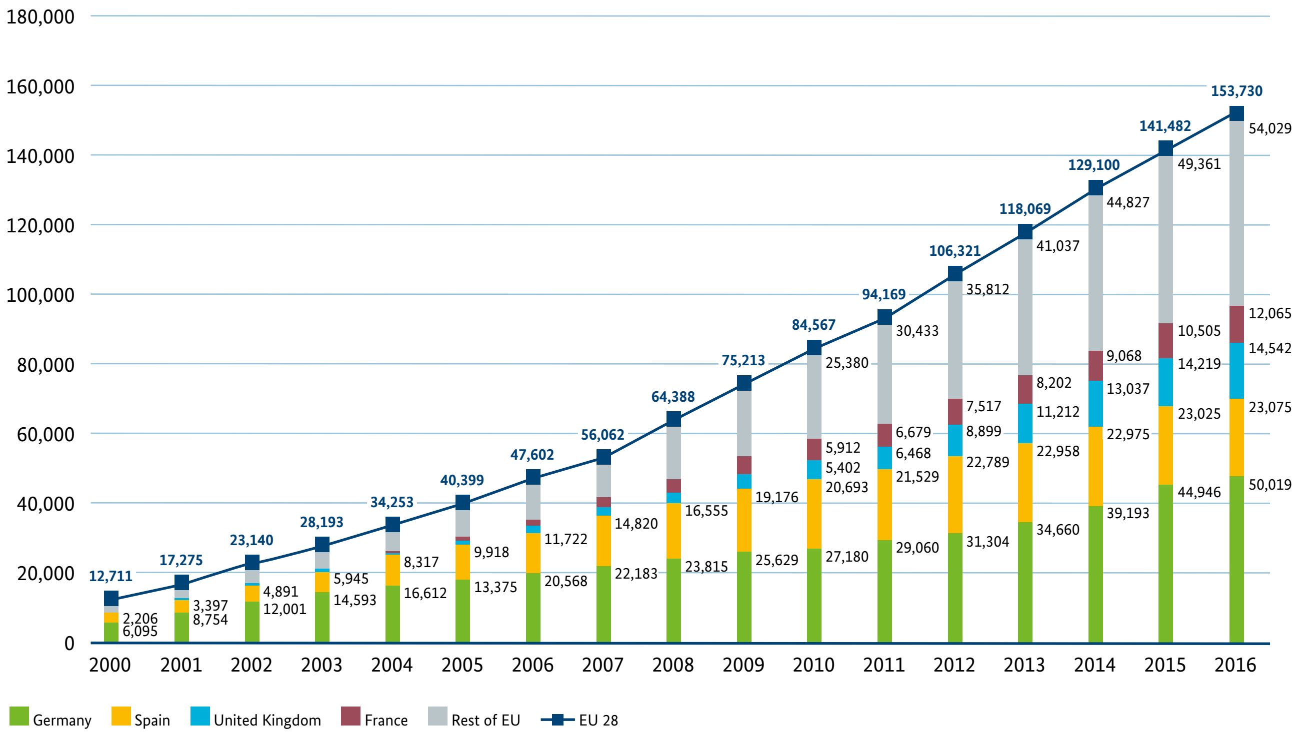
No wind energy use in Malta

Source: EWEA [40]

year (3,000 megawatts). This meant that by the end of 2016, offshore wind energy installations across the EU had a combined total capacity of 12,631 megawatts. Here, the United Kingdom (41%) led the pack, ahead of Germany (33%), Denmark (10%) and Belgium (9%).

All the EU's wind energy installations together generated just under 303 terawatt hours of electricity in 2016, covering approximately 11% of total electricity consumption as in the preceding year [38].

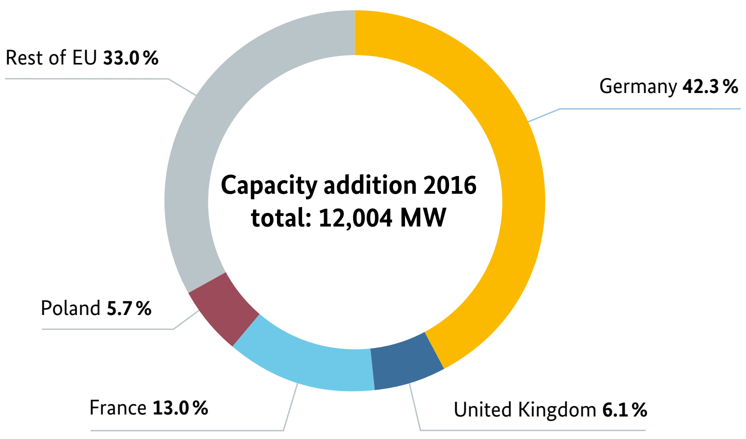
Figure 48: Development of the cumulated wind energy capacity inthe EU Member States



Total cumulated windenergy power capacity in the EU in 2016 is not exactly equal to the sum of installed capacity at the end of 2015 plus newbuild in 2016; this is due to the repowering and decommissioning of existing wind turbines and the rounding of data.

Source: EUROSTAT (NRG – 113a) [39], EWEA 'Wind in Power' [40]

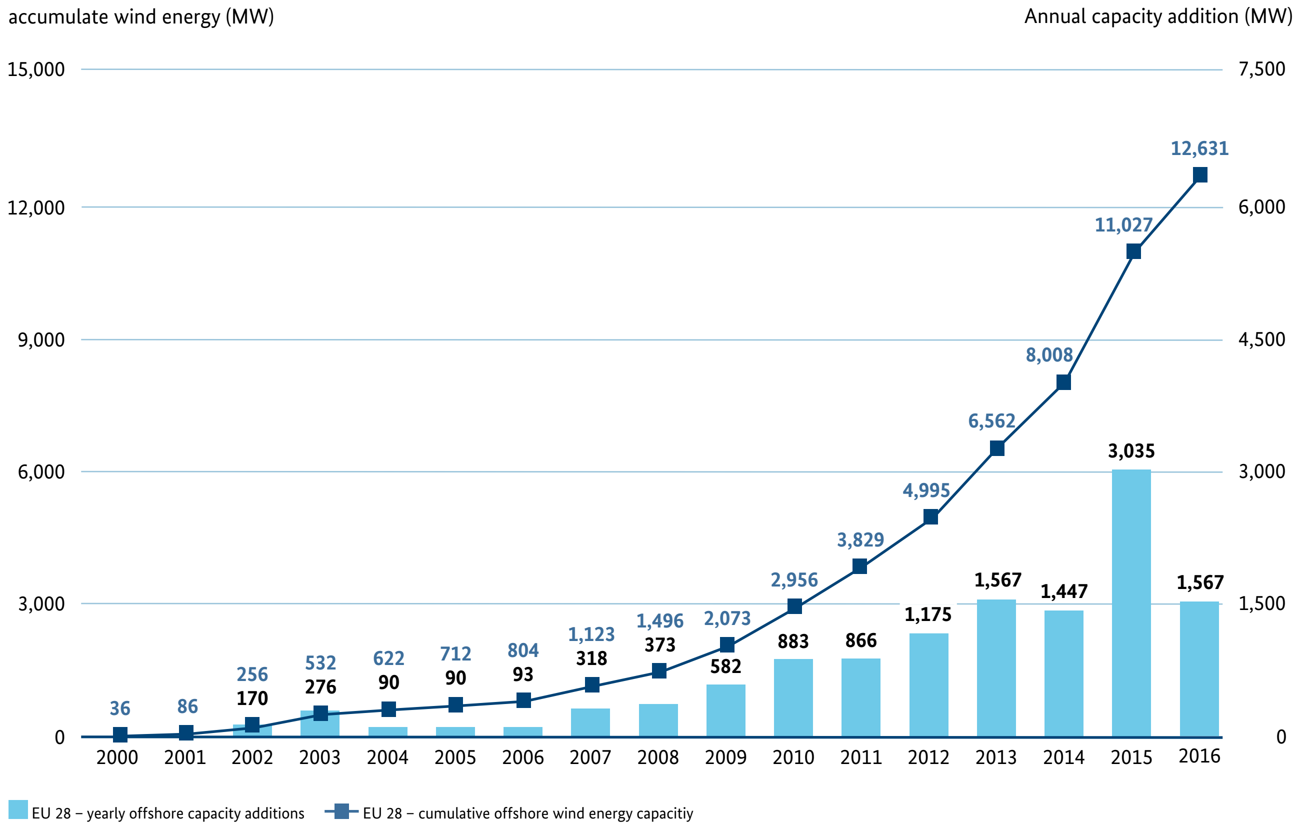
Figure 49: Expansion of wind power capacity in the EU Member States in 2016



Total cumulated windenergy power capacity in the EU in 2016 is not exactly equal to the sum of installed capacity at the end of 2015 plus newbuild in 2016; this is due to the repowering and decommissioning of existing wind turbines and the rounding of data.

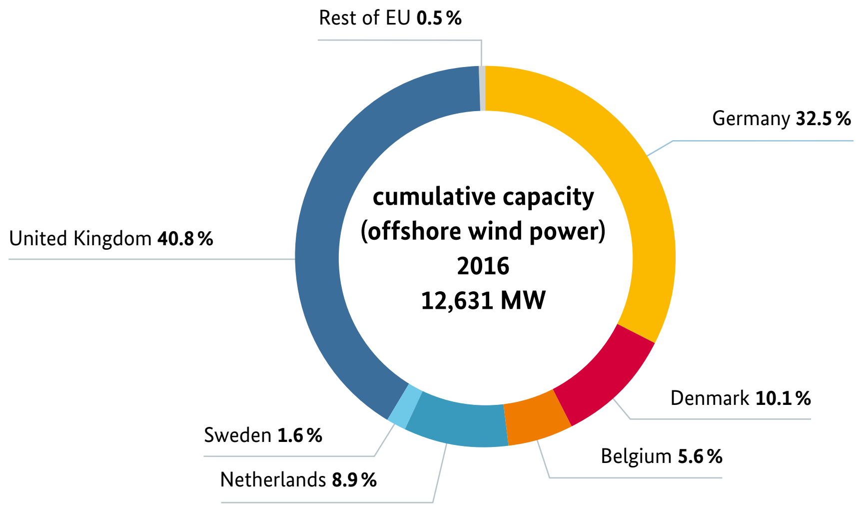
Source: EUROSTAT (NRG – 113a) [39], EWEA 'Wind in Power' [40]

Figure 50: Expansion and cumulated installed offshore wind power capacity



Source: EWEA 'Offshore' [41]

Figure 51: Share in total offshore wind power capacity held by individual countries in 2016



Source: EWEA 'Offshore' [41]

Solar energy use – electricity generation

After recovering slightly in 2015, the European photovoltaics market, declined sharply in 2016, recording its lowest growth rate since 2009 (almost 6.4 gigawatts). Compared with the record year of 2011, the photovoltaics market has thus shrunk by more than 70% [42].

As in the preceding year, the UK (42%) accounted for the largest share of this increase in capacity, followed by Germany (25%), the Netherlands (10%) and France (9%).

Looking at the total photovoltaics capacity installed in the EU at the end of 2016, which amounted to 100,935 megawatts, Germany is still well in front (41%), followed by Italy (19%), the United Kingdom (11%) and France (7%). Germany was also ahead in per-capita terms, at 503 kilowatts per 1,000 inhabitants. The next highest figures were registered by Italy with 318 kilowatts and Greece with 241 kilowatts per 1,000 inhabitants.

Generating over 105 billion kilowatt hours of electricity, photovoltaics covered just under 4% of total electricity consumption in the EU in 2016, as in the preceding year.

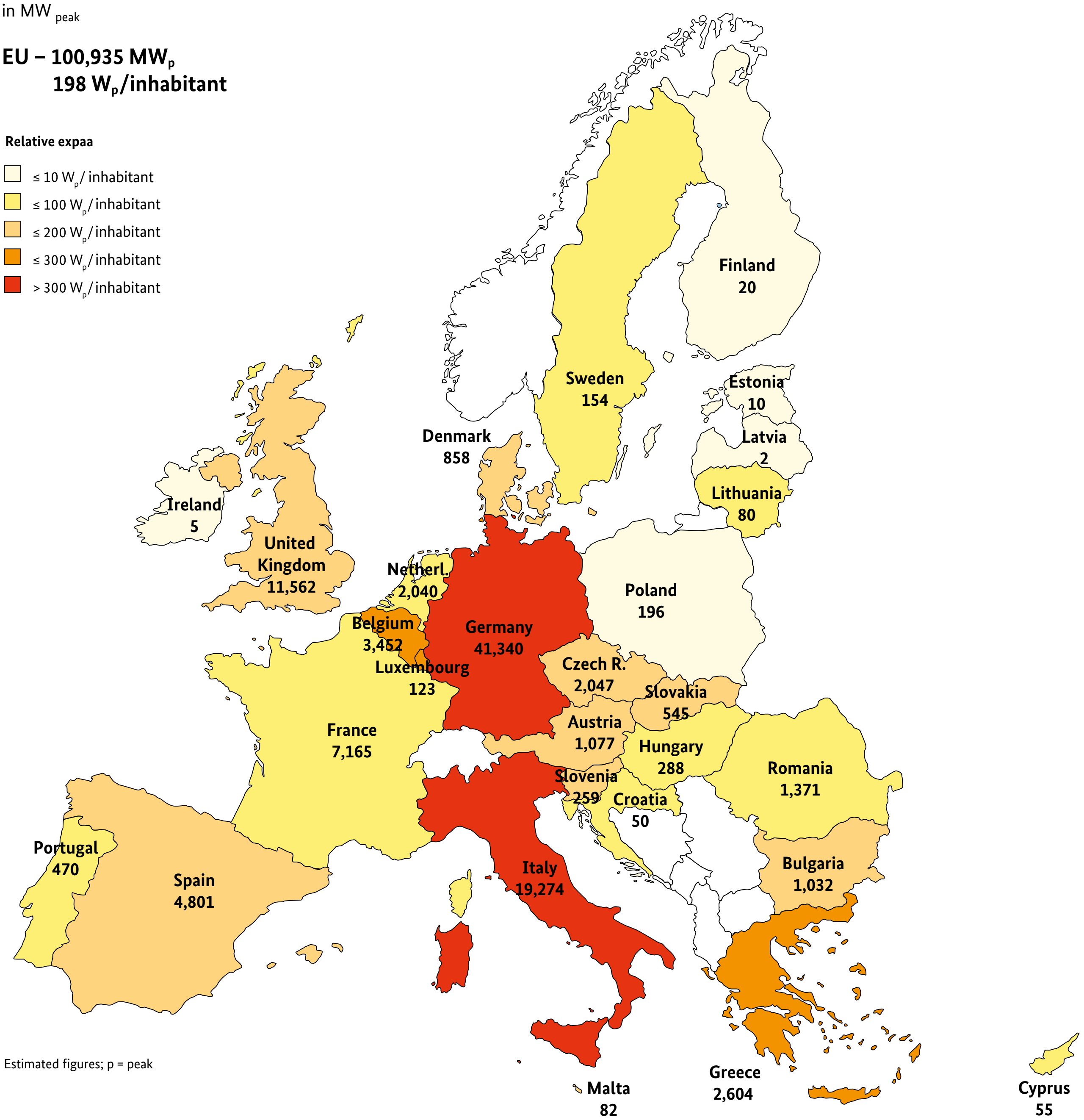
Figure 52: Total installed photovoltaics capacity in the EU at the end of 2016

in MW $_{peak}$

EU – 100,935 MW$_p$
198 W$_p$/inhabitant

Relative expaa

- ≤ 10 W$_p$/ inhabitant
- ≤ 100 W$_p$/ inhabitant
- ≤ 200 W$_p$/ inhabitant
- ≤ 300 W$_p$/ inhabitant
- > 300 W$_p$/ inhabitant



Estimated figures; p = peak

Source: EurOberservER 'Photovoltaic Barometer' [44]

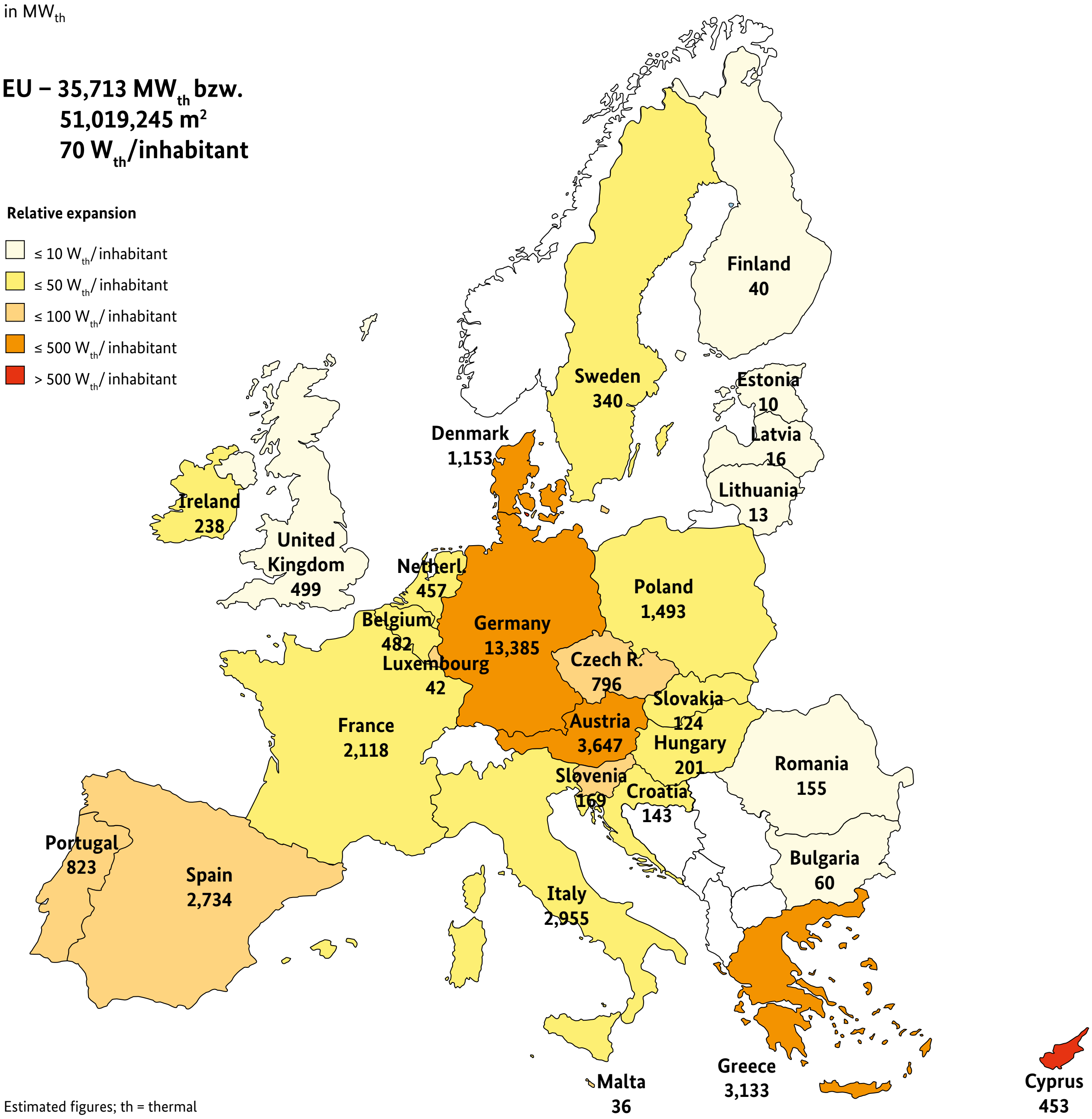
Solar thermal power plants are also used in the EU to generate electricity using solar energy. However, use of this technology is only commercially viable in the southern European countries, with Spain having been both EU and global leader in this field for a long time – helped along by an attractive feed-in tariff. As a result, almost all of the more than 2,300 megawatts of installed capacity of solar thermal power plants in the EU is sited in Spain. At roughly 5 billion kilowatt hours of electricity, the installations cover around 2% of Spanish electricity consumption each year [43].

Solar energy – heat supply

According to the EurObserv'ER solar thermal barometer [45], over 2.6 million square metres of solar collector surface area was newly installed in the EU in 2016, corresponding to thermal output of 1.82 gigawatts; this marked a 4.6% fall against the preceding year. The fact that oil and gas prices remained low has evidently ensured that there was no market recovery in 2016 either.

Figure 53: Total installed solar thermal capacity in the EU at the end of 2016

in MW_{th}



Estimated figures; th = thermal

Source: EurOberserv'ER 'Solar Thermal Barometer' [45]

The Danish market, however, actually countered this trend, almost doubling in size over the preceding year. This is thanks to the fact that Denmark is increasingly developing heat networks that are based on the feed-in of solar heat. This means that expansion is not dependent on investment trends in the area of private households. The highest sales in 2016 were again recorded in Germany, with a total of 766,000 square meters of newly installed collector surface area. In second place came Denmark (500,000 sq. m), followed by Greece (270,000 sq. m), Spain (212,000 sq. m) and Italy (210,000 sq. m). The Polish market, which ranked second in 2015 (at 277,000 sq. m.), shrank in 2016 by over 50%, falling down into eighth place (at 115,000 sq. m.).

This meant that at the end of 2016, the EU had a total installed collector surface area of over 51 million square meters. This equates to a thermal capacity of 35.7 gigawatts. At 19.12 million square meters, Germany had by far the largest collector surface area, followed by Austria (5.21 million) and Greece (4.48 million). In per-capital terms, Cyprus tops the rankings, with 0.76 square metres, ahead of Austria (0.60), Greece (0.42) and Germany (0.23).

Renewable energy sources in the transport sector

EU Directive 2009/28/EC sets just one binding target for the transport sector, namely for each EU Member State to raise the share of renewable energy sources in transport sector to 10% by 2020.

Owing to the discussion about the sustainability of first-generation biofuels and to increasing interest in electric mobility, the use of both biodiesel and bioethanol declined in 2016. This also led investment in biofuel production capacity to fall [42].

Looking at the production of biofuel within the EU, the generation of biodiesel sank in 2016 by 5% over the preceding year, falling to 10.7 billion litres. Germany and France remained the biggest producer countries, generating 3.0 billion litres and 1.5 billion litres respectively. The production of biodiesel fell in these countries by 11% over the preceding year, but actually rose in Spain (to more that 1.1 billion litres) and Poland (to 0.9 billion litres). Bioethanol production in Europe also fell by a total of 6%, dropping to 4.8 billion litres [42].

By contrast, the consumption of biofuels in the EU rose in 2016 by 1.3%, climbing to over 167 terawatt hours. Biodiesel sales rose by 2.4%, while sales of bioethanol fell by 3.1% [46].

Regional sales of electric vehicles rose by 14% in 2016. This means that Europe accounts for 29% of global sales of electric vehicles, with Norway leading the market, followed by the Netherlands, the United Kingdom and France [42].

Figure 54: Consumption of biofuels in the EU Member States in 2015 and 2016

	2015				2016[3]			
	Bioethanol	Biodiesel[1]	Others[2]	Total	Bioethanol	Biodiesel[1]	Others[2]	Total
	(billion kWh)				(billion kWh)			
Austria	0.7	6.9	0.01	7.6	0.7	6.7	0.01	7.4
Belgium	0.4	2.5	–	3.0	0.5	4.5	–	5.0
Bulgaria	0.4	1.3	–	1.7	0.4	1.3	–	1.7
Croatia	–	0.3	–	0.3	–	0.3	–	0.3
Cyprus	–	0.1	–	0.1	–	0.1	–	0.1
Czech Republic	0.9	2.9	–	3.8	0.6	2.7	–	3.3
Denmark[4]	–	2.7	–	2.7	–	2.8	–	2.8
Estonia	0.04	-	–	0.0	0.04	–	–	0.0
Finland	0.7	4.3	0.02	5.0	0.7	4.3	0.02	5.0
France	5.0	29.8	–	34.8	5.5	30.7	–	36.2
Germany	8.8	20.6	0.4	29.7	8.8	20.6	0.3	29.8
Greece	–	1.7	–	1.7	–	1.7	–	1.7
Hungary	0.5	1.5	–	2.0	0.5	1.6	–	2.1
Ireland	0.4	1.1	–	1.5	0.4	1.0	–	1.4
Italy	0.2	13.3	–	13.5	0.3	11.7	–	12.0
Latvia	0.1	0.2	–	0.3	0.1	0.2	–	0.3
Lithuania	0.1	0.7	–	0.8	0.1	0.6	–	0.7
Luxembourg	0.1	0.9	–	0.9	0.1	0.9	–	1.0
Malta	–	0.1	–	0.1	–	0.1	–	0.1
Netherlands	1.7	2.1	–	3.7	1.4	1.6	–	3.0
Poland	1.8	7.3	–	9.1	1.9	6.3	–	8.2
Portugal	0.2	3.8	–	4.0	0.2	2.9	–	3.2
Romania	0.7	1.6	–	2.4	0.7	1.6	–	2.4
Slovakia	0.4	1.4	–	1.7	0.4	1.4	–	1.7
Slovenia	0.1	0.3	–	0.3	0.1	0.3	–	0.3
Spain	2.2	9.2	–	11.4	1.6	9.8	–	11.4
Sweden	1.6	9.5	1.2	12.3	1.3	12.8	1.2	15.3
United Kingdom	4.7	6.1	–	10.9	4.5	6.5	–	11.0
Region EU 28	**31.7**	**131.8**	**1.6**	**165.1**	**30.8**	**134.9**	**1.6**	**167.3**

1 Value for biodiesel also contains a share of bioethanol, no data are available for individual biofuels
2 Biogas in Germany, Sweden and Finland; plant oil consumption and unspecified biofuels, especially in Germany, Romania, Hungary, Ireland and Luxembourg
3 Estimated values
4 Biodiesel and bioethanol together
2016 data for Croatia, Malta, Lithuania, Estonia, Slovenia, Bulgaria, Romania and Slovakia was not available at the time the EurObserv'ER was published.
Source: EurObserv'ER [46]

Part III: Global use of renewable energy sources

Renewable energy has been playing an ever greater role in worldwide electricity generation for some years now. However, the global population is growing at rapid speed, and if the increase in demand is to be met in a sustainable manner, the pace at which renewable energy is being developed must continue to be stepped up

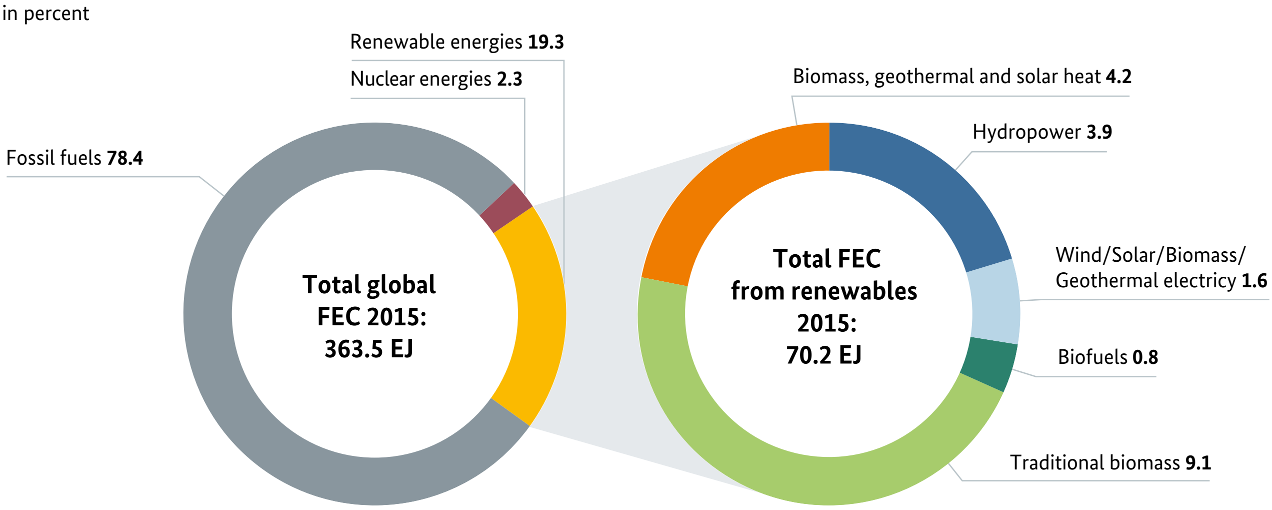
Wind and solar energy are considered to have the greatest potential for meeting the world's growing demand for energy. These are the technologies that have been posting the largest growth rates in the recent past. According to REN21 [42], more than 200 gigawatts of power generation capacity from wind energy and photovoltaics have been installed each year for the past four years alone (global total). Geothermal energy, marine energy, and modern biomass technologies are also of importance. Modern renewable energy technologies are a key factor in combating poverty, especially in developing countries, where more than one billion people still do not have access to electricity. In future, renewable energy technologies, being decentralised by nature, could provide a basic electricity supply; the options range from off-grid photovoltaic systems for individual households, to renewable energy installations that supply entire villages with electric power. Worldwide, more than 8 million photovoltaics (off-grid or mini-grid) systems were sold in 2016 alone. Renewables can give more people access to modern forms of energy, particularly electricity, improve people's living conditions and open up opportunities for economic development.

According to estimates by REN21 [42], renewables accounted for 19.3% of total final energy consumption in 2015. Some 78.4% continued to be derived from fossil fuels and 2.3% from nuclear energy. However, modern forms of using renewable energies accounted for just 10.2%, while the use of traditional biomass (9.1%) made up almost half of the share covered renewable energy.

Traditional biomass use refers primarily to the generation of heat from firewood and charcoal, without the use of major technical aids. The potential offered by these forms of renewable energy is largely exhausted, and they are generally not used in a sustainable fashion. According to estimates by the IEA, as many as around 2.7 billion people rely on traditional biomass use for cooking. Simple cooking

Figure 55: Distribution of global final energy consumption in 2015

in percent



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

Quelle: REN21: Renewables 2017 Global Status Report, REN21 Secretariat, Paris, 2017 [42] and heating methods based on the use of biomass and open fires carry health risks and often lead to an over-exploitation of natural resources and irreversible deforestation [49]. According to estimates by the World Health Organisation (WHO), the use of traditional biomass for heating and cooking causes the premature death of 4.3 million people each year (http://www.who.int/mediacentre/factsheets/fs292/en/#). However, over the past few years, the use of simple, clean cooking stoves, which require up to 60% less fuel and produce less smoke emissions, has also developed considerably, partly as a result of funding programmes. According to REN21 [42], more than 10 million such stoves started to be used in 2015 in China alone.

The remaining field of final energy provided from renewable energy is dominated by the generation of heat from biomass using modern combustion techniques, geothermal heat, solar-generated heat, and hydropower. Power generation from sun, wind, biomass and geothermal energy accounted for 1.6% of total final energy consumption in 2015.

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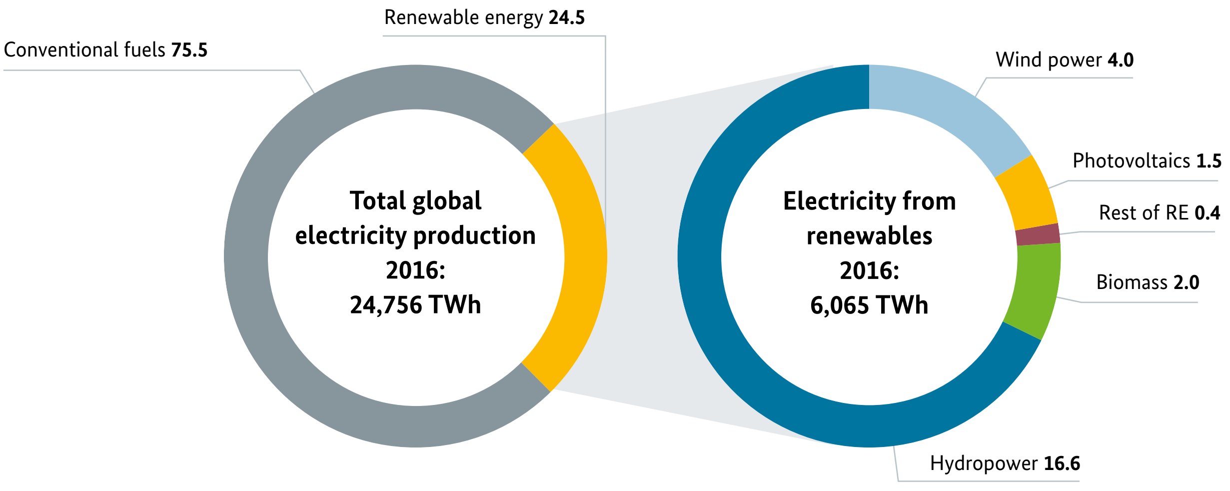
Electricity generation from renewable energy sources

According to REN21 [42], the share of renewable energy in global final energy consumption increased significantly in 2016, rising to 24.5% (2015: 23.7%). Hydropower (16.6%), the use of which remained unchanged over the preceding year, still accounted for the largest share of power generation from renewable energy. The current growth in electricity generation from renewables is based on an increase in the shares of wind energy and photovoltaics, which climbed from 3.7% to 4.0% and 1.2% to 1.5% respectively year-on-year.

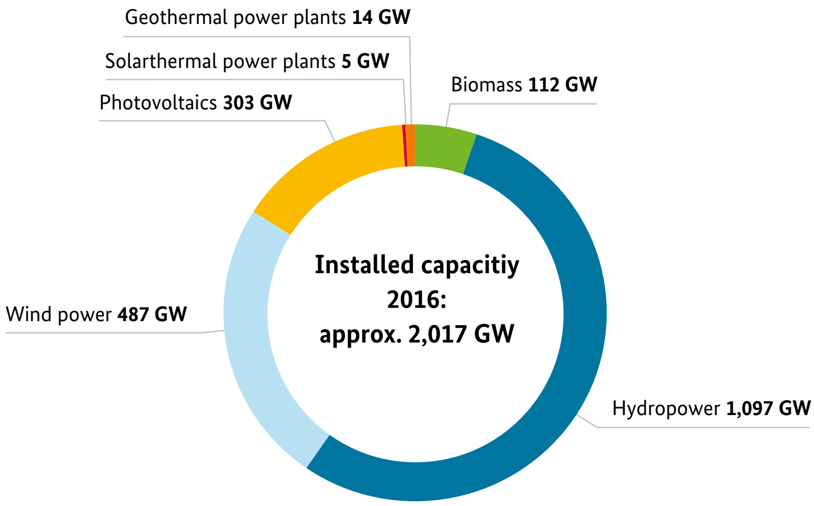
In 2016, a further 161 gigawatts of power generation capacity from renewables was built around the world. This is equivalent to 62% of total capacity expansion in that year, making 2016 another record year. Some 47% of this expansion was based on new photovoltaics systems and 34% on wind power installations. By the end of 2016 2,017 gigawatts of power generation capacity from renewables was installed worldwide. The largest share was hydropower (1,097 gigawatts), followed by wind energy (487 gigawatts) in second place and photovoltaics (303 gigawatts) in third.

Figure 56: Distribution of global electricity generation in 2016
in percent



Source: REN21: Renewables 2017 Global Status Report, REN21 Secretariat, Paris, 2017 [42]

Figure 57: Total installed power generation capacity based on renewables at the end of 2016



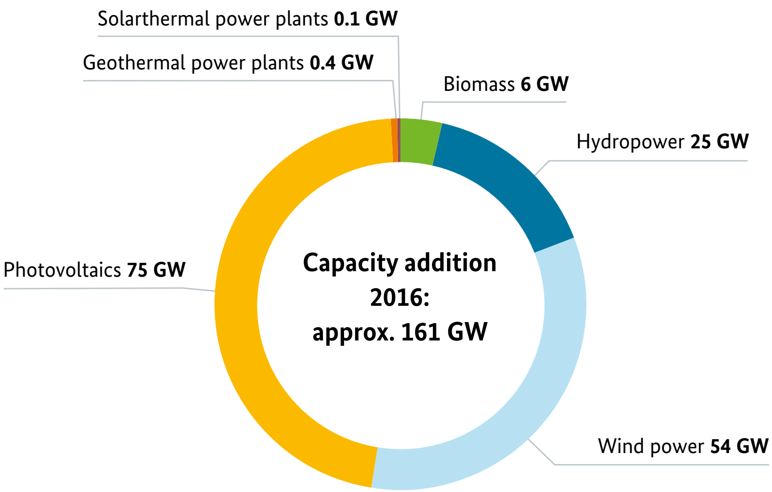
Source: REN21: Renewables 2017 Global Status Report, REN21 Secretariat, Paris, 2017 [42]

Excluding hydropower, the world's power generation capacity based on renewables totalled 921 gigawatts at the end of 2016. China has extended its lead position, with a current total of 258 gigwatts, followed by the USA (145 gigawatts), Germany (98 gigawatts), Japan (51 gigwatts) and India (46 gigawatts) [42].

Hydropower registered a global increase in capacity of 25 gigawatts in 2016, the largest portion of which (almost 9 gigawatts) was built in China. Brazil took second place (5.3 gigawatts of new hydroelectric power), followed by Ecuador and Ethiopia (each with around 1.5 gigawatts). In terms of total installed hydropower, China again came in top, followed by Brazil, the USA, Canada and Russia.

In 2016, global **wind power** capacity increased by 54 gigawatts, if by slightly less than in the preceding year (64 gigawatts). The decline could be traced back to the Chinese market, which did, however, account for the largest share of newly installed capacity (23.4 gigawatts). This was fol-

Figure 58: Expansion of power generation capacity based on renewables in 2016



Discrepancies due to rounding

Source: REN21: Renewables 2017 Global Status Report, REN21 Secretariat, Paris, 2017 [42] lowed by newbuild in the USA (8.2 gigawatts), Germany (5 gigwatts) and India (3.6 gigawatts). At the end of 2016, the largest share of total installed wind power capacity was located in China, followed by the USA and Germany. However, in per-capita terms, Denmark still has the highest installed capacity, followed by Sweden and Germany. Some 2.2 gigawatts of offshore capacity was newly installed around the world, just over half the amount in the preceding year only. At the end of 2016, global offshore wind power capacity amounted to 14.4 gigawatts.

In contrast, 2016 saw another new record in the newbuild of **photovoltaics** installations, which totalled 75 gigawatts. This marked a 50% increase over the preceding year. Here, China led the field with 34.5 gigawatts, while the USA also doubled its newbuild figures (14.8 gigawatts) compared to the preceding year. In third place came Japan (8.6 gigwatts), followed by India (4.1 gigawatts) in fourth. This meant that at the end of 2016, a total of 303 gigawatts of photovoltaics capacity was installed worldwide, of which 77.4 gigawatts was located in China. Following in second place was Japan (42.8 gigawatts), pushing Germany (41.3 gigawatts) into third, with the USA (40.9 gigwatts) a close fourth. However, in per-capita terms, Germany still has the highest installed capacity, ahead of Japan and Italy.

In 2016, total installed power generation capacity from **biomass** increased by about 6%, rising to 112 gigawatts worldwide. The greatest share of this capacity was located in the USA, followed by China, Germany and Brazil. In the same year, around 0.4 gigawatts of new power generation capacity from geothermal energy was installed around the world. The largest share was built in Indonesia, where a 200-megawatt power plant was constructed. At the end of 2016, total power generation capacity based on **geothermal** energy was 13.5 gigawatts. The largest shares were to be found in the USA, followed by the Philippines, Indonesia and New Zealand.

Renewable energy sources in the other sectors

In 2016, around 25% of global final energy consumption for heating was covered by renewable energy. However, more than two-thirds of this continued to be based on traditional biomass use, and therefore cannot be termed non-sustainable. At the same time, some 9% of the heat consumed around the world was provided by modern technologies based on renewable energy. Roughly 90% of this was based on biomass, 8% on the use of solar thermal technology, and 2% on geothermal energy [42].

The expansion of solar thermal power slowed in 2016, falling by around a fifth to roughly 21 gigawatts. This was its lowest figure since 2007 and was due to the low price of oil. The solar thermal capacity of 456 gigawatts installed worldwide at the end of 2016 suffices to provide an annual 375 billion kilowatt hours of solar-based heat. At 71%, the bulk of the collector surface area was installed in China; the United States followed a long way behind at 4%, after which came Turkey and Germany with 3% each.

Following newbuild totalling 1.3 gigawatts in 2016, global installed thermal capacity for the direct use of geothermal heat (without heat pumps) amounted to 23 gigawatts at the end of that year. It provided some 79 billion kilowatt hours of heat. At 20.6 billion kilowatt hours, China was the largest user of geothermal heat, followed by Turkey (12.5 billion kWh), Iceland (7.4 billion kWh) and Japan (7.1 billion kWh).

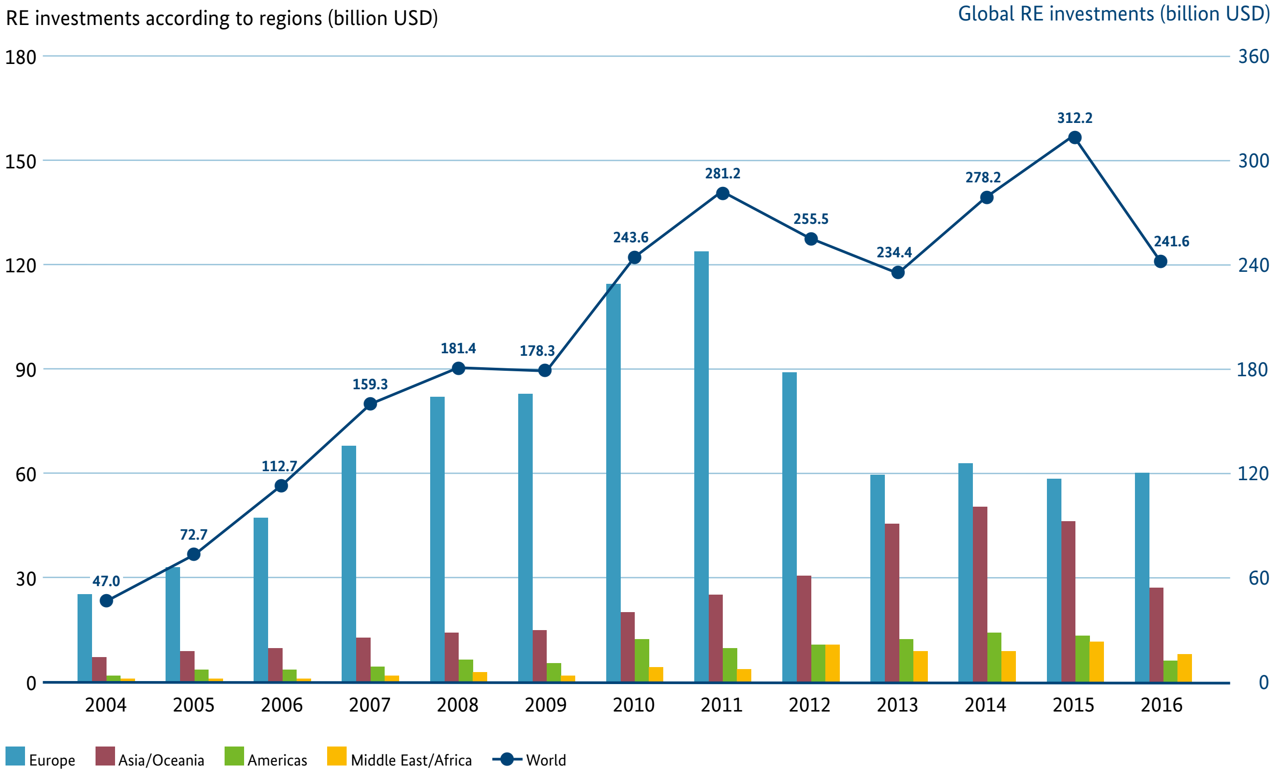
Final energy consumption in the transport sector has risen by around 2% per year since 2005. This sector now accounts for 28% of total final energy consumption and 23% of energy-related greenhouse gas emissions. Around 4% of global fuel consumption is covered by biofuels. In 2016, bioethanol production remained roughly stable, at 98.6 billion litres, while the production of biodiesel rose slightly, climbing to 30.8 billion litres. The largest producer of biofuel was the USA, followed by Brazil [42].

Investment in renewable energy sources and employment

After reaching a new all-time high in 2015, worldwide investments in renewable energy (excl. large hydropower) declined in 2016 by 23%, falling to US$241.6 billion, despite the record number of installations. The main reason for the decline was falling prices for photovoltaics and wind power installations [50].

In emerging and developing countries, investment fell by 30% to US$116.6 billion. This was due not only to falling costs for renewables technologies, but also to a lower rate of expansion in this sector in China, which accounts for around two thirds of the market. In China alone, there was a decline of 32%, to a market value of US$78.3 billion. In the industrial countries, the decline in investment was considerably lower (14%), leaving a market worth 125 billion US dollars. In global rankings, the USA comes in second behind China (US$46.4 billion), followed by the UK (US$24 billion) [50]. Looking at individual technologies, the highest volume of global investment in 2016 was made in photovoltaics (US$113.7 billion), closely followed by wind energy (US$112.5 billion).

Figure 59: Investment in renewable energy sources according to region



Source: Frankfurt School-UNEP Centre/BNEF [50]

In global terms, the number of employees in the renewables sector continued to grow in 2016. According to an estimate by IRENA [51], around 9.8 million people worked in this sector in 2016. Most of these (just under 3.1 million) were employed in the photovoltaics sector, followed by the biofuel industry (over 1.7 million). Most of these jobs (62%) were located in Asia, especially in China. The largest growth in 2016 was recorded by China, the USA and India.

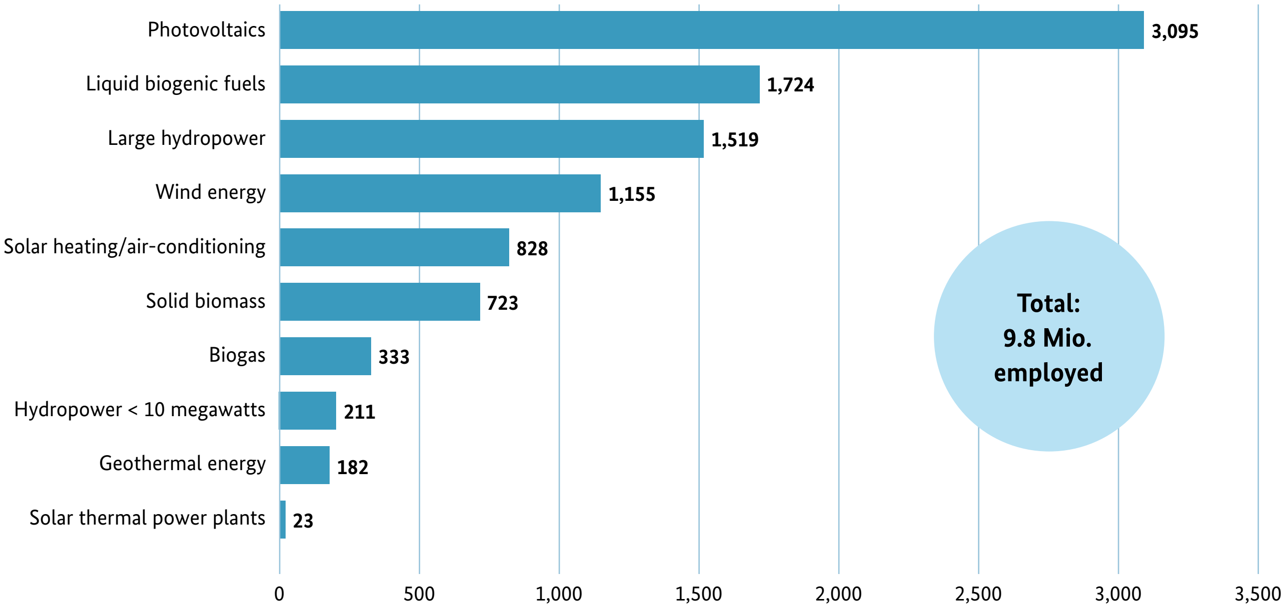
Figure 60: Investment in 2015 and 2016 according to renewable-energy sector

Sector	2015 RE-investment	2016 RE-investment	Growth rate 2015/2016
		(billion USD)	(%)
Wind energy	124.2	112.5	-9
Solar energy	171.7	113.7	-34
Biofuels	3.5	2.2	-37
Biomass[1]	6.7	6.8	1
Hydropower[2]	3.5	3.5	0
Geothermal power	2.3	2.7	17
Ocean energy	0.2	0.2	0
Total	**312.2**	**241.6**	**-23**

1 Incl. waste
2 Hydropower plants < 10 MW only
Source: Frankfurt School-UNEP Centre/BNEF [50]

Figure 61: Persons employed in the renewable energy sectors in 2016

in 1,000 employees



Source: IRENA [51]

Annex

International networks for renewable energy sources

The renewables2004 conference in Bonn – and the follow-up process

The first International Renewable Energy Conference – renewables2004, which was initiated by the German government and held in Bonn, put renewable energy on the global agenda. This conference provided crucial momentum: shortly after it took place, the Renewable Energy Policy Network for the 21st Century (REN21) was established. This registered association publishes an annual Global Status Report which informs the political debate on renewable energy. The 2004 conference also initiated the conclusion of the IEA Implementing Agreement on Renewable Energy Technology Deployment (RETD). It also produced the groundswell that led to the founding of the International Renewable Energy Agency (IRENA).

International Renewable Energy Agency (IRENA)

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation dedicated to worldwide promotion of the growth and sustainable use of renewable energy. IRENA now has 150 members, with another 30 states currently in the accession process. Mr Adnan Z. Amin from Kenya has been Director-General of IRENA since 2011. IRENA is headquartered in Abu Dhabi, United Arab Emirates. The IRENA Innovation and Technology Centre, one of its three core divisions, is based in Bonn. IRENA currently employs over 100 international experts.

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 and developing countries, as well as emerging economies, on driving growth in 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

IRENA began publishing work programmes and budgets in two-year cycles in 2014. The current work programme (2016/2017) is divided into six thematic programme areas:

1. Planning for the renewable energy transition
2. Enabling investment and growth
3. Renewable energy access for sustainable livelihoods
4. Regional action agenda
5. Islands: Lighthouses for renewable energy deployment
6. Gateway to knowledge on renewable energy

Main bodies and structure

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

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 Secretariat implements the IRENA work programme and assists the Assembly, Council and other sub-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.

The Knowledge, Policy and Finance Centre (KPFC) is the global clearinghouse for knowledge on renewable energy. It is also a Centre of Excellence for policies and financial issues relating to renewable energy. The KPFC is a one-stop shop for statistics on costs, employment, resource potential, investment conditions and the socio-economic 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.

The Country Support and Partnerships (CSP) division helps countries and regions accelerate the introduction and growth of renewable energy. The division works with a wide variety of public and private stakeholders on developing and implementing strategies to accelerate the adoption of renewable energy in Africa, Asia, Europe, Latin America and on islands. In particular, CSP conducts Renewable Readiness Assessments in individual developing countries. These projects identify priority areas for action in individual countries and guide policymakers in driving renewable energy growth in their respective country.

The Innovation and Technology Centre (IITC) in Bonn, Germany, seeks to accelerate the adoption of renewable energy technologies. The IITC provides a framework for supporting technological development and innovation and works on ways to cut costs and apply industrial standards more broadly. As it carries out its part of the IRENA work programme, the IITC works closely with the KPFC and CSP divisions in Abu Dhabi.

The IITC provides governments with solutions towards a speedier transition to the use of renewable energy technologies which take account of their national needs, economic conditions and available resources. This work includes analysing current technology costs and standards. To support governments in creating effective technology and innovation policy, the IITC develops scenarios, strategies and technology development guidelines. It also produces roadmaps for the use of renewable energy in cities and industrial processes and for attaining the goal of the UN's Sustainable Energy for All initiative, which is to double the global share of renewable energy to 36% by 2030. IRENA serves as the renewable energy hub in this initiative and outlines how this goal is to be achieved in the REmap 2030 study developed by the IITC.

Further information on IRENA's governing bodies can be found in the IRENA Statute.

The founding of IRENA

Calls for an international organisation dedicated to the promotion of renewable energy were first made in the early 1980s. As global interest in renewable energy grew, so did demand for an organisation of this kind, until this was clearly articulated by a large number of countries at the 2004 International Renewable Energy Conference ("renewables2004") in Bonn. The idea was put into action at the IRENA Founding Conference on 26 January 2009. The organisation was fully established when the first meeting of the Assembly was held on 4 and 5 April 2011 at the Abu Dhabi headquarters.

Products developed by IRENA

IRENA not only produces publications, but also databases, including a number designed to facilitate networking. One example is REsource, a search engine for finding data and analyses on renewable energy, presented in the form of facts and figures for each country. The Global Atlas for Renewable Energy, the Sustainable Energy Marketplace and the IRENA Project Navigator are online platforms that support project development.

The most important publications include REPA 2030 (global and regional level) looking at prospective expansion in renewable energy, capacity statistics, manuals on specific technologies and analyses.

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 29 OECD member countries. 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. Its efforts here focus particularly on establishing Association with major emerging countries. This began in November 2015, with China, Indonesia and Thailand being granted Association status. There is now a total of six Associated Countries.

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

In addition, the IEA is 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 detailed country reviews setting out policy recommendations, as well as the annual [49], 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 Medium-Term Renewable Energy Market Report in 2016, with a forecast extending up to 2021. The IEA also publishes technology roadmaps on renewable energy. The IEA and the International Renewable Energy Agency (IRENA) cooperate closely upon the basis of a partnership agreement signed by the two organisations in January 2012.

The German 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 and have been discussed within a dedicated working group since 2013. The focus of this group is being expanded and extended under the 2017 German G20 presidency, leading it 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, Building and Nuclear Safety. The aim is to look more closely at the central role of the energy sector in the implementation of the Paris Climate Agreement and of the 2030 Agenda on Sustainable Development.

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 strong impact in the respective host country.

The conference in Beijing (BIREC 2005) not only evaluated the follow-up process to the Bonn conference, but also discussed the use of renewable energy sources in developing countries. The subsequent Washington International Renewable Energy Conference (WIREC 2008) laid one particular focus on the progress made in expanding renewable energy capacity in industrial countries. Like renewables2004, WIREC gave rise to a large number of voluntary commitments, thereby perpetuating the spirit of the Bonn conference. The next conference in the series was the Delhi International Renewable Energy Conference (DIREC 2010) 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 expansion of renewable energy worldwide, and to support the initiative for the UN's International Year of Sustainable Energy For All. In January 2013, the Abu Dhabi International Renewable Energy Conference (ADIREC) took place as part of the Sustainable Energy Week held in the city. The Sustainable Energy Week hosted not only the ADIREC, but also the third session of the IRENA Assembly and the annual World Future Energy Summit. The last – and sixth – International Conference on Renewable Energies took place in Cape Town, South Africa (SAIREC) in early October 2015. The countries attending discussed the development of renewable energy in Africa, particularly sub-Saharan Africa, the contribution renewable energy makes to economic growth and prosperity, and the contribution it makes to climate protection.

Renewable Energy Policy Network for the 21st Century (REN21)

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 political 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 research community and private-sector stakeholders from the fields of energy, the environment and development.

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 geographic distribution of installed renewable capacity, growth targets, policy instruments and global investment in renewable energy.

In addition to the Global Status Report, REN21 also publishes Regional Status Reports that examine in greater depth the development of renewables in individual global regions. In 2015, a report was published on the Southern African Development Community (SADC) region for example, and in 2016, a further regional status report on the Eastern African Community was released. A report on 17 countries in Central Asia, the Balkans and in the Caucasus is scheduled to be published in 2017.

In 2013, REN21 launched a companion to the Global Status Report, the Global Futures Report. This report, which has only been published once, presents a overview of possible directions and expectations for the future growth of renewable energy. Based on scenarios and interviews with experts, it describes and compares the expectations of various players for the future of renewables, key issues and important policy options. The report was published for the Abu Dhabi International Renewable Energy Conference in 2013 (ADIREC 2013) and was highly regarded around the world.

REN21 (together with the Renewable Energy & Energy Efficiency Partnership – REEEP) is also involved in REEGLE, an online information platform, and operates an interactive world map on renewable energy, the Renewables Interactive Map, on its own website. The Secretariat of REN21 is located in Paris.

Further information at: www.ren21.net

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 on issues relating to energy, climate and the economy. The event was co-organised by the Federal Ministry for Economic Affairs and Energy and the Federal Foreign Office.

In 2016, the event was attended by more than 1,000 domestic and foreign decision-makers from the political sphere, from business, science and academia, civil society, and world-leading energy experts from a total of 70 countries. This also included numerous foreign and energy ministers, as well as high-ranking delegations from all over the world. The aim of the conference was to continue the international dialogue on a secure, environmentally compatible and affordable global energy transition, following on from the successful climate summit in Paris. Attendees in 2016 were, for the first time, also offered an extensive side programme. The excursions, which were provided in cooperation with the German Energy Agency, enabled those attending to experience the German energy transition directly on location.

Further information is available at:
www.energiewende2016.com

Clean Energy Ministerial (CEM)

Launched in 2009, the Clean Energy Ministerial (CEM) is a multilateral forum that was set up to promote sustainable energy generation right around the world. It is attended by some 24 industrial countries and emerging economies, as well as by representatives for the European Union.

Cooperation at the CEM takes place across nine working groups in which Member States usually focus on specific individual technologies. There are also 'campaigns', which take place at short notice, and often include players from the private sector and the 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.

Together with Denmark and Spain, Germany (represented by the Economic Affairs Ministry) co-leads the multilateral working group on solar and wind energy, which is currently working to improve conditions for companies when it comes to purchasing renewable energy, and to increase the flexibility of conventional power plants so that they can incorporate increasing volumes of intermittent renewable energy. Germany is also involved in initiatives on energy-efficient electrical appliances, energy management systems in industry, electric mobility and smart grids. 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 initiatives. The most recent Clean Energy Ministerial Meeting took place in San Francisco, USA from 1–2 June 2016. The next (eighth) Clean Energy Ministerial Meeting, which is to take place from 7–8 June 2017, is hosted by China.

Further information can be found at:
www.cleanenergyministerial.org

SE4ALL – 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 the year 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, 1.1 billion people worldwide have no access to electricity. This figure is forecast to remain essentially unchanged until 2030 if no additional efforts are undertaken. Two times this number of people are reliant on the use of traditional biomass.

A high-ranking group of 46 advisors from industry, government and civil society has drawn up an agenda for action in order to implement the three individual targets. As the relevant steps are then taken, it will be necessary 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.

Further information at: http://www.se4all.org

Information on methodology

Some of the figures published in this report are provisional. When 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.

The amounts of energy (gross electricity consumption, final energy consumption from renewables for heating 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 energy consumption on this basis.

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 rules for calculating whether a target will be reached. 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 the segment's growth.

In order to be able to include the contribution made by bioliquids and biofuels towards achieving the overall target and the target in the transport sector, they must fulfil specific sustainability criteria.

The share for the transport sector also includes electricity generated from renewable sources and consumed in all types of electric vehicles, based on a factor of 2.5. Furthermore, a factor of 2 is applied to biofuels from waste, lignocellulose, biomass-to-liquids (BtL) and biogas from waste.

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."

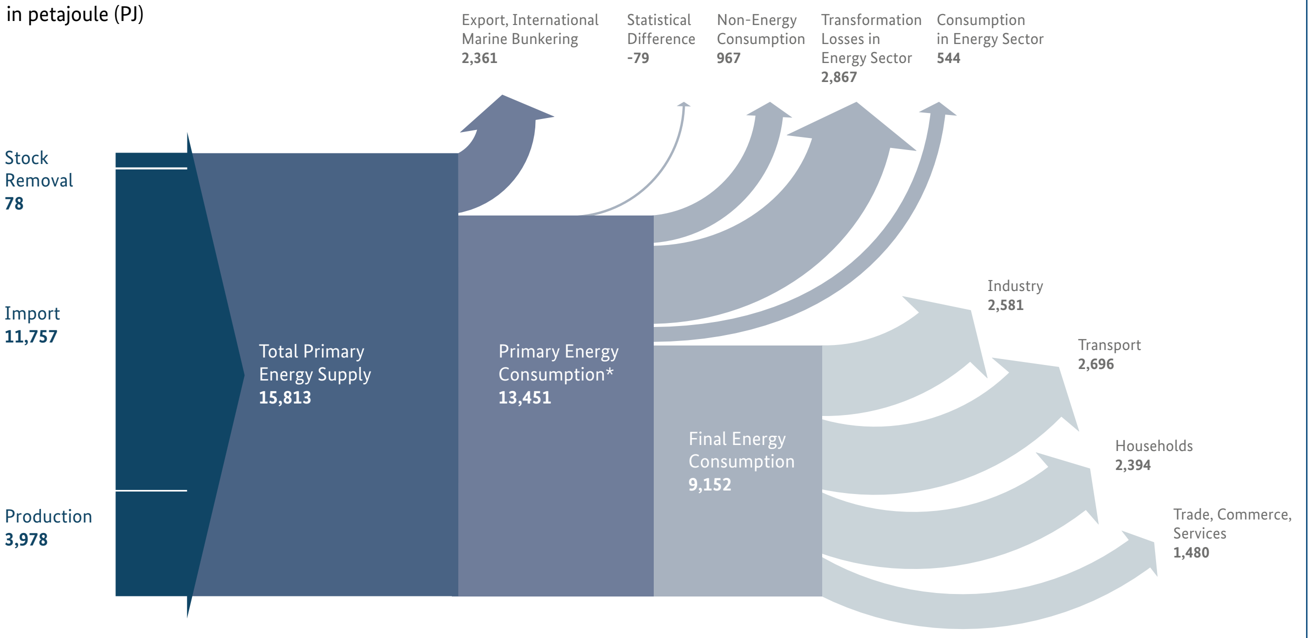
Thus, it is of limited value to compare data determined in accordance with the rules set out in the EU Directive with statistics from other sources, such as national statistics or data relating to the Renewable Energy Sources Act.

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

The German Government's Energy Concept 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, which also factors in real generation of electricity from wind and hydropower and the actual consumption of biofuels in transport.

Figure 62: Schematic diagram of energy flows in Germany in 2016

in petajoule (PJ)



Deviations from the total amounts are due to rounding.
The total proportion of renewable energy sources of the primary energy consumption is 12.6%.
* Data preliminary.
29,3 Petajoule (PJ) ≙1 Mio. t SKE

Source: Arbeitsgemeinschaft Energiebilanzen 07/2017

Adjustment of installed capacity from photovoltaics installations:

For the years 2010 to 2014, figures for the installed capacity of photovoltaics installations were adjusted to reflect those published by the Bundesnetzagentur (Federal Network Agency). This removes discrepancies between the data published by the Bundesnetzagentur and AGEE Stat. From 2015 onwards, figures on installed capacity will be updated based upon the register of facilities (ground-mounted installations) and the register of photovoltaics installations (roof installations).

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. This is particularly due to investment in plant construction. 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.

As part of steps to consolidate investment time series, methodological adjustments were undertaken, which means that the current method is different to that used to generate previous estimates. These adjustments primarily include the assigning of investments for installations where construction takes place over a period of several years to the appropriate period. The changes particularly relate to offshore wind installations, installations that use deep geothermal energy, large hydropower plants, and large CHP plants using biomass and biogas plants. They have resulted in investment amounts being assigned to different years compared with in previous publications.

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

The costs of operating and maintaining plants is 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 (incl. the research reports on the Renewable Energy Sources Act Progress Report, for example [52] and the final report on the monitoring of power generation from biomass [53]), the evaluations of the Market Incentive Programme [54], and the evaluations of KfW funding for renewable energy sources [55].

The calculation of the costs arising from supplying fuel for heat and power generation also includes the costs of solid and liquid heating fuels and of the substrates used to produce biogas. The solid biomass heating 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 €4.7 billion.

Conversion factors

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

Unity 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 calorie and derived units such as coal equivalent and oil equivalent are still used as alternatives.

Conversion factors		PJ	TWh	Mtce	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 net calorific value.

Greenhouse 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
HCl	Hydrogen chloride (Hydrochloric acid)
HF	Hydrogen fluoride (Hydrofluoric acid)
CO	Carbon monoxide
NMVOC	Non-methane volatile organic compounds

List of abbreviations

Technical terms

AusglMechV	Ordinance on the equalisation mechanism (Ausgleichsmechanismus-Verordnung)
BCHP	Block-type heating power station
Biokraft-NachV	Biofuel Sustainability Ordinance (Biokraftstoff-Nachhaltigkeitsverordnung)
BioSt-NachV	Biomass Electricity Sustainability Ordinance (Biomassestrom-Nachhaltigkeitsverordnung)
BRICS	Brazil, Russia, India, China and South Africa
CHP	Combined heat and power plant
CHP Act	Combined Heat and Power Act
COP-15	15th Conference of the Partie
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EEWärmeG	Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz)
EnergieStG	Energy Taxation Act (Energiesteuergesetz)
EnStatG	Energy Statistics Act (Energiestatistikgesetz)
FEC	Final energy consumption
GFEC	Gross final energy consumption
GHG	Greenhouse gas
GSR	Global Status Report
HH	Households
HP	Heating plant
HVO	Hydrogenated Vegetable Oils
MAP	Market Incentive Programme (Marktanreizprogramm)
N/A	Not available
NQ	Not quantified
NREAP	National Renewable Energy Action Plan
PEC	Primary energy consumption
R&D	Research and development
RE	Renewable energies
StromEinspG	Act on the Sale of Electricity to the Grid (Stromeinspeisungsgesetz)
SystEEm	Integration of renewable energy sources and regenerative energy supply systems
TCS-sector	Trade, commerce and service sector
TSO	Transmission system operator
USD	United States dollars

Glossary

Acidification potential

Potential contribution of an acidifying air pollutant (SO_2, NO_X, NH_3) to acidification. It describes the increase in the concentration of H+ ions in the air, water and soil. Sulphur compounds and nitrogen compounds from anthropogenic emissions react in the atmosphere to form sulphuric acid or nitric acid, which falls to the ground as acid rain and has harmful effects on soil, water, living organisms and buildings. SO_2, being a reference gas, has a global warming potential of 1. The relative acidification potential of nitrous oxides (NO_X) is 0.696. The factor used for ammonia (NH_3) is 1.88. Acidification potential is expressed in SO_2 equivalents.

Air pollutant

Any substance present in the air which can have harmful effects on human health or on the environment as a whole.

Assessable final consumption

There are two categories of assessable final consumption: regular (i.e. non-privileged) final consumption, and privileged final consumption.

Avoidance factor

Avoided emissions per unit of final energy from renewable sources (electricity, heat or motor fuel).

Biodiesel

Diesel-quality methyl ester of a vegetable or animal oil intended for use as a biofuel. Regarded as a first-generation biofuel. Rapeseed oil is the main oil used in Germany. It can also be refined from soy oil, palm oil or sunflower seed oil. Biodiesel can also be produced from waste substances such as frying oil and animal oils.

Bioethanol

Ethanol produced from biomass and/or the biodegradable fraction of waste and intended for use as a biofuel. Bioethanol, like biodiesel, is regarded as a first-generation biofuel. Unlike biodiesel, however, bioethanol is used in petrol engines. If bioethanol is added to conventional petrol, the product is known, for example, as E5 (5% admixture), E10 (up to 10%) or E85 (up to 85%).

Biofuel

Liquid or gaseous motor fuels made from biomass.

Biogas

A combustible gas formed by fermenting biomass or the biodegradable fraction of waste. It consists largely of methane (CH_4) and carbon dioxide (CO_2). When purified and treated, it can reach the quality of natural gas.

Biogenic (municipal) waste

Fraction of waste which can be composted under anaerobic or aerobic conditions and which is generated in agriculture, fisheries and forestry, industry and households. This includes, for example, waste wood and residual wood, straw, garden waste, liquid manure, biodegradable waste, fatty waste. Municipal waste in particular includes waste types such as household waste, household-type commercial waste, bulky waste, road sweepings, market waste, compostable waste, garden and park waste, and waste from the separate collection of paper, board, glass, plastics, wood and electrical and electronic equipment. By convention, the biogenic fraction of municipal waste is 50%.

Biomass

All organic material arising from or generated by plants and animals. Where biomass is used for energy purposes, a distinction must be made between regrow able raw materials (energy crops) and organic residues and waste.

Biomethane

Treated crude biogas (CO_2 content approximately 30% to 45% by volume) of which carbon dioxide and trace substances were removed to obtain a product with a methane content and purity comparable to natural gas (CO_2 content not exceeding 6% by volume).

Carbon dioxide (CO_2)

Carbon dioxide (CO_2) is a colourless and odourless gas which is a natural component of the atmosphere. Consumers (humans and animals) release it by breathing, and producers (plants, green algae) transform it into energy-rich organic compounds by means of photosynthesis. Carbon dioxide is also formed as a waste product of energy production in the complete combustion of carbonaceous fuels.

Carbon dioxide is the most important of the climate-relevant atmospheric trace gases with the property of being "opaque" to long-wave heat radiation. It thus prevents the equivalent re-radiation of the short-wave solar radiation reaching the Earth and increases the risk of a rise in the Earth's surface temperature. It serves as a "reference gas" for determining the CO_2 equivalent of other greenhouse gases and is therefore assigned a global warming potential of 1.

CO_2 equivalent

This unit for the global warming potential of a gas states the quantity of CO_2 that would have the same greenhouse effect as the gas in question over a period of 100 years. The equivalence factors used follow the values specified in the IPCC Second Assessment Report: Climate Change (1995), which are used for national emission reporting.

Coal equivalent

Unit for the energy value of primary energy sources. Amount of energy released by burning a standardised kilogram of hard coal.

Combined solar thermal plants

Solar thermal plants used to provide not only hot water, but also heating support.

District heating

Thermal energy supplied to the consumer via a system of insulated pipes.

EEG surcharge

As of 1 January 2010, the Equalisation Scheme Ordinance requires electricity suppliers to pay an EEG surcharge to transmission system operators (TSOs) for every kilowatt hour of electricity. The EEG surcharge is the same throughout Germany. It aims to cover the difference between the EEG feed-in tariffs and the proceeds collected by the TSOs from marketing EEG electricity at the exchange. Electricity suppliers that supply electricity to final consumers may pass the EEG surcharge onto their customers.

Efficiency

Ratio between input and output. It is not the same as the utilisation rate, which expresses the ratio of energy input to energy yield.

Electric mobility

Use of electric vehicles on road and rail.

Electric power

Electric power states how much work is performed in a particular period of time. Physical power is defined as work per unit of time. Power (P) is measured in watts (W). 1 kilowatt (kW) = 1,000 watts, while 1 megawatt (MW) = 1,000 kW.

Emission balance

An emission balance compares the emissions avoided by an energy source with the emissions caused by that source. In balances for renewable energy sources, the avoided emissions correspond to the emissions from conventional energy sources that are replaced by renewable energy, while the caused emissions result from the upstream chains and the operation of the renewable sources.

Emission factor
An emission factor describes the quantity of emissions caused by an energy source in relation to a unit of final energy. As well as this input-based view (gram per kilowatt hour (g/kWh) of final energy), however, the emission factor may also be based on product output (g/kWhel). Moreover, emission factors are always process-specific and plant-specific.

Emissions
Emissions are the gaseous, liquid and solid substances that are given off into the environment (soil, water, air) from a plant, building or means of transport. Releases of heat, radiation, noise and odours also count as emissions.

Energy
Fundamental physical quantity that describes the capacity of a system to perform work. Its basic unit is the joule (J). In terms of physics, energy cannot be created or destroyed, but only converted from one form into another. Examples of energy types include kinetic, potential, electrical, chemical and thermal energy.

Energy crops
Crops grown for energy purposes, for example cereals such as maize, wheat, rye or triticale, grasses like zebra grass (Miscanthus), pasture grass, and also oil seeds such as rapeseed and sunflower seed, fast-growing trees, poplars and willows, and beet and hemp.

Energy sources
Energy sources are substances in which energy is mechanically, thermally, chemically or physically stored.

Feed-in tariff
A government-mandated minimum price is paid for every kilowatt hour of electricity fed into the grid, provided it is generated from certain energy sources, most of which are renewable. These tariffs are higher than market prices. This reduces the risk of price fluctuations and enables plants to be operated profitably. In Germany, feed-in tariffs are governed by the Renewable Energy Sources Act (EEG).

Final energy
Final energy is the portion of primary energy that reaches the consumer after deducting transmission and conversion losses and is then available for other uses. Final energy forms include district heating, electricity, hydrocarbons such as petrol, kerosene, fuel oil or wood, and various gases such as natural gas, biogas and hydrogen.

Final energy consumption (FEC)
Final energy consumption is the direct use of energy sources in individual consumption sectors for energy services or the generation of useful energy.

Fossil fuels
Fossil fuels are finite energy resources formed from biomass under high pressure and temperature over millions of years. They are hydrocarbons such as oil, coal and natural gas.

Geothermal energy
Use of renewable terrestrial heat at various depths. In the case of near-surface geothermal energy, the heat of the earth is supplied by the sun. It gradually heats up the soil from the top down. In the winter, the soil stores a large proportion of this heat. In the case of deep geothermal energy, the heat is released by the decay of natural radioactive isotopes. The influence of this energy source increases with depth.

Global warming potential (GWP)
Potential contribution of a substance to the warming of near-surface layers of the atmosphere, relative to the global warming potential of carbon dioxide (CO_2 expressed as global warming potential (GWP, CO_2 = 1). The GWP of a substance depends on the reference period and is used to compare the greenhouse effect.

	of different gases and express their contribution to global warming. CO_2, being a reference gas, has a global warming potential of 1. According to the Fourth IPPC Assessment Report: Climate Change 2007, the relative global warming potential of methane (CH_4) over a 100-year period is 25. The GWP of nitrous oxide (N_2O) is 298. Global warming potential is expressed in CO_2 equivalents.
Greenhouse effect	Various greenhouse gases contribute to global warming by absorbing and re-emitting solar radiation. This is known as the greenhouse effect. A distinction is made between a natural and an anthropogenic (man-made) greenhouse effect.
Greenhouse gases	Atmospheric trace gases which contribute to the greenhouse effect and which can be of natural or anthropogenic origin. Examples are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs).
Gross electricity consumption	Gross electricity consumption corresponds to the sum of total electricity generated in Germany (wind, water, sun, coal, oil, gas, etc.), plus electricity imports and minus electricity exports. Net electricity consumption is gross electricity consumption minus grid and transmission losses.
Gross electricity generation	Gross electricity generation comprises the total amount of electricity generated in a country. Net electricity generation is determined by subtracting the captive consumption of the generating plants.
Gross final energy consumption (GFEC)	Gross final energy consumption refers to the final energy consumption of the final consumer, plus the losses incurred in the generating units and during transport. The gross final energy consumption for renewable energy is the final energy consumption for households, transport, industry, skilled trades, commerce and services, plus on-site consumption in the conversion sector as well as line and flare losses. Section 1 of the Annex to this report shows the shares of renewable energy in gross final energy consumption, calculated pursuant to Directive 2009/28/EC (utilising special calculation rules such as "normalised" electricity supply from wind and hydropower). This report implicitly classifies renewable energy used in electric vehicle and railway applications as electricity. There are still no methods for allocating the shares of renewable electricity in the transport sector that do not involve double-counting. However, these contributions are described in detail in the report submitted to the European Commission regarding the fulfilment of the 2020 minimum target of 10% renewable energy in transport.
Heat pump	Technical installation which can be used to raise the temperature of available heat energy by inputting mechanical energy, in order to permit technical use. The principle of the heat pump is also used in refrigerators, but there it is used for cooling purposes.
Kreditanstalt für Wiederaufbau (KfW)	Bank of Germany's federal and Land authorities. Assists various projects by providing low-interest loans.
Landfill gas	Energy-rich gas formed by rotting waste. May contain up to 55% methane (CH_4) and 45% carbon dioxide (CO_2).

Local heating

Heat transmission over relatively short distances within and between buildings. Heat production is decentralised and close to where it is needed. Unlike district heating, local heating is often not generated as a co-product.

Marine energy

Collective term for various forms of mechanical, thermal and physicochemical energy present in the waters of the world's oceans. Examples include the use of marine current power and tidal and wave power plants.

Market Incentive Programme for renewable energy in the heating market (MAP)

Programme to incentivise plants that generate heat from renewable energy sources.

Methane (CH_4)

Methane (CH_4) is a non-toxic, colourless and odourless gas. After carbon dioxide (CO_2) it is the most important greenhouse gas released by humans. According to the Fourth IPPC Assessment Report: Climate Change (2007) its climate impact is some 25 times greater than that of CO_2 over a 100-year period, but it occurs in the atmosphere in much smaller quantities.

Near-surface geothermal energy and ambient heat

Near-surface geothermal energy is taken to mean the abstraction of heat from drilling depths of up to 400 metres to supply buildings, plants or infrastructure. Heat is abstracted from the ground by means of a heat exchanger and adjusted to the desired temperature at the surface by a heat pump.

Ambient heat, by contrast, is an indirect manifestation of solar energy, which is stored in energy media such as air, surface water or the upper layers of the soil. It is characterised by a relatively low level of heat which can be harnessed by heat pumps.

Net calorific value

Also known as lower calorific value or lower heating value. Usable heat energy released during the combustion of a particular fuel. Unlike the gross calorific value, the net calorific value does not measure the heat of vaporisation of the water vapour in the exhaust.

Nitrous oxide (N_2O)

N_2O (nitrous oxide/laughing gas) is a colourless gas that is an oxide of nitrogen. Like carbon dioxide (CO_2) and methane (CH_4), it has a direct impact on the climate. According to the IPCC (1995), its climate impact is 310 times greater than carbon dioxide, but it occurs in the atmosphere in much smaller quantities. The principal anthropogenic source of nitrous oxide emissions is the use of nitrogen fertilisers in the agricultural sector.

Nuclear fuel

Fissile isotopes of radioactive chemical elements such as uranium, plutonium or thorium which are used as fuels in nuclear power plants.

Offshore wind turbine

A wind turbine for generating electricity in marine waters.

Photovoltaics (PV)

Direct conversion of solar radiation into electrical energy by means of semiconductors, often known as "solar cells".

Physical energy content method

Statistical quantification method used when preparing an energy balance. When there is no standardised conversion factor (net calorific value, etc.) for a particular energy source, the energy content of the energy source is quantified using an assumed efficiency. Nuclear energy is assumed to have an efficiency of 33%, while wind, solar and hydropower are assumed to be 100% efficient. The physical energy content method based on the international convention has been used in Germany since the 1995 reporting year.

Precursors of ground-level ozone

Ozone is a trace gas and a natural component of the earth's atmosphere. It is formed in the near-surface layers of the atmosphere when ozone precursor substances are exposed to sunshine. The most important precursors are nitrogen oxides and volatile organic compounds (VOC), followed by carbon monoxide and methane.

Primary energy

Primary energy is the theoretically available energy content of a naturally occurring energy source before it undergoes conversion.

Primary energy sources include finite energy sources such as lignite and hard coal, oil, natural gas and fissile material such as uranium ore, and renewable energy sources (solar energy, wind energy, hydropower, geothermal energy and tidal energy).

Primary energy is converted into another stage in power plants or refineries. Conversion losses occur in this process. Parts of some primary energy sources are used for non-energy purposes (e.g. oil for the plastics industry).

Primary energy consumption (PEC)

Primary energy consumption (PEC) is the net total of domestic production and fuel exports minus marine bunkers and changes in stock.

Process heat

Process heat is needed for technical processes such as cooking, forging, smelting or drying. It may be produced by means of combustion, electricity or, in the best case, exhaust heat.

Regrowable raw materials

Biomass produced by the agricultural and forestry sectors that is used to supply energy (energy crops) or as a material.

Renewable Energy Heat Act (EEWärmeG)

The 2009 Act on the Promotion of Renewable Energy in the Heat Sector (shortened to: Renewable Energy Heat Act – EEWärmeG) sets out the obligations of owners of new buildings to meet some of their heating (and cooling) requirements from renewable energy sources. The first amendment to the act came into force on 1 May 2011.

Renewable energy sources (RES)

Energy sources which, on a human time scale, are available for an infinite period of time. Nearly all renewable energy sources are ultimately fuelled by the sun. The sun will eventually burn out and so is not, strictly speaking, a renewable energy source. However, present knowledge indicates that the sun is likely to continue in existence for more than 1 billion years, which is virtually unlimited from a human perspective.

The three original sources are solar radiation, geothermal energy and tidal energy. These can be harnessed either directly or indirectly in the form of biomass, wind, hydropower, ambient heat and wave energy.

Renewable Energy Sources Act (EEG)

The 2000 Act on Granting Priority to Renewable Energy Sources (shortened to: Renewable Energy Sources Act – EEG) regulates the grid operators' obligation to purchase electricity generated from renewable sources before all other sources, the (declining) feed-in tariffs for the individual generation methods, and the procedure for allocating the resulting additional costs among all electricity customers. It has been amended several times. The last amendment was in 2016.

Repowering

Replacement of older power generation plants by new and more powerful plants at the same site. This plays a particularly important role in the wind energy industry.

Secondary energy	Energy obtained from primary energy as a result of a conversion process. The quantity of useful energy is reduced by the conversion stages. Secondary energy sources are "line bound", such as electricity, district heating and town gas. Also, the refinement of fuels such as coal and coke in briquette plants, oil in refineries or natural gas in CO_2 and H_2S removal units makes for better availability and thus counts as conversion to secondary energy.
Secondary energy source	Unlike primary energy sources, secondary energy sources are obtained from the conversion of primary energy sources. This includes all hard coal and lignite products, petroleum products, blast furnace gas, converter gas, coke oven gas, electricity and district heating. Secondary energy sources can also be obtained by converting other secondary energy sources.
Sewage gas	Energy-rich gas formed in the digestion towers of sewage works. It is one of the biogases. Its main component is methane.
SO_2 equivalent	Unit used to state the acidification potential of an air pollutant.
Solar cell	Converts light directly into electricity. The photons in solar radiation temporarily release electrons in semiconductors (mainly silicon, obtained from quartz sand) from their atomic bonds, thereby generating an electric current. This functional principle is known as the photovoltaic effect.
Solar thermal power stations	Power stations where direct solar radiation is converted into heat, transferred to a heat-transfer medium (e.g. heat-transfer oil, water, air) and transformed into electrical energy in a prime mover (e.g. steam turbine, gas turbine).
Substitution factor	Describes the extent to which individual energy sources are replaced by another energy source. In the context of emission accounting, substitution factors are used in particular to describe the replacement of primary and secondary fossil fuels with renewable energy sources.
Transmission losses	These losses occur during the transmission and conversion of electrical energy. Transmission losses increase as the square of the current transmitted. That is the reason why electricity is stepped up to higher voltages in transformers prior to transmission over long distances.
Upstream chains	Processes that occur before plant operation and involve the production, provision and processing of fuels and materials needed to build and operate energy generation plants.
Useful energy	The energy available to the final user for meeting his needs. It is obtained directly from final energy. Useful energy may come in the form of light, mechanical work, heat for space heating or cooling for space cooling.
Wind turbine	In the strict sense, plants for converting wind energy into electrical energy. There is no clear-cut definition of the borderline to "small wind turbines".
Wood pellets	Standardised cylindrical pellets of dried untreated waste wood (sawdust, wood shavings, waste wood from forestry) with a diameter of 6 mm and a length of 10 to 30 mm. They are produced under high pressure without the addition of any chemical bonding agents and have a net calorific value of approximately 5 kWh/kg.

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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 und www.erneuerbare-energien.de