Federal Ministry
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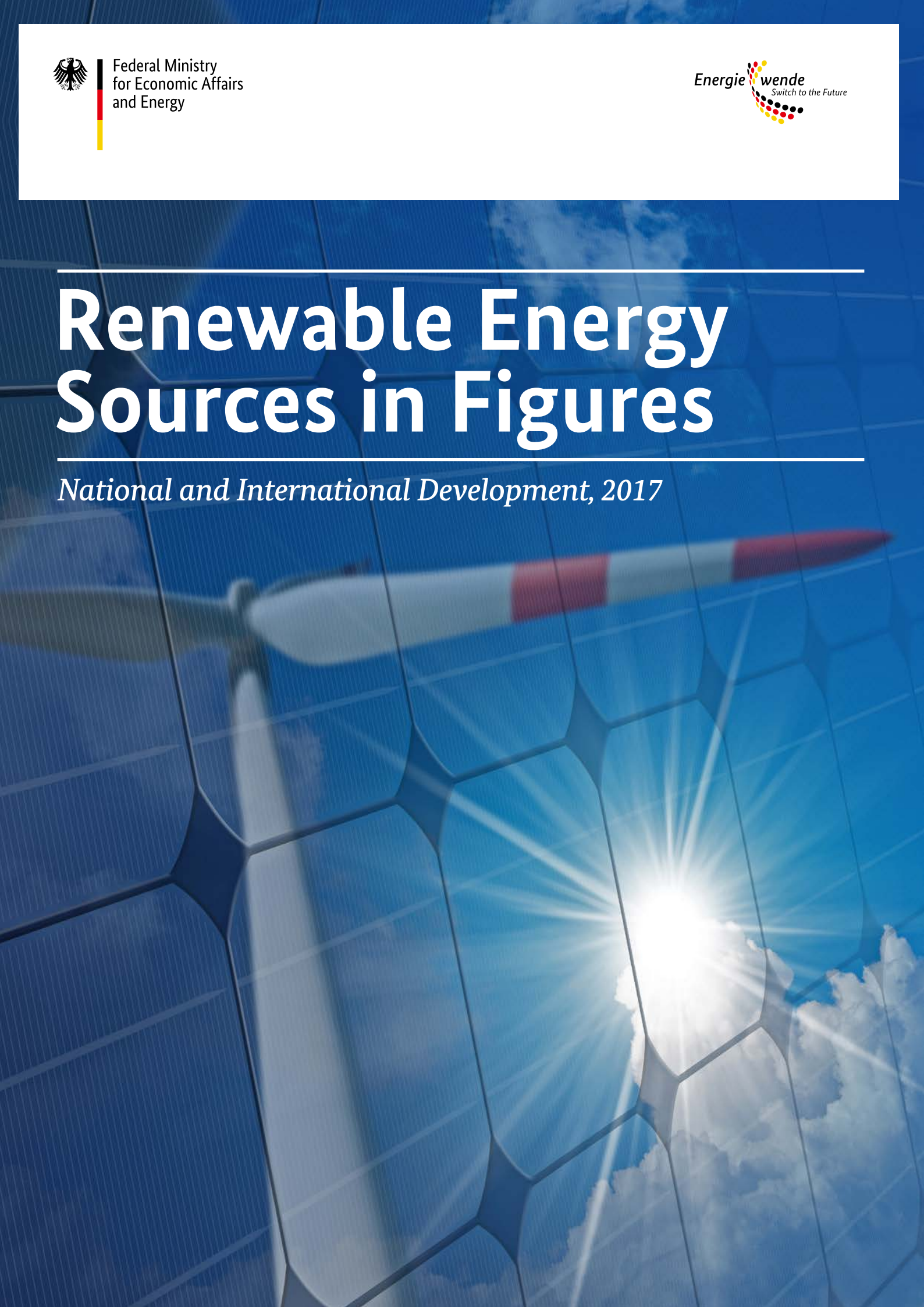
# Renewable Energy Sources in Figures

*National and International Development, 2017*



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# Renewable Energy Sources in Figures

*National and International Development, 2017*

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# Introduction

Dear Reader,

the latest edition of "Renewable Energy Sources in Figures – National and International Development" informs in detail on the development of renewable energy sources (RES) in Germany in 2017 with extensive, up-to-date statistical data. These data also serve as an important basis for monitoring progress towards the Federal Government's goals for the energy transition. They also, and provide the foundation for defining the framework for the further development of renewable energy well beyond 2020.

In the areas of electricity, heat and transport, renewable energy in Germany developed as follows in 2017:

## Electricity

There was a pronounced increase in renewable energy in the electricity sector in 2017, with electricity generation from renewable sources up approximately 14 % on 2016. The share of renewables in total electricity consumption rose from 31.6 % in 2016 to 36.0 % in 2017.

## Heat

Heat generated from renewable increased slightly in 2017, at the same time its share of total heat consumption declined slightly from 13.5 % in 2016 to 13.2 % in 2017, due to an increase in total heat consumption attributable to sound economic development.

## Fuels

With a slight increase in renewable energy in the transport sector and an increase in total fuel consumption, the share of renewable energy in transport remained constant at 5.2 %. Sales of biofuels have been stagnating at the same level for several years.

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

## Lower greenhouse gas emissions thanks to renewable energy

In 2017, greenhouse gas emissions of 177 million tonnes of $CO_2$ equivalent were avoided, with the electricity sector alone accounting for 135 million tonnes, the heating sector for 35 million tonnes and the transport sector for 7 million tonnes.

## Increased RES investment and economic stimulus from renewables

Investment in renewable energy systems as an economic factor for Germany increased to €15.7 billion in 2017. Economic stimulus from the operation of renewable energy facilities also continued to rise and was slightly higher than the investment amount, at €16.2 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. Furthermore, statistics from the Federal Environment Agency, the Federal Statistical Office, the Working Group on Energy Balances and many other sources also fed into the data.

In addition to reporting on the development of renewable energy, this publication also provides information on other topics, such as the Renewable Energy Sources Act (EEG), the Renewable Energies Heat Act (EEWärmeG) and the promotion of renewable energy in the heating and transport sectors and in the field of research and development.

Apart from providing the latest information regarding the development of renewable energy in Germany, this publication also reports on progress in the use of renewable energy sources in the European Union, which has also set itself ambitious goals. In November 2016 the European Commission presented the extensive "Clean Energy for all Europeans" legislative package, which is currently still in the legislative process. The legislative package seeks to

redefine the European energy framework through to 2030. Central elements for governance of the Energy Union, a new EU electricity market design and a review of the Renewable Energy Directive, the Energy Efficiency Directive and Buildings Directive are put forward in this context. More detailed information is provided in Part II of this publication "Renewable Energy in the European Union".

Data on the global use of renewable energy sources are provided in the final section.

The information for 2017 presented in this publication reflects the situation as at the editorial deadline for this brochure (August 2018), which means that certain figures are provisional.

Alongside this brochure, on its website the Federal Ministry for Economic Affairs and Energy provides updated time series showing the development of renewable energy sources in Germany since 1990, plus a variety of diagrams. These time series and diagrams will be updated at the end of 2018/start of 2019 (see: www.erneuerbare-energien.de/EE/ee-in-zahlen-zeitreihen and www.erneuerbare-energien.de/EE/Redaktion/DE/Bilderstrecken/entwicklung-der-erneuerbaren-energien-in-deutschland-im-jahr-englisch.html).

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

Yours sincerely,

The Federal Ministry for Economic Affairs and Energy

Berlin, September 2018

# 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 and Nuclear Safety (BMU)
- 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.erneuerbare-energien.de (in German only).

# Part I:
# Renewable energy in Germany

**The energy transition is central to a secure, environmentally friendly and economically successful future. This involves the fundamental restructuring of Germany's energy supply, moving it away from nuclear and fossil fuels and towards renewable energy and increased energy efficiency. We have already come a long way: more than one-third of our electricity now derives from the wind, sun and other renewable sources. In 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 remained constant for a number of years.**

## Expansion of renewable energy

The share of renewable energy sources (RES) in electricity consumption has grown steadily, increasing from around 6 % in 2000 to 36.0 % in 2017. The aim for Germany is to get 40-45 % of its electricity from renewable energy sources by 2025, as set down in the Renewable Energy Sources Act (RES Act). The Renewable Energy Sources Act, entered into force in 2000 and has since been revised several times, aimed to facilitate market access for young technologies like wind energy and solar energy plants (also solar radiation energy or photovoltaics) by guaranteeing their purchase at fixed rates. It thereby laid the foundation 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 the coalition agreement, coalition parties CDU, CSU and SPD agreed to increase the share of renewable energy in the electricity sector to 65 % by 2030. This will require the continued expansion of renewable energy use in a way that is ambitious, efficient, synchronised with grid development and increasingly market-oriented.

The most recent amendment – the 2017 Renewable Energy Sources Act – ushered in the next phase of the energy transition: Under the new terms, the amount of funding for renewable electricity is no longer set by the government. Instead, since 1 January 2017 the level of funding has been determined through an auction-based system. This represents a paradigm shift in the system of funding for renewable energy. The 2017 RES Act is the key to achieve effective annual quantitative steering and to bring renewables even closer to the market. With the reform of the RES Act, the technology-specific amount of funding provided to large-scale solar installations (> 750 kilowatt), onshore wind, offshore wind and biomass is determined through an auction system. As small installations with a capacity of less than 750 kilowatt are generally exempted from the obligation to take part in the auction process, this helps maintain stakeholder diversity.

More information on the auctions and results is available at www.bmwi.de/Redaktion/EN/Artikel/Energy/res-2017.html or www.bundesnetzagentur.de/EN/Areas/Energy/Companies/RenewableEnergy/RenewableEnergy_node.html.

The initial results of the auctions confirm that the reform is an important step towards a successful energy transition. Average award values have dropped, particularly in the case of photovoltaics. For example, the award price for photovoltaic fell around 50 % from 9.17 ct/kWh in the first auctioning round of the pilot auction in April 2015 to 4.59 ct/kWh in the auctioning round in June 2018. In the case of onshore wind energy, the average volume-weighted award values dropped in 2017 from 5.71 ct/kWh in the first round to 4.28 ct/kWh and 3.82 ct/kWh in the second and third round. In 2018, the average volume-weighted award value rose to 4.73 ct/ kWh in the first round to 5.73 ct/kWh and 6.16 ct/kWh in the second and third round.

High project completion rates of around 95 % in the case of ground-mounted PV installations from the first five auctioning rounds also demonstrate that the projects that are awarded funding generally do get built. In addition to the technology-specific auctions, the 2017 RES Act also contains provisions for the first time for a pilot project in which joint auctions will be held for photovoltaics and onshore wind energy installations from 2018 to 2020 inclusive, with 400 megawatt up for auction each year. This means that the two technologies directly compete with one another in the auction. The outcome of the first auctioning round in April 2018 was that 32 awards were granted for bids with a volume of 210 megawatts. All awards went to PV installations without exception.

The 2017 reform of the Renewable Energy Sources Act is also a key component towards achieving the European goals for the expansion of renewable energy. Under the provisions of EU Directive 2009/28/EC on the promotion and use of energy from renewable sources, Germany is required to generate 18 % of its gross final energy con-

sumption from renewable energy sources by 2020. The electricity sector plays a central role here.

A major instrument for heating/cooling is the Renewable Energies Heat Act (Erneuerbare-Energien-Wärmegesetz, EEWärmeG), in addition to the Market Incentive Programme which 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 (Biokraftstoffquotengesetz). Furthermore, when it comes to the use of green electricity in the transport sector, the Electric Mobility Strategy and, from 2016, the purchase premium for electric vehicles are areas worth mentioning.

Under the provisions of the Renewable Energies Heat Act, by 2020 renewables are to account for 14 % of final energy consumption for heating and cooling, and for 10 % of final energy consumption in the transport sector in keeping with the requirements of EU Directive 2009/28/EC.

These renewable energy targets are building blocks to achieving the climate goals set down by the Federal Government (40 % reduction in greenhouse gas emissions by 2020 compared with 1990 levels). In order to deliver on these goals, as set down in the coalition agreement between CDU, CSU and SPD the Federal Government will continue to oversee the implementation of the measures defined in the 2020 Climate Action Programme, assess their impact on emissions reduction and examine what additional measures need to be taken.

## Monitoring the energy transition and the Progress Report on the Renewable Energy Sources Act

The Federal Government's "Energy for the Future" monitoring process regularly reviews the progress made in the transformation of Germany's energy system. The monitoring process primarily involves analysing and consolidating the many energy statistics available and putting them into an easy-to-understand format – thus providing an overview of the current status of the energy transition in an annual monitoring report. As part of this process, the Federal Government issued its sixth Monitoring Report on the energy transition in June 2018.

A panel of four experts scientifically oversees and evaluates the monitoring process. More information on the monitoring process is provided on the BMWi website at www.bmwi.de/Redaktion/EN/Dossier/energy-transition.html

The Federal Government also presented the Progress Report on the Renewable Energy Sources Act in June 2018. To be presented every four years, the Progress Report is also based on the data documented here and presents the current state of the expansion of renewable energy as well as the greenhouse gas emissions avoided and fossil fuel savings as a result of renewable expansion. It also focuses on the special compensation arrangements for energy-intensive industries, the market integration of renewable energy and the costs of expansion. The Progress Report and the scientific interim reports from attendant research projects are published on the website of the Federal Ministry for Economic Affairs and Energy and can be accessed at www.erneuerbare-energien.de/EE/Navigation/DE/Recht-Politik/Das_EEG/EEG-Erfahrungsberichte-und-Studien/eeg-erfahrungsberichte-und-studien.html.

The figures presented in this brochure are the primary data basis for tracking progress in the expansion of renewable energy. These data are also used for the "Energy of the Future" monitoring process, the Progress Report on the Renewable Energy Sources Act and for many other reporting obligations which Germany has to meet at national and international level.

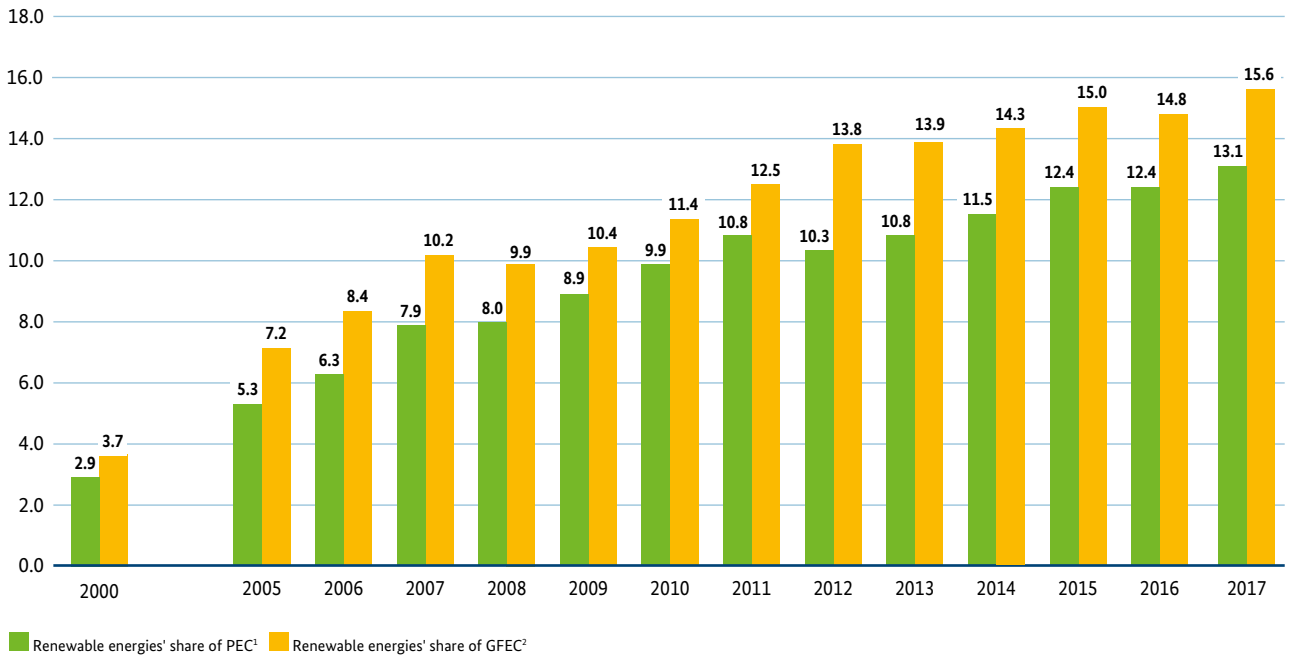
## Figure 1: Renewable energy in Germany – status quo

| Categories | 2017 | 2016 |
|---|---|---|
| **Renewable energy share (%)** | | |
| of gross final energy consumption | 15.6 | 14.8 |
| of gross electricity consumption | 36.0 | 31.6 |
| of final energy consumption in heating /cooling | 13.2 | 13.5 |
| of final energy consumption in transport | 5.2 | 5.2 |
| of primary energy consumption | 13.1 | 12.4 |
| **Avoidance of greenhouse gas emissions through the use of renewable energy sources** | | |
| Total greenhouse gas avoidance | 177.1 million t | 158.1 million t |
| of which through electricity with remuneration under the EEG | 115.6 million t | 98.9 million t |
| **Economic impetus through the use of renewable energy sources** | | |
| Investment in the construction of renewable energy plants | 15.7 billion € | 15.4 billion € |
| Costs/Revenues from the operation of renewable energy plants | 16.2 billion € | 15.6 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 Reduction in renewables' share in primary energy consumption due to change in methodology from 2012 onwards, preceding years not yet revised.

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

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; AGEB [1]; EUROSTAT [2] and other sources; see Figure 6, some figures are provisional

## Electricity

### Pronounced increase in electricity generation from renewable energy sources

A total of 216 billion kilowatt hours of electricity were generated from renewable energy sources in 2017. This translates to an increase of almost 14 % on the previous year (2016: 190 billion kilowatt hours). Solar, wind, biomass, hydro and geothermal combined were therefore able to clearly consolidate their second-place ranking, behind lignite, in the German electricity mix. Accordingly, the share of renewables in gross electricity consumption increased significantly, climbing from 31.6 % in 2016 to the 36.0 % in 2017.

### Record year for onshore wind energy

Onshore wind energy, in particular, continued to see strong growth in 2017. With 5,489 megawatts of new capacity installed, 2017 was a record year for expansion in this field, outstripping all other years. Minus the dismantling of old installations in the same period – which also reached a new all-time high of 478 megawatts – net expansion amounted to 5,011 megawatts. This equates to an increase of approximately 21 % on the previous year (4,158 megawatts), and is even roughly 8 % higher than the previous record set in 2014 (4,651 megawatts). At the end of 2017, a total of 50,466 megawatts of installed onshore wind capacity was connected to the grid. Onshore wind energy installations produced roughly 88 billion kilowatt hours, which was a represents a sharp increase compared to the previous year (2016: 68 billion kilowatt hours). Apart from capacity additions, significantly better wind conditions than in the previous year was the major contributing factor to this increase.

### Offshore wind energy also taking off

While the expansion of offshore wind energy was trending downwards in 2016, 2017 saw a significant increase in new capacity with 1,275 megawatts connected to the grid (compared to 849 megawatts in 2016). This means that 5,407 megawatts of wind energy capacity were installed in the German sea area at the end of 2017. With 18 billion kilowatt hours, the North Sea and the Baltic Sea produced 44 % more electricity in 2017 than in the previous year (12.3 billion kilowatt hours).

Overall, total wind energy generated 105.7 billion kilowatt hours in 2017, covering 17.6 % of Germany's total gross electricity consumption.

**Figure 3: Renewables-based electricity generation in 2017 and 2016**

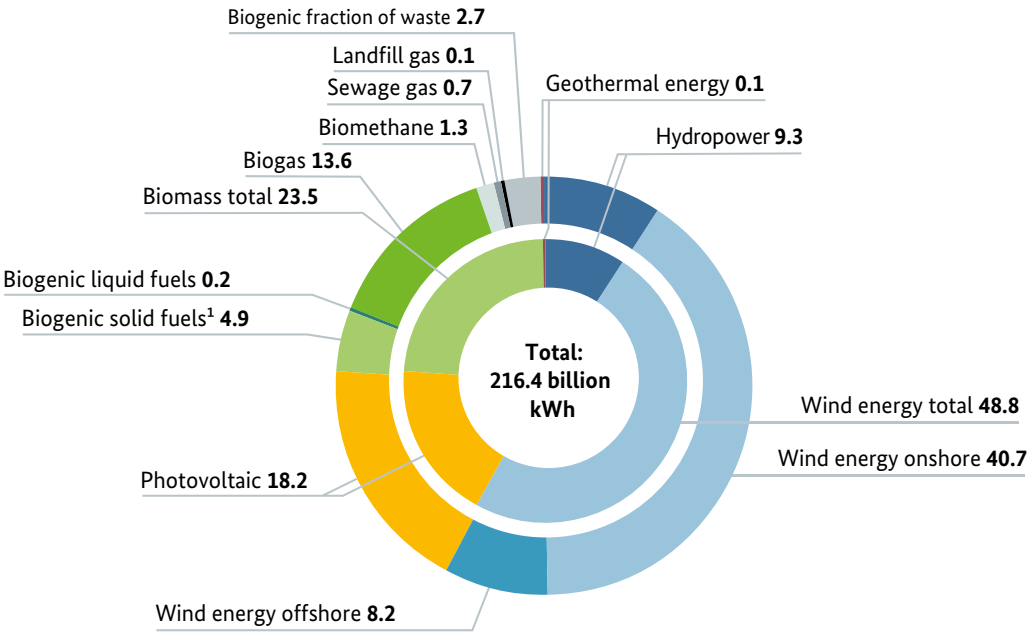
| | Renewable energy sources 2017 | | Renewable energy sources 2016 | |
|---|---|---|---|---|
| | Gross electricity generation (GWh)[4] | Share of gross electricity consumption (%)[5] | Gross electricity generation (GWh)[4] | Share of gross electricity consumption (%)[5] |
| Hydropower[1] | 20,150 | 3.4 | 20,546 | 3.4 |
| Onshore wind energy | 88,018 | 14.7 | 67,650 | 11.3 |
| Offshore wind energy | 17,675 | 2.9 | 12,274 | 2.0 |
| Photovoltaic | 39,426 | 6.6 | 38,098 | 6.4 |
| Biogenic solid fuels[2] | 10,624 | 1.8 | 10,795 | 1.8 |
| Biogenic liquid fuels | 513 | 0.1 | 497 | 0.1 |
| Biogas | 29,323 | 4.9 | 29,263 | 4.9 |
| Biomethane | 2,757 | 0.5 | 2,643 | 0.4 |
| Sewage gas | 1,480 | 0.2 | 1,440 | 0.2 |
| Landfill gas | 300 | 0.05 | 358 | 0.1 |
| Biogenic fraction of waste[3] | 5,946 | 1.0 | 5,930 | 1.0 |
| Geothermal energy | 163 | 0.03 | 175 | 0.03 |
| **Total** | **216,375** | **36.0** | **189,669** | **31.6** |

1 For pumped-storage power plants, only electricity generation from natural inflow
2 Including sewage sludge
3 Biogenic share of waste in waste incineration plants estimated at 50 %
4 1 GWh = 1 million kWh
5 Based on gross electricity consumption, 2017: 600.4 billion kWh; 2016: 599.9 billion kWh, according to AGEE-Stat, there from fossil and nuclar based gross electricity production according to AGEB [3]

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

**Figure 4: Renewables-based electricity generation in 2017**

in percent

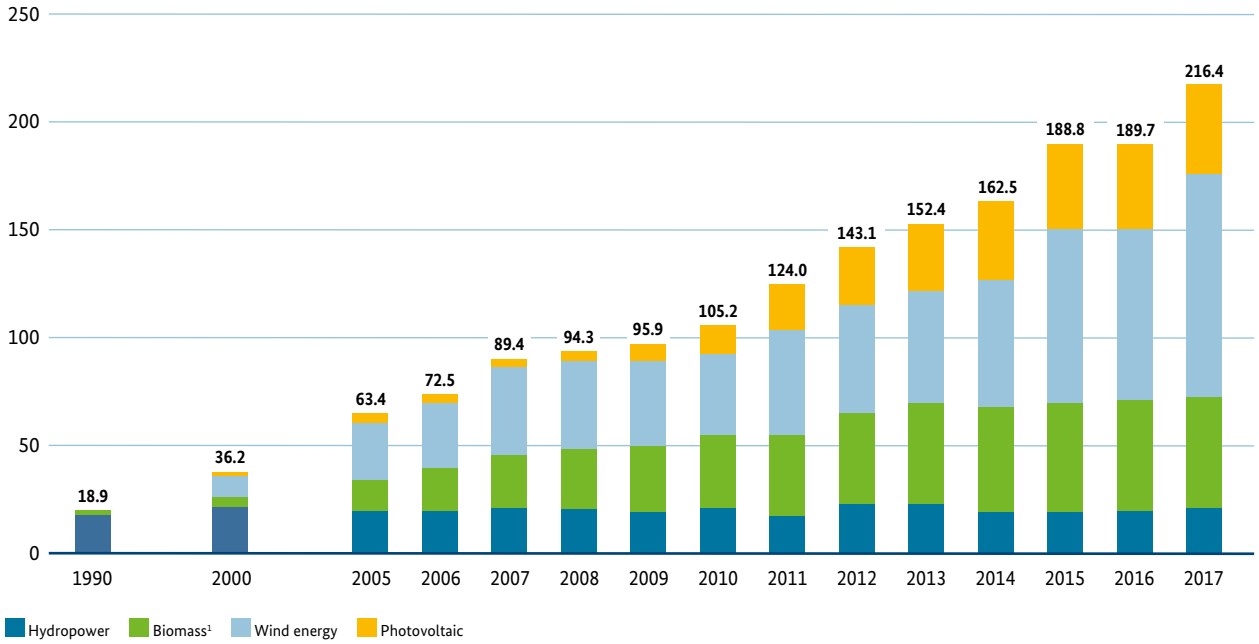



1 Including sewage sludge

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

**Figure 5: Electricity generation from renewable energy sources**

in billion kWh




1 Solid and liquid biomass, biogas, biomethane, landfill gas and sewage gas, sewage sludge and 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 are provisional

**Figure 6: Electricity generation from renewable energy sources**

| | Hydropower[1] | Onshore wind energy | Offshore wind energy | Biomass[2] | Photovoltaic | Geothermal energy | Total gross electricity generation | Share of gross electricity consumption |
|---|---|---|---|---|---|---|---|---|
| | | | (GWh)[3] | | | | (GWh)[3] | (%) |
| **1990** | 17,426 | 72 | 0 | 1,435 | 1 | 0 | **18,934** | **3.4** |
| **2000** | 21,732 | 9,703 | 0 | 4,731 | 60 | 0 | **36,226** | **6.3** |
| **2005** | 19,638 | 27,774 | 0 | 14,706 | 1,282 | 0 | **63,400** | **10.2** |
| **2006** | 20,031 | 31,324 | 0 | 18,934 | 2,220 | 0 | **72,509** | **11.6** |
| **2007** | 21,170 | 40,507 | 0 | 24,616 | 3,075 | 0 | **89,368** | **14.3** |
| **2008** | 20,443 | 41,385 | 0 | 28,014 | 4,420 | 18 | **94,280** | **15.2** |
| **2009** | 19,031 | 39,382 | 38 | 30,886 | 6,583 | 19 | **95,939** | **16.4** |
| **2010** | 20,953 | 38,371 | 176 | 33,925 | 11,729 | 28 | **105,182** | **17.0** |
| **2011** | 17,671 | 49,280 | 577 | 36,891 | 19,599 | 19 | **124,037** | **20.3** |
| **2012** | 21,755 | 50,948 | 732 | 43,217 | 26,380 | 25 | **143,057** | **23.5** |
| **2013** | 22,998 | 51,819 | 918 | 45,528 | 31,010 | 80 | **152,353** | **25.1** |
| **2014** | 19,587 | 57,026 | 1,471 | 48,301 | 36,056 | 98 | **162,539** | **27.4** |
| **2015** | 18,977 | 72,340 | 8,284 | 50,341 | 38,726 | 133 | **188,801** | **31.5** |
| **2016** | 20,546 | 67,650 | 12,274 | 50,926 | 38,098 | 175 | **189,669** | **31.6** |
| **2017** | 20,150 | 88,018 | 17,675 | 50,943 | 39,426 | 163 | **216,375** | **36.0** |

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

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

3 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; StBA [56], [59]; BNetzA [4]; ÜNB [5]; ZSW; DENA [64]; BDEW; AGEB [3]; DBFZ; some figures are provisional

## Upward trend in the expansion of photovoltaic capacity

As in 2016, there was a slight upward trend in the expansion of photovoltaics in 2017. 1,660 megawatts of new PV capapcity was installed in 2017. While this equates an increase of 11 % on 2016 (1,492 megawatts), it is still far below the annual expansion target of 2,500 megawatts. By the end of 2017, PV installations across Germany had a combined total capacity of 42,376 megawatts. Electricity generation increased to 39.4 billion kilowatt hours, up 3 % on the previous year (38.1 billion kilowatt hours). Solar power therefore accounted for 6.6 % of gross electricity consumption in Germany.

## Trend towards the flexibilisation of biogas installations continues

With 315 megawatts of capacity added in 2017, the electricity generation capacity of biogas installations again saw significantly stronger expansion in 2017 than in the previous year (202 megawatts). However, more than 98 % of this additional capacity was installed by existing facilities in order to respond flexibly to sharp increases in demand (and in doing so receive the flexibility premium). This capacity increased the flexibility of supply, but only has a marginal impact on the level of electricity production. (2017: 29.32 billion kilowatt hours, 2016: 29,26 billion kilowatt hours). Only minor changes in capacity and electricity generation can be reported for solid and liquid biomass.

Electricity generation from biomethane plants increased slightly from 2.6 billion kilowatt hours in 2016 to 2.8 billion kilowatt hours in 2017. In 2017, a total of 50.94 billion kilowatt hours of electricity were produced from solid, liquid and gaseous biomass, including landfill gas, sewage gas and the biogenic share of municipal waste (2016: 50.93 billion kilowatt hours), which is equivalent to 8.5 % of total gross electricity consumption.

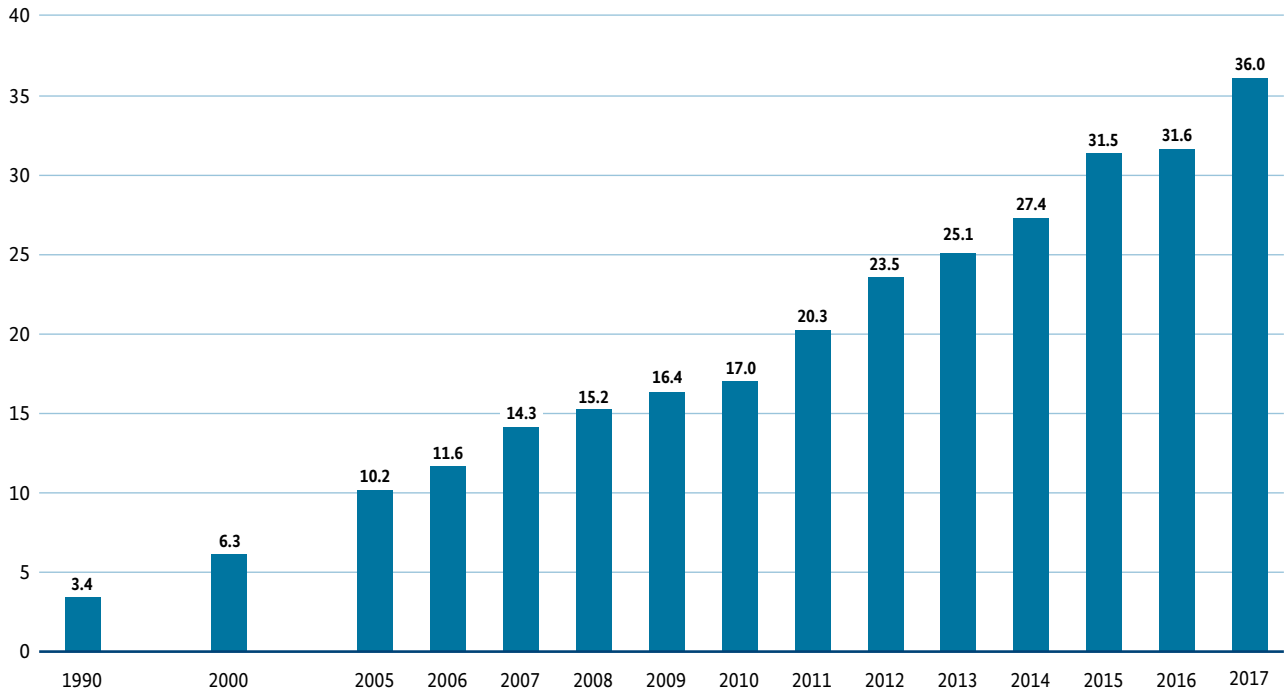
## Hydroelectric and geothermal energy

With only a slight change in the installed capacity, electricity generation from hydroelectric installations fell slightly to 20.2 billion kilowatt hours due to weather conditions (2016: 20.5 billion kilowatt hours). This translates into 3.4 % of gross electricity consumption.

The volume of electricity generated from geothermal energy decreased to 163 million kilowatt hours (compared with 175 million kilowatt hours in 2016). No additional capacity was added in this area in 2017.

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

in percent

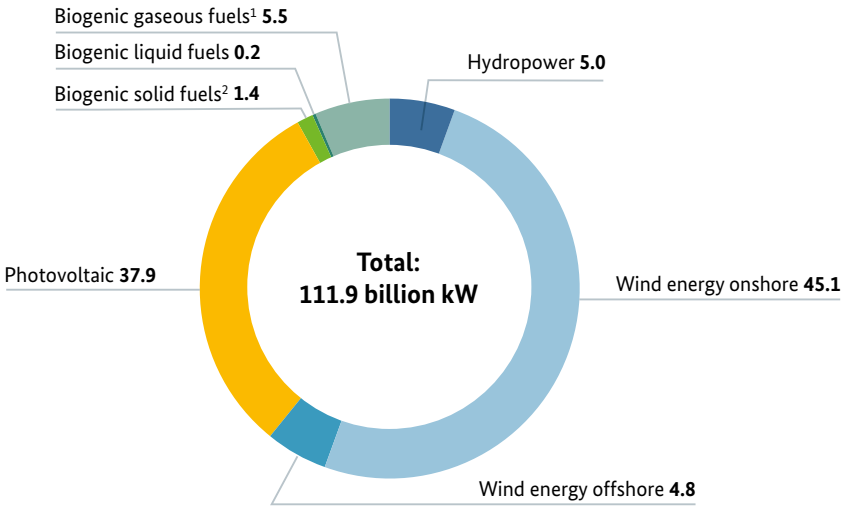



Under the 2017 Renewable Energy Sources Act (EEG), renewable energy must make up 40-45 % of gross electricity consumption by 2025.

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

**Figure 8: Installed power generation capacity based on renewables energy source, 2017**

in percent




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

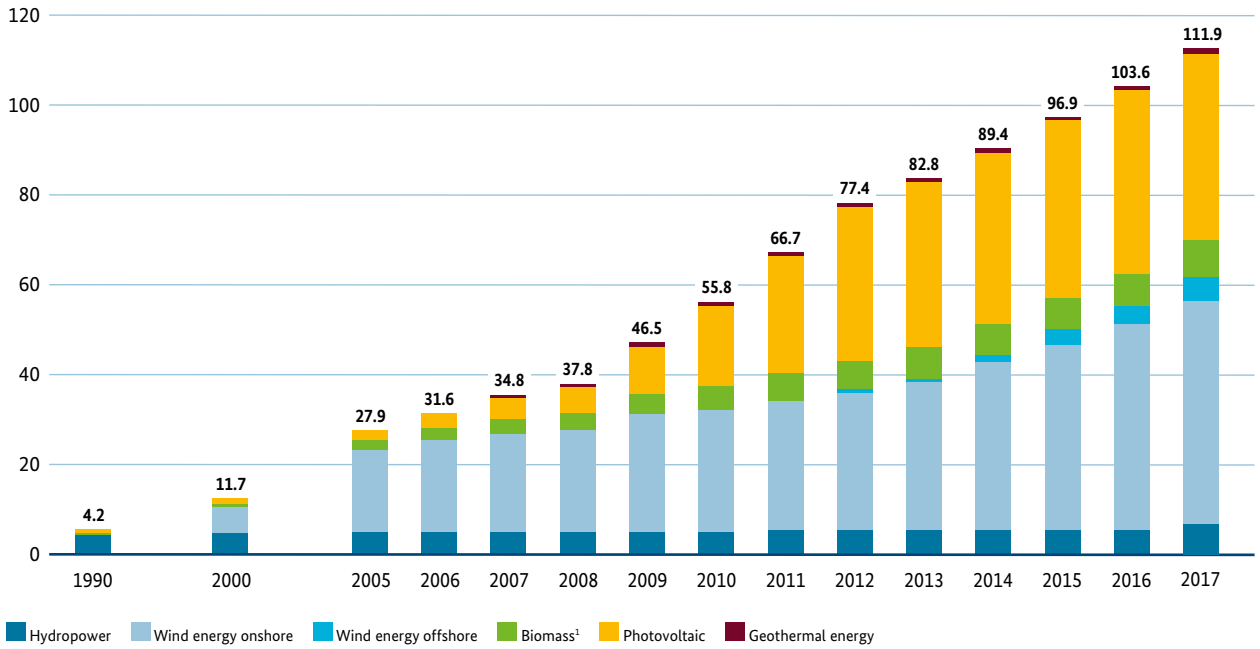
1 Biogas, biomethane, landfill gas and sewage gas

2 Incl. sewage sludge, excluding biogenic share of waste

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

**Figure 9: Installed power generation capacity based on renewables**

Gigawatt [GW]




1 Solid and liquid biomass, biogas, biomethane, landfill gas, sewage gas and sewage sludge, excluding 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 are provisional

## Figure 10: Installed power generation capacity based on renewables

| | Hydropower[1] | Wind energy onshore | Wind energy offshore | Biomass[2] | Photovoltaic | Geothermal energy | Total capacity |
|---|---|---|---|---|---|---|---|
| | | | | (MW)[3] | | | |
| **1990** | 3,982 | 55 | 0 | 129 | 2 | 0 | **4,168** |
| | | | | | | | |
| **2000** | 4,831 | 6,097 | 0 | 703 | 114 | 0 | **11,745** |
| | | | | | | | |
| **2005** | 5,210 | 18,248 | 0 | 2,352 | 2,056 | 0.0 | **27,866** |
| **2006** | 5,193 | 20,474 | 0 | 3,010 | 2,899 | 0.0 | **31,576** |
| **2007** | 5,137 | 22,116 | 0 | 3,392 | 4,170 | 3.0 | **34,818** |
| **2008** | 5,164 | 22,794 | 0 | 3,687 | 6,120 | 3.0 | **37,768** |
| **2009** | 5,340 | 25,697 | 35 | 4,873 | 10,566 | 8.0 | **46,519** |
| **2010** | 5,407 | 26,823 | 80 | 5,460 | 18,006 | 8.0 | **55,784** |
| **2011** | 5,625 | 28,524 | 188 | 6,419 | 25,916 | 8.0 | **66,680** |
| **2012** | 5,607 | 30,711 | 268 | 6,753 | 34,077 | 19.0 | **77,435** |
| **2013** | 5,590 | 32,969 | 508 | 7,036 | 36,710 | 30.0 | **82,843** |
| **2014** | 5,580 | 37,620 | 994 | 7,260 | 37,900 | 33.0 | **89,387** |
| **2015** | 5,589 | 41,297 | 3,283 | 7,467 | 39,224 | 34.0 | **96,894** |
| **2016** | 5,598 | 45,455 | 4,132 | 7,667 | 40,716 | 39.0 | **103,607** |
| **2017** | 5,605 | 50,466 | 5,407 | 7,987 | 42,376 | 39.0 | **111,880** |

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

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

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

3 1,000 MW = 1 GW

Sources: Federal Ministry for Economic Affairs and Energy (BMWi) based on data from AGEE-Stat; StBA [56], [60]; AGEB [1]; Thünen-Institut [7], [58]; ZSW [47]; FNR [54]; Uni HH [55]; DENA [64]; DBFZ; LIAG [8]; GZB [10]; BDH; BSW; DEPV; BWP; IEA/ESTIF [11]; some figures are provisional

## Heat

### Slight decline in the share of renewables in heat consumption

Final energy consumption for heat generation derived from renewable sources increased slightly in 2017 compared with the previous year. The consumption of wood (including wood pellets) by private households accounted for the largest share, with 66 billion kilowatt hours. This translates to a slight increase of roughly 3 % on the previous year (2016: 64 billion kilowatt hours). One reason for this development is the growth in the use of modern wood pellet combustion systems, with 28,000 new systems installed. As a result, the consumption of wood pellets also rose slightly to 2.1 million tonnes (2016: 2.0 million tonnes).

The use of geothermal energy and ambient heat in combination with heat pumps is continuing its upward trend, with around 91,000 new systems (including hot water heat pumps) installed in 2017 – more than in any other year before. With the heat pump installed base now totalling 975,000, heat pumps in Germany provided 12.4 billion kilowatts hours of heating in 2017, an increase of 9 % on the previous year.

In contrast, the expansion of solar thermal installations has been declining for a number of years. The total area of newly installed solar collectors amounted to 625,000 square metres in 2017. This amounts to a further year-on-year decrease of 15 % (2016: 739,000 square metres) and is the lowest level recorded in 15 years. At roughly 7.9 billion kilowatt hours, the production of heat from solar thermal energy was up 2 % on the previous year (7.7 billion kilowatt hours), but more hours of sunshine in 2017 also contributed to this increase.

**Figure 11: Final energy consumption for heat generation based on renewable energy sources in 2016 and 2017**

| | Renewable energy sources 2017 | | Renewable energy sources 2016 | |
|---|---|---|---|---|
| | Final energy consumption heat (GWh)[8] | Share of final energy consumption for heat[9] in (%) | Final energy consumption heat (GWh)[8] | Share of final energy consumption for heat[9] in (%) |
| Biogenic solid fuels (households)[1] | 65,806 | 5.2 | 64,004 | 5.2 |
| Biogenic solid fuels (TCS sector)[2] | 14,204 | 1.1 | 13,475 | 1.1 |
| Biogenic solid fuels (industry)[3] | 27,000 | 2.1 | 27,031 | 2.2 |
| Biogenic solid fuels (HP/CHP)[4] | 6,145 | 0.5 | 6,259 | 0.5 |
| Biogenic liquid fuels[5] | 2,140 | 0.2 | 2,106 | 0.2 |
| Biogas | 14,010 | 1.1 | 13,917 | 1.1 |
| Biomethane | 3,634 | 0.3 | 3,563 | 0.3 |
| Sewage gas | 2,178 | 0.2 | 2,053 | 0.2 |
| Landfill gas | 127 | 0.01 | 136 | 0.01 |
| Biogenic fraction of waste[6] | 12,093 | 0.9 | 11,669 | 1.0 |
| Solar thermal energy | 7,853 | 0.6 | 7,693 | 0.6 |
| Deep geothermal energy | 1,171 | 0.1 | 1,146 | 0.1 |
| Near-surface geoth. energy, ambient heat[7] | 12,442 | 1.0 | 11,419 | 0.9 |
| **Total** | **168,803** | **13.2** | **164,471** | **13.5** |

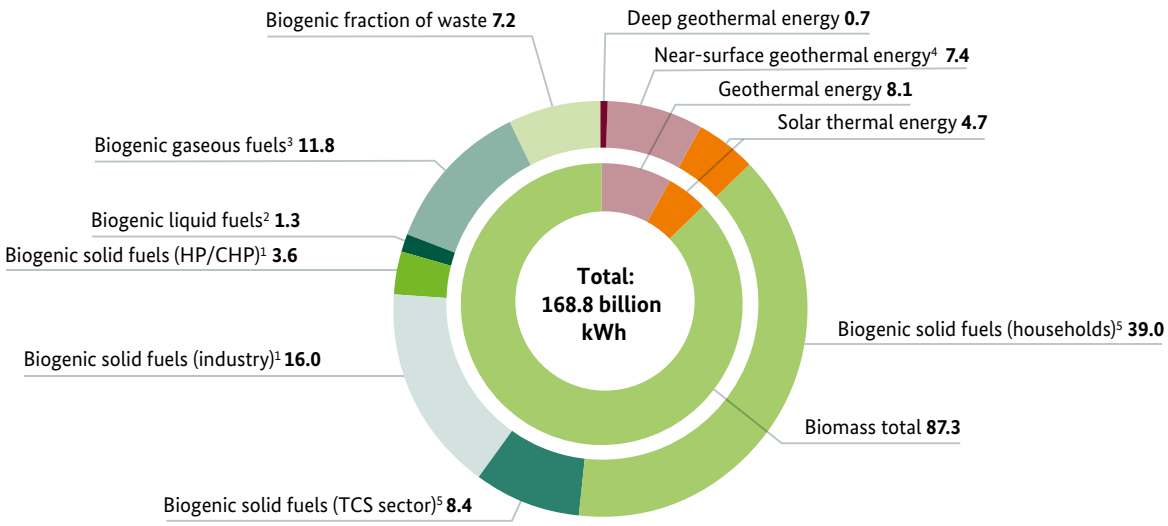
1 Mostly wood, incl. wood pellets and charcoal
2 Including charcoal, TCS = trade, commerce, services sectors
3 Including sewage sludge
4 Including sewage sludge; HP = heating plants, CHP = combined heat and power plants
5 Including consumption of biodiesel in agriculture, forestry, construction and military
6 Estimated at 50 % in waste incineration plants
7 Renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)
8 1 GWh = 1 million kWh
9 Relates to final energy consumption for space heating, hot water, process heat, air conditioning and process cooling, 2017: 1,276.0 billion kWh; 2016: 1,222.4 billion kWh according to AGEB [1].
For more details on the methodology for calculating the share and on correspondence to the RES goal for the heating sector, see the "Information on methodology" section.

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

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

**Figure 12: Final energy consumption for heat generation based on renewable energy sources, 2017**

in percent

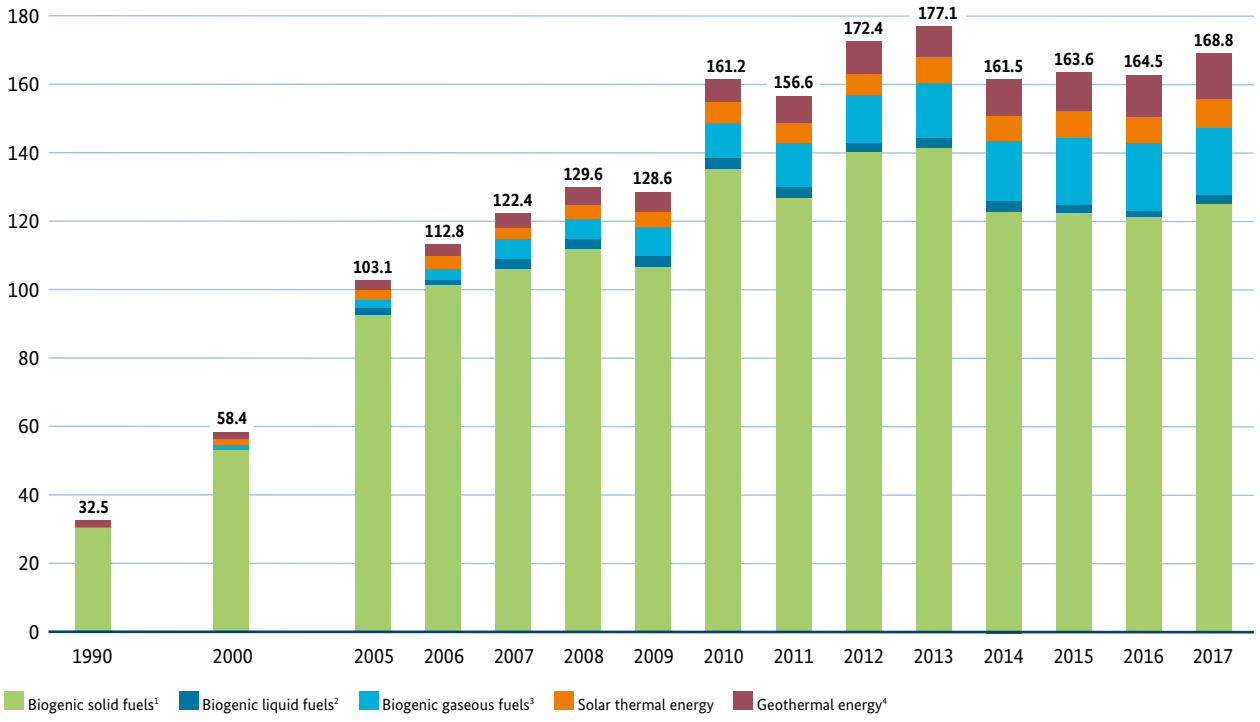



1 Including sewage sludge
2 Including consumption of biodiesel in agriculture, forestry, construction and military
3 Biogas, biomethane, sewage gas and landfill gas
4 Renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)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

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

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

in billion kilowatt hours (kWh)




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

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

Overall, the consumption of heat generated from renewable energy sources rose to 168.8 billion kilowatt hours (2016: 164.5 billion kilowatt hours). Of this, biomass, including the biogenic share of municipal waste, accounted for the largest share by far (87.3 %), followed by geothermal and ambient heat (8.1 %) and solar thermal (4.7 %). On the other hand, total final energy consumption for heat generation increased by approximately 4 % in 2017, primarily for economic reasons. As a result, the share of renewables in total final energy consumption for heating and cooling dropped to 13.2 % (2016: 13.5 %).

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

| | Solid biomass[1] | Liquid biomass[2] | Gaseous biomass[3] | Solar thermal energy | Near-surface geoth. energy, ambient heat[4] | Total FEC heat | RE share of FEC of heat |
|---|---|---|---|---|---|---|---|
| | | | (GWh)[5] | | | (GWh)[5] | (%) |
| **1990** | 30,573 | 0 | 0 | 131 | 1,812 | **32,516** | **2.1** |
| | | | | | | | |
| **2000** | 53,604 | 8 | 1,355 | 1,292 | 2,170 | **58,429** | **4.4** |
| | | | | | | | |
| **2005** | 93,405 | 713 | 3,163 | 3,028 | 2,815 | **103,124** | **8.0** |
| **2006** | 101,231 | 1,296 | 3,494 | 3,547 | 3,272 | **112,840** | **8.6** |
| **2007** | 106,794 | 1,902 | 5,778 | 3,934 | 3,961 | **122,369** | **10.4** |
| **2008** | 112,076 | 2,642 | 5,666 | 4,474 | 4,783 | **129,641** | **10.1** |
| **2009** | 106,734 | 3,287 | 7,654 | 5,250 | 5,719 | **128,644** | **10.8** |
| **2010** | 135,253 | 3,178 | 10,521 | 5,592 | 6,627 | **161,171** | **12.1** |
| **2011** | 127,728 | 2,437 | 12,489 | 6,389 | 7,540 | **156,583** | **12.9** |
| **2012** | 140,584 | 2,019 | 14,594 | 6,640 | 8,570 | **172,407** | **14.1** |
| **2013** | 142,044 | 2,081 | 16,708 | 6,701 | 9,596 | **177,130** | **13.9** |
| **2014** | 123,455 | 2,217 | 17,909 | 7,206 | 10,695 | **161,482** | **14.0** |
| **2015** | 122,859 | 2,111 | 19,470 | 7,706 | 11,479 | **163,625** | **13.6** |
| **2016** | 122,438 | 2,106 | 19,669 | 7,693 | 12,565 | **164,471** | **13.5** |
| **2017** | 125,248 | 2,140 | 19,949 | 7,853 | 13,613 | **168,803** | **13.2** |

1 Including the biogenic share of waste (estimated at 50 % in waste incineration plants), sewage sludge and charcoal; decrease 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; data for TCS sector (trade, commerce and service) only available from 2003 onwards

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

3 Biogas, biomethane, sewage gas and landfill gas

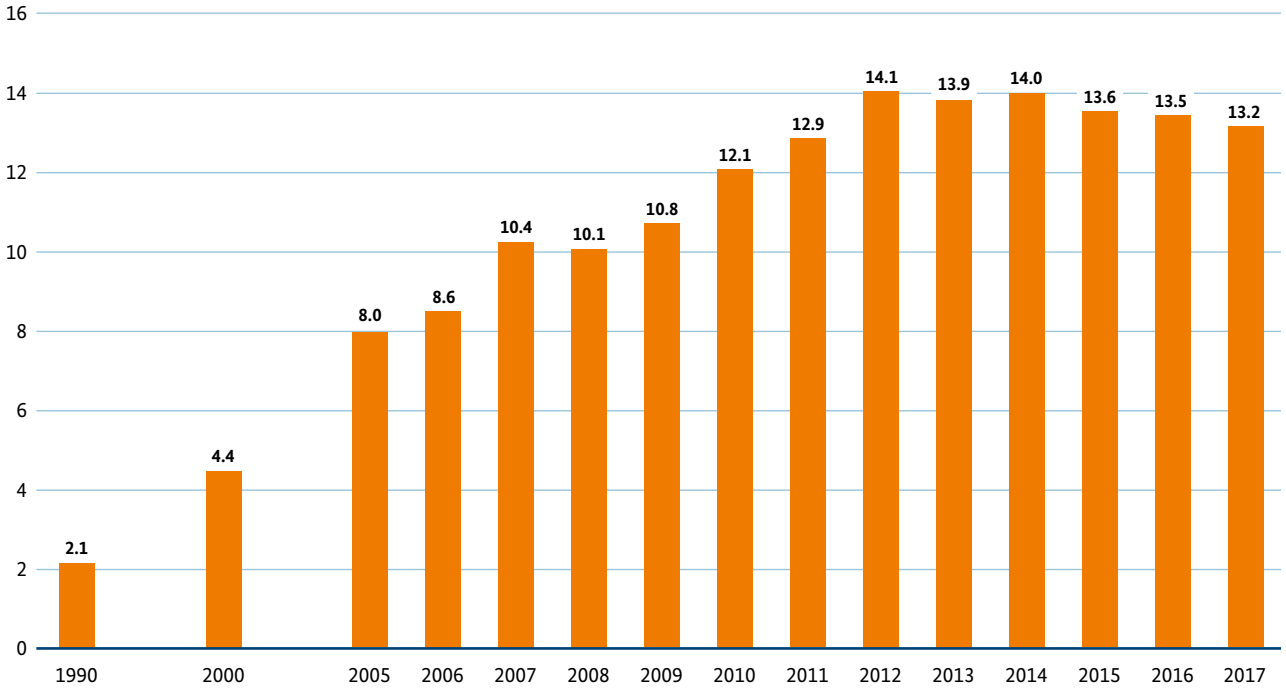
4 Including heat from deep geothermal energy and renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)

5 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy (BMWi) based on data from AGEE-Stat; StBA [56], [60]; AGEB [1]; Thünen Institute [7], [58]; ZSW [47]; FNR [54]; Uni HH [55]; DENA [64]; DBFZ; LIAG [8]; GZB [10]; BDH; BSW; DEPV; BWP; IEA/ESTIF [11]; some provisional figures

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

in percent



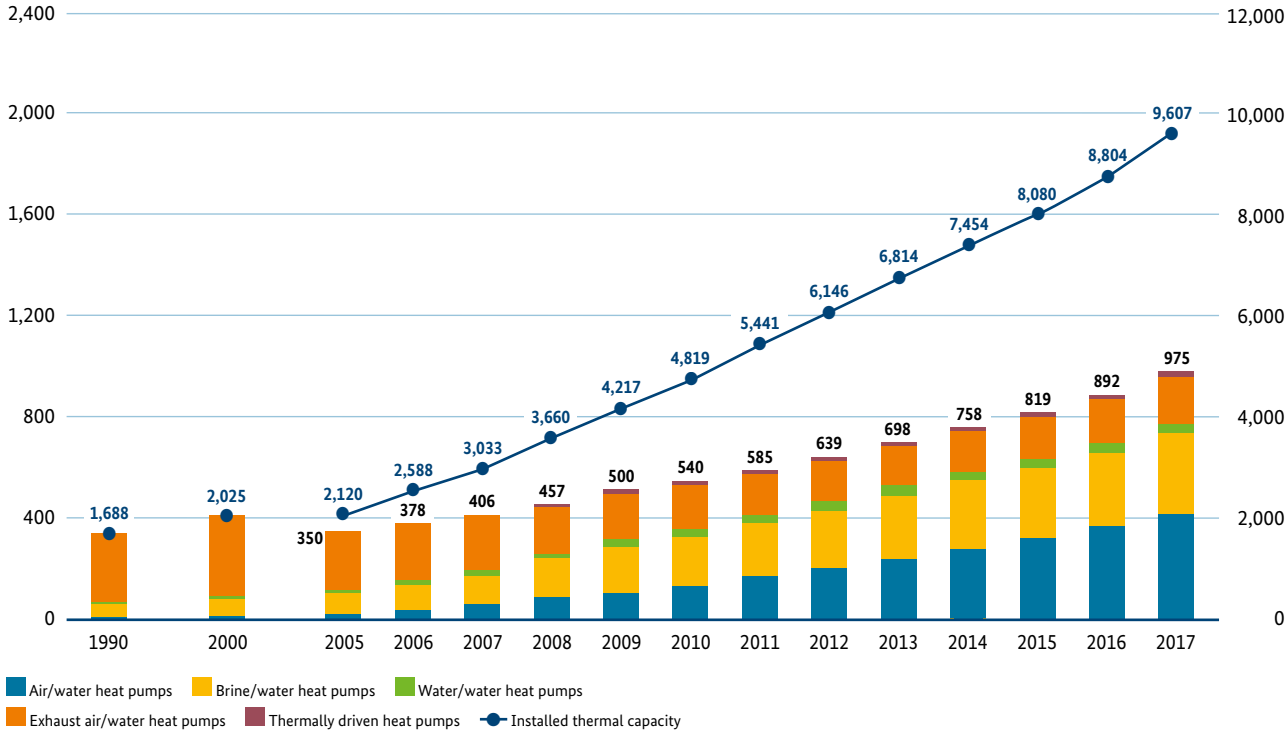

Under the Renewable Energies Heat Act, renewable energy must make up 14 % of final energy consumption for heating and cooling by 2020.

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

## Figure 16: Development of heat pump stock

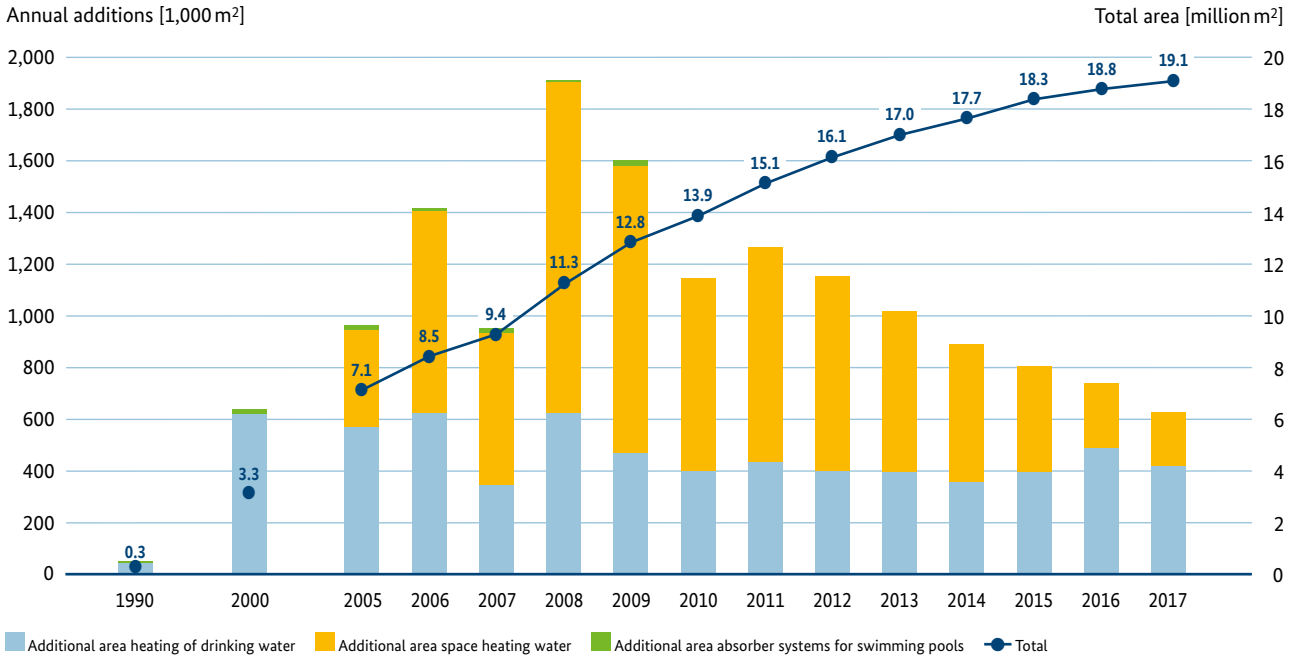
Number of heat pumps in thousand

Installed thermal power [MW]




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

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




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

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

**Figure 18: Solar-based heat: area and heat generation capacity of solar collectors in Germany**

| | | 1990 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative area | (1,000 m²) | 348 | 3,250 | 7,085 | 13,914 | 15,100 | 16,140 | 17,020 | 17,746 | 18,339 | 18,812 | 19,091 |
| Cumulative output | (MW) | 243 | 2,275 | 4,959 | 9,739 | 10,569 | 11,298 | 11,913 | 12,422 | 12,837 | 13,168 | 13,364 |

Figures take account of old installations taken out of service.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; BDH; BSW; IEA/ESTIF [11]

## Transport

### Sales of biofuels stable

In 2017, sales of biofuels rose slightly by 1 % to 3.2 million tonnes, with biodiesel sales increasing by 1.9 % while the sale of bioethanol dropped by 1.5 %. While the deployment of biomethane in the transport sector rose by 17.9 % to 445 million kilowatt hours, it continues to play a limited role in the field of biofuels.

With growth in the sale of electric vehicles still being slow, the development of renewable electricity consumption in the transport sector largely corresponds to the share of renewables in the electricity mix. Accordingly, there was a significant increase of 15 % to roughly 4.3 billion kilowatt hours (2016: 3.7 billion kilowatt hours) was seen here in 2017. The share of renewable energy in total final energy consumption in the transport sector (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) remained at the same level as 2016, at 5.2 %.

**Figure 19: Consumption of renewable energy sources in the transport sector in 2016 and 2017**

| | Renewable energy sources 2017 | | Renewable energy sources 2016 | |
|---|---|---|---|---|
| | 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] | 21,258 | 3.2 | 20,866 | 3.2 |
| Vegetable oil | 10 | 0.002 | 42 | 0.006 |
| Bioethanol | 8,530 | 1.3 | 8,663 | 1.3 |
| Biomethane | 445 | 0.1 | 379 | 0.1 |
| RE electricity consumption in transport [2] | 4,248 | 0.6 | 3,709 | 0.6 |
| **Total** | **34,491** | **5.2** | **33,659** | **5.2** |

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

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

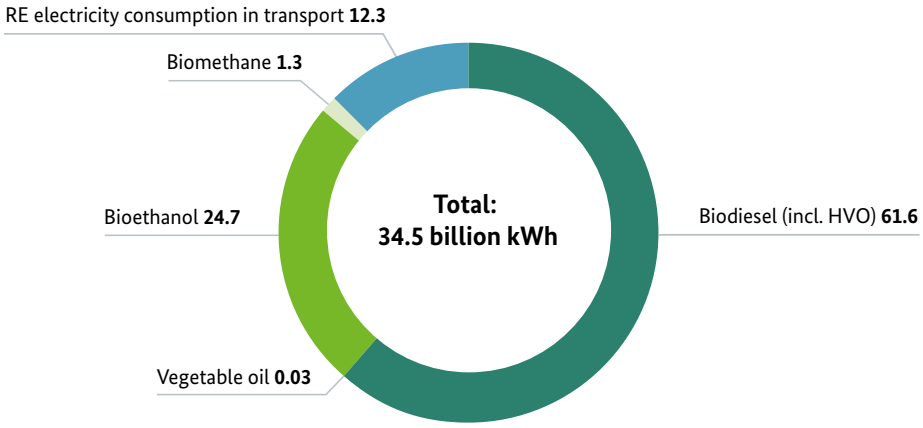
3 GWh = 1 million kWh

4 Based on final energy consumption in transport in 2017: 657.1 billion kWh; 2016: 649.7 billion kWh, ZSW accordingto BAFA and AGEB [1]

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

**Figure 20: Consumption of renewable energy sources in the transport sector, 2017**

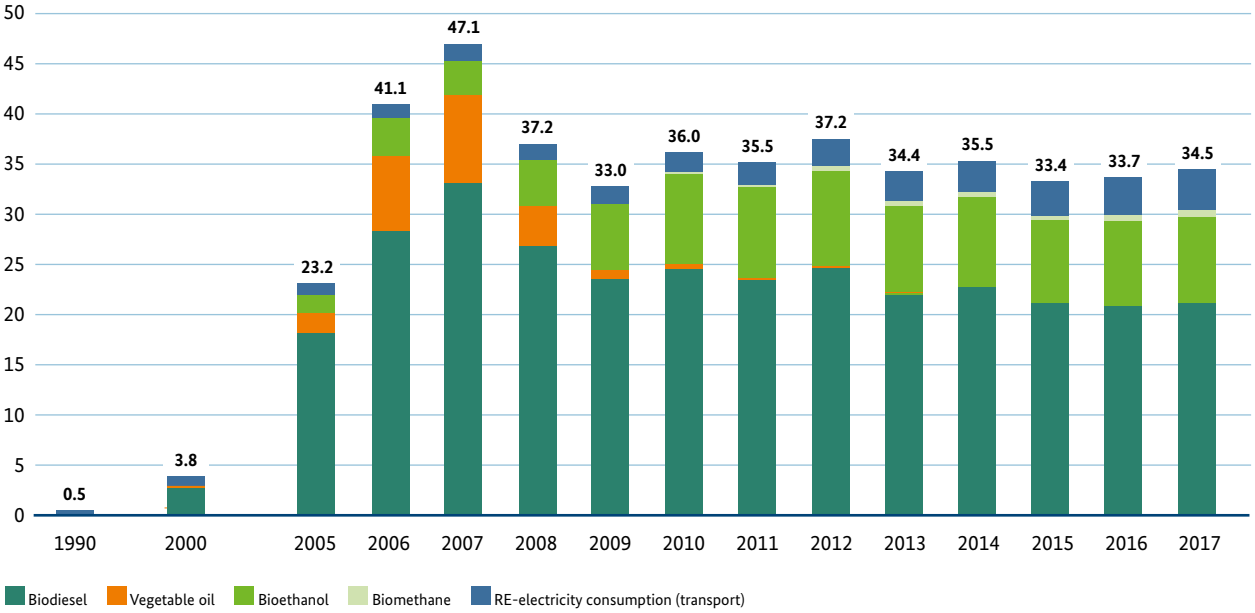
in percent




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

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

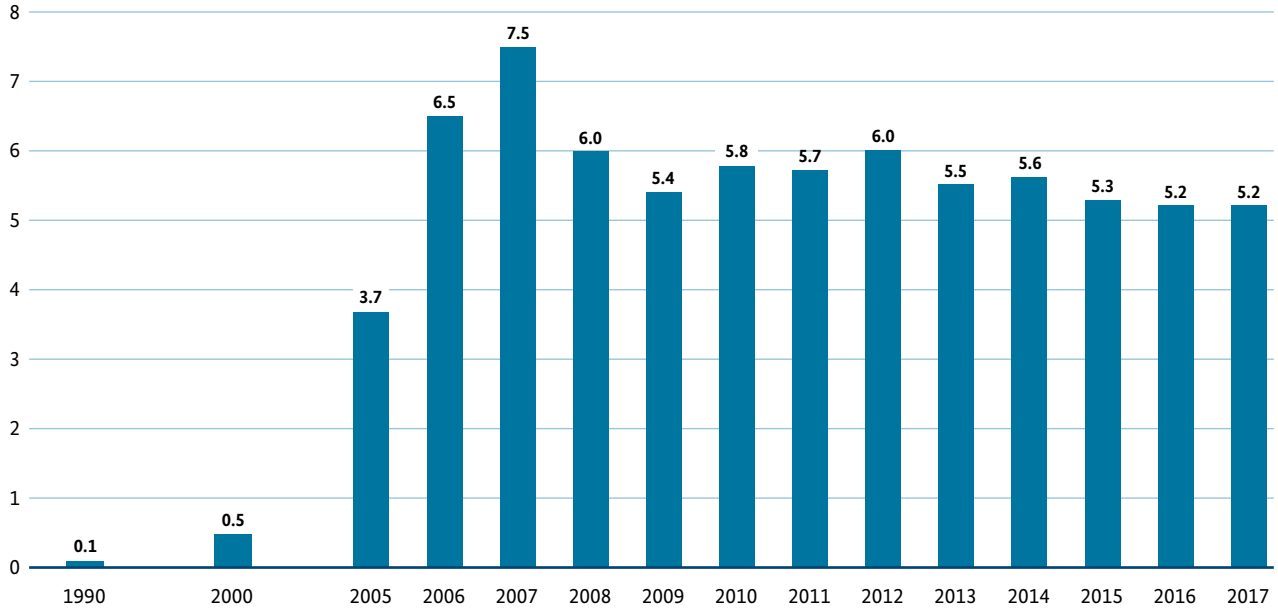
Final energy consumption of transport in billion kilowatt hours




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

## Figure 22: Share of renewable energy in final energy consumption in the transport sector

in percent




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

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

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

| | Biodiesel[1] | Vegetable oil | Bioethanol | Biomethane | RE electricity consumption[2] | Final energy consumption of transport | Share of FEC of transport |
|---|---|---|---|---|---|---|---|
| | | | (GWh)[3] | | | (GWh)[3] | (%) |
| **1990** | 0 | 0 | 0 | 0 | 465 | **465** | **0.1** |
| | | | | | | | |
| **2000** | 2,583 | 167 | 0 | 0 | 1,002 | **3,752** | **0.5** |
| | | | | | | | |
| **2005** | 18,046 | 2,047 | 1,780 | 0 | 1,343 | **23,216** | **3.7** |
| **2006** | 28,364 | 7,426 | 3,828 | 0 | 1,475 | **41,093** | **6.5** |
| **2007** | 33,182 | 8,752 | 3,439 | 0 | 1,755 | **47,128** | **7.5** |
| **2008** | 26,630 | 4,188 | 4,673 | 4 | 1,693 | **37,188** | **6.0** |
| **2009** | 23,411 | 1,044 | 6,669 | 13 | 1,908 | **33,045** | **5.4** |
| **2010** | 24,474 | 637 | 8,711 | 75 | 2,060 | **35,957** | **5.8** |
| **2011** | 23,606 | 209 | 9,090 | 92 | 2,467 | **35,464** | **5.7** |
| **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 | 3,175 | **35,508** | **5.6** |
| **2015** | 20,840 | 21 | 8,648 | 345 | 3,553 | **33,407** | **5.3** |
| **2016** | 20,866 | 42 | 8,663 | 379 | 3,709 | **33,659** | **5.2** |
| **2017** | 21,258 | 10 | 8,530 | 445 | 4,248 | **34,491** | **5.2** |

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

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

3 1 GWh = 1 million kWh

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; BAFA [65]; BLE [21], [63]; FNR; ZSW; BMF [12]; BReg [13], [15], [16], [17]; StBA [14]; DBFZ; AGQM; UFOP; some provisional figures

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

| | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (1,000 tonnes) | | | | | | | |
| 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 | 2,002 | 2,064 |
| Vegetable oil | 16 | 196 | 711 | 838 | 401 | 100 | 61 | 20 | 25 | 1 | 6 | 2 | 4 | 1 |
| Bioethanol | 0 | 238 | 512 | 460 | 625 | 892 | 1,165 | 1,233 | 1,249 | 1,206 | 1,229 | 1,173 | 1,175 | 1,157 |
| Biomethane[2] | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 7 | 25 | 36 | 33 | 25 | 28 | 33 |
| **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** | **3,255** |

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

2 Calculated using a calorific value of 48.865 MJ/kg according to BDEW convention (BDEW = Federal Association of Energy and Water Management)

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

## Emissions avoided through the use of renewable energy sources

The expansion of renewable energy makes a key contribution to meeting our climate targets. Emissions with a total global warming potential (GWP) of approximately 177 million tonnes of $CO_2$ equivalent were avoided in 2017. The power sector accounted for 135 million tonnes of these savings. Emissions of around 35 million tonnes were avoided in the heating sector and some 7 million fewer tonnes of $CO_2$ equivalent were emitted through the use of biofuels in the transport sector (see Figure 25).

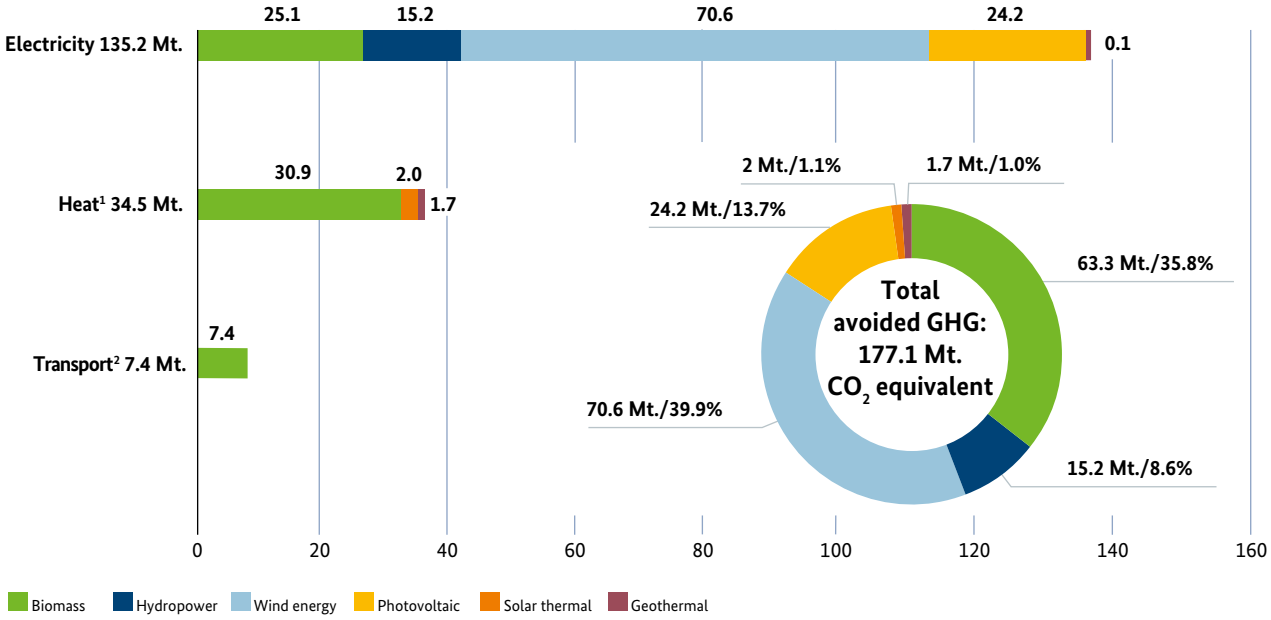
The results for the electricity and heating sector depend significant on the specific fossil and nuclear fuels that the renewable energy sources replace. The current figures also take account of the difference in efficiency between renewables-based heating installations and those based on conventional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

In order to calculate the volume of greenhouse gas emissions that were avoided in the electricity sector, technology-specific substitution factors were used. The calculation model employed also makes it possible to identify the geographical location where the emissions were avoided. This shows that roughly two-thirds of the greenhouse gas emissions that were avoided through gross electricity generation from renewables are accounted for by Germany, and around one-third by a shift in generation in neighbouring countries [18]

With regard to the use of biomass for energy purposes, the type and origin of the feedstock used also play a key role in the emissions balance [20]. If the feedstock is not biogenic residual material or 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.

**Figure 25: Net balance of the greenhouse gas emissions avoided through the use of renewable energy sources, 2017**

million tonnes of $CO_2$ equivalents (Mt. $CO_2$-eq.)




1 Does not include charcoal consumption
2 Only biogenic fuels in the transport sector (excluding use in agriculture, forestry, construction or military) based on preliminary data from the Federal Ministry of Food and Agriculture for 2017, and does not include electricity consumption in the transport sector

Sources: Federal Environment Agency, [19] – 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 2017" (in German) [19].

The calculation of emissions from biofuels is based on self-assessment and estimates of the level of greenhouse gas emissions (incl. the feedstock base), introduced with the greenhouse gas quota, as published by the Federal Ministry of Food and Agriculture in its annual Evaluation and Progress Report on the Biofuel/Biomass Energy Sustainability Ordinance [21]. The emissions of the individual greenhouse gases and air pollutants were derived by the Federal Environment Agency roughly on the basis of published figures for total greenhouse gas emissions, and also taking into account the findings of the research project 'BioEm' [20] and other expert studies, as well as various assumptions and reasoning by analogy.

Overall, it is likely that the figures for emissions reduction based on the use of biofuels are too optimistic. This is due to the general use of the regional NUTS2 values for biomass cultivation, the way in which the use of methanol in biodiesel production has been calculated thus far, and the requirements for substituting carbon dioxide emissions from fossils through those from biogenic fuels.

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 cause 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 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 [22]. As a result, savings in greenhouse gas emissions linked to biofuels reported by the Member States for 2015 decreased between 40 % and 80 % [23]. Under the rule set down in the draft Renewable Energy Directive II for 2021–2030, which was adopted in 2018, Member States that set a cap for conventional biofuels with potentially high emissions from ILUC (indirect land use change) that is below the pan-EU cap of 7 % may reduce the RES target of 14 % by 2030 by the same amount [61]. According to the current situation, Germany intends to cap support for conventional biofuels at 5.3 % [62].

**Figure 26: Net emissions balance for renewable energy sources used in electricity, heat and transport in 2017**

| | | Renewables-based electricity generation total: 216,375 GWh | | Renewables-based heat consumption total: 168,803 GWh[5] | | Renewables-based consumption for transport total: 34,491 GWh[6,7] | | Total |
|---|---|---|---|---|---|---|---|---|
| | Greenhouse gas/ Air pollutant | Avoidance factor (g/kWh) | Avoided emissions (1,000 t) | Avoidance factor (g/kWh) | Avoided emissions (1,000 t) | Avoidance factor (g/kWh) | Avoided emissions (1,000 t) | Avoided emissions (1,000 t) |
| Greenhouse effect[1] | $CO_2$ | 610 | 131,924 | 216 | 36,089 | 267 | 8,085 | 176,099 |
| | $CH_4$ | 0.95 | 205.3 | −0.21 | −35.35 | −0.07 | −2.25 | 168 |
| | $N_2O$ | −0.03 | −6.2 | −0.01 | −2.3 | −0.07 | −2.19 | −11 |
| | $CO_2$ equivalent | 625 | 135,193 | 207 | 34,515 | 244 | 7,379 | 177,088 |
| Acidification[2] | $SO_2$ | 0.16 | 33.9 | 0.09 | 15.4 | 0.01 | 0.17 | 49 |
| | $NO_X$ | 0.11 | 24.1 | −0.18 | −30.5 | −0.16 | −4.69 | −11 |
| | $SO_2$ equivalent | 0.23 | 50.7 | −0.04 | −5.9 | −0.10 | −3.13 | 42 |
| Ozone[3] Particles[4] | CO | −0.38 | −82.0 | −2.83 | −471.7 | 0.00 | −0.10 | −554 |
| | NMVOC | 0.00 | 0.2 | −0.18 | −30.1 | 0.03 | 0.89 | −29 |
| | Particles | 0.004 | 0.9 | −0.12 | −19.4 | −0.01 | −0.22 | −19 |

1 Other greenhouse gases ($SF_6$, FKW, H-FKW) are not included
2 Other air pollutants with acidification potential ($NH_3$, HCl, HF) are not included
3 NMVOC and CO are important precursors for ground-level ozone, which contributes significantly to 'summer smog'
4 Here, dust comprises the total emissions of suspended particulate matter of all particle sizes
5 Does not include charcoal consumption
6 Does not include the consumption of biodiesel (incl. HVO) in agriculture, forestry, construction and the military and electricity consumption in the transport sector
7 Based on provisional data from the Federal Ministry of Food and Agriculture for 2017

Source: Federal Environment Agency (UBA) [19] based on the sources quoted therein

The calculations of the emissions savings arising from the use of renewable energy sources are based on net figures in all three sectors. This is done by offsetting 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 the replacement of fossil and nuclear energy sources 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 of some air pollutants associated with heating have risen as more wood is burned in old stoves and tiled ovens. However, under current legislation, these units will have to be gradually taken out of use or replaced. The negative balances for carbon monoxide, volatile organic compounds and dust emissions (all particle sizes) are particularly significant. With regard to biofuels, there is an increase in nitrous oxide and methane emissions from the cultivation of energy crops.

## Reduction in the use of fossil fuels thanks to renewable energy

Figures 27 and 28 show the amount of fossil fuels saved by using renewable energy sources for electricity, heat and transport in 2017 and from 2007 to 2017. 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 hard coal have to be imported, these savings have also lead to a reduction in German energy imports.

Being a country that is poor in resources, Germany had to import 98 % of its crude oil and just under 91 % of its natural gas in 2017. 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, 2017**

| | Lignite | Hard coal | Natural gas | Petroleum/ heating oil | Diesel fuel | Petrol | Total |
|---|---|---|---|---|---|---|---|
| | | | | Primary energy (billion kWh) | | | |
| Electricity | | 304.3 | 144.9 | | | | **449.3** |
| Heat | 11.8 | 12.8 | 59.3 | 48.7 | 1.5 | | **134.0** |
| Transport | | | 0.5 | | 17.4 | **9.0** | **26.9** |
| **Total** | **11.8** | **317.1** | **204.7** | **48.7** | **18.9** | **9.0** | **610.2** |
| | | | | Primary energy (PJ) | | | |
| **Total** | **42.4** | **1,141.6** | **736.9** | **175.3** | **68.1** | **32.5** | **2,196.7** |
| which corresponds to[1]: | 3.5 million t[2] | 42.3 million t[3] | 20,945 million m³ | 4,904 million litres | 1,898 million litres | 1,001 million litres | |

The savings in fossil fuels are calculated using the same methodology as is used to calculate emission balances, see UBA [19].

1 Savings in primary energy were calculated using the net calorific values determined by AGEB [9]

2 Including approx. 2.6 million t lignite, approx. 0.2 million t lignite briquettes and approx. 0.6 million t pulverised coal

3 Including approx. 42.2 million t hard coal and approx. 0.1 million t coke from hard coal

Source: Federal Environment Agency [19] based on the sources quoted therein

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

| | Electicity | Heat | Transpot | Total |
|---|---|---|---|---|
| | | Primary energy (billion kWh) | | |
| **2007** | 194.4 | 92.1 | 24.3 | **310.8** |
| **2008** | 204.3 | 95.8 | 18.7 | **318.8** |
| **2009** | 199.4 | 97.7 | 16.1 | **313.3** |
| **2010** | 215.0 | 124.6 | 17.8 | **357.4** |
| **2011** | 261.9 | 122.5 | 18.7 | **403.1** |
| **2012** | 300.2 | 133.1 | 22.0 | **455.3** |
| **2013** | 319.6 | 135.4 | 21.0 | **476.0** |
| **2014** | 337.2 | 126.4 | 21.5 | **485.1** |
| **2015** | 391.6 | 128.2 | 20.0 | **539.9** |
| **2016** | 393.9 | 130.0 | 24.5 | **548.4** |
| **2017** | 449.3 | 134.0 | 26.9 | **610.2** |

Source: Federal Environment Agency [19] 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 remuneration for renewable electricity and priority for the feeding of green electricity into the electricity grid before all other types of electricity.

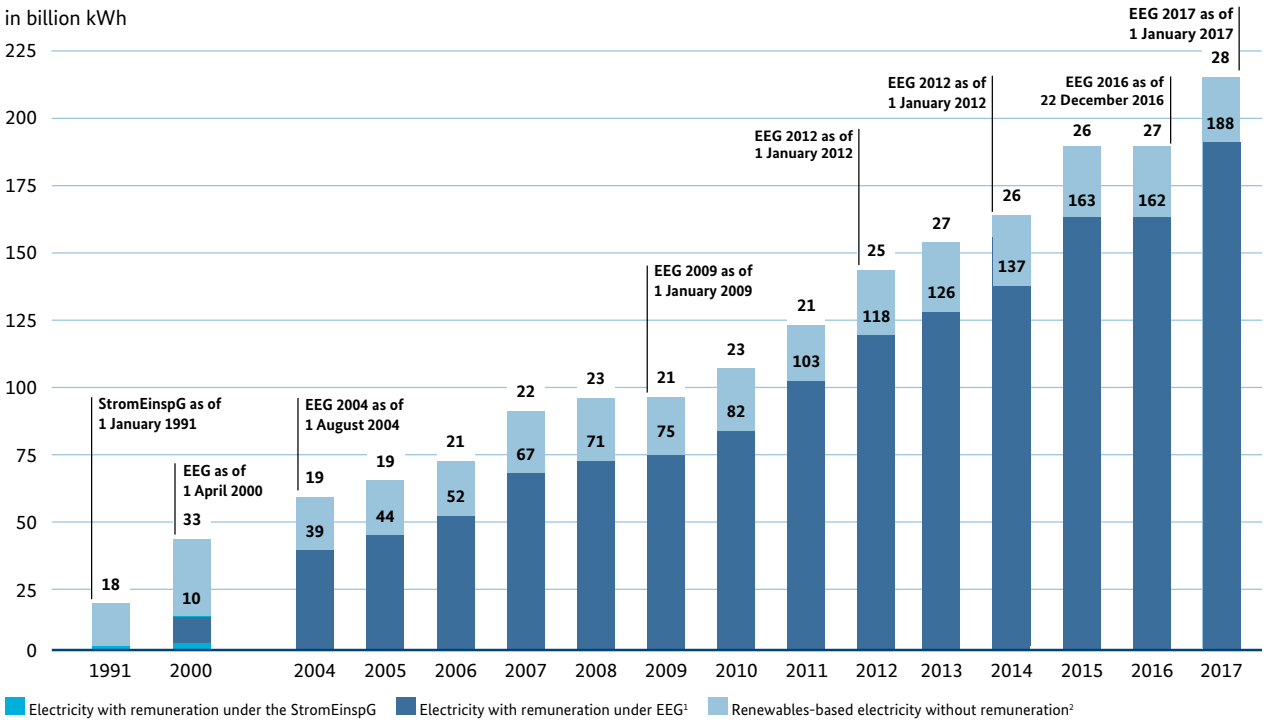
The Act has already been amended several times in order to take account of technological developments and to increasingly bring renewable energy closer to the market. The shift towards the use of auctions under the 2017 amendment of the RES Act and the Offshore Wind Energy Act has recently come into effect. This means that remuneration rates for electricity from solar power installations, 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 216 billion kilowatt hours in 2017. This increase has been driven by onshore wind, solar power (photovoltaics (PV)), 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 39 billion kilowatt hours.

The RES Act does not, however, incentivise all electricity generated from renewable energy sources. For example, it does not provide support for large hydropower plants or conventional power stations that incinerate biomass alongside their regular fuel. Electricity remunerated under the RES Act is therefore only part of the total electricity generated from renewable energy sources, as Figure 29 illustrates. Since 2000, this electricity generation (with remuneration under the RES Act) has risen from around 10 billion kilowatt hours to 188 billion kilowatt hours in 2017.

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

**Figure 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 solar power installations that is fed into the grid and consumed on site and for which there is no entitlement to remuneration under the RES Act

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

## The renewable energy surcharge (EEG surcharge)

Operators of wind energy, solar, biomass and other installations entitled to remuneration under the RES Act generally market their own electricity or sell it via service providers. They receive a market premium from the grid operators for this electricity. The market premium compensates for the difference between the feed-in tariff and the average price on the electricity exchange. 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 (Ausgleichsmechanismus-Verordnung, (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 transmission system operators' EEG surcharge information platform (www.netztransparenz.de; in German only).

**Aggregate EEG surcharge = forecasted 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 has dropped slightly in 2018 compared to the previous year. One of the main reasons for this is the price of electricity on the spot market, which has been rising again since 2017. Market revenues for green electricity have therefore also increased, and the EEG surcharge has decreased as a result.

As the RES Act guarantees remuneration for a period of 20 years, there is a considerable cost burden linked to the EEG surcharge in the form of the remuneration payments to existing installations. A large proportion of existing installations were built between 2009 and 2012 and receive con-

siderably higher rates of remuneration than those built today. Since then, the cost of renewable energy has fallen sharply, with the result that new installations only need a fraction of the remuneration provided during that time. The expansion of 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 remuneration rates for new installations entitled to remuneration under the RES Act is determined via competitive auctions. The results of the first rounds of auctions for photovoltaics and onshore and offshore wind energy installations have caused remuneration rates to fall considerably. These auctions also permit quantitative steering, ensuring that expansion targets are adhered to effectively. This is designed to make the continued expansion of renewable energy sources more predictable, reliable and, most importantly, more cost-effective.

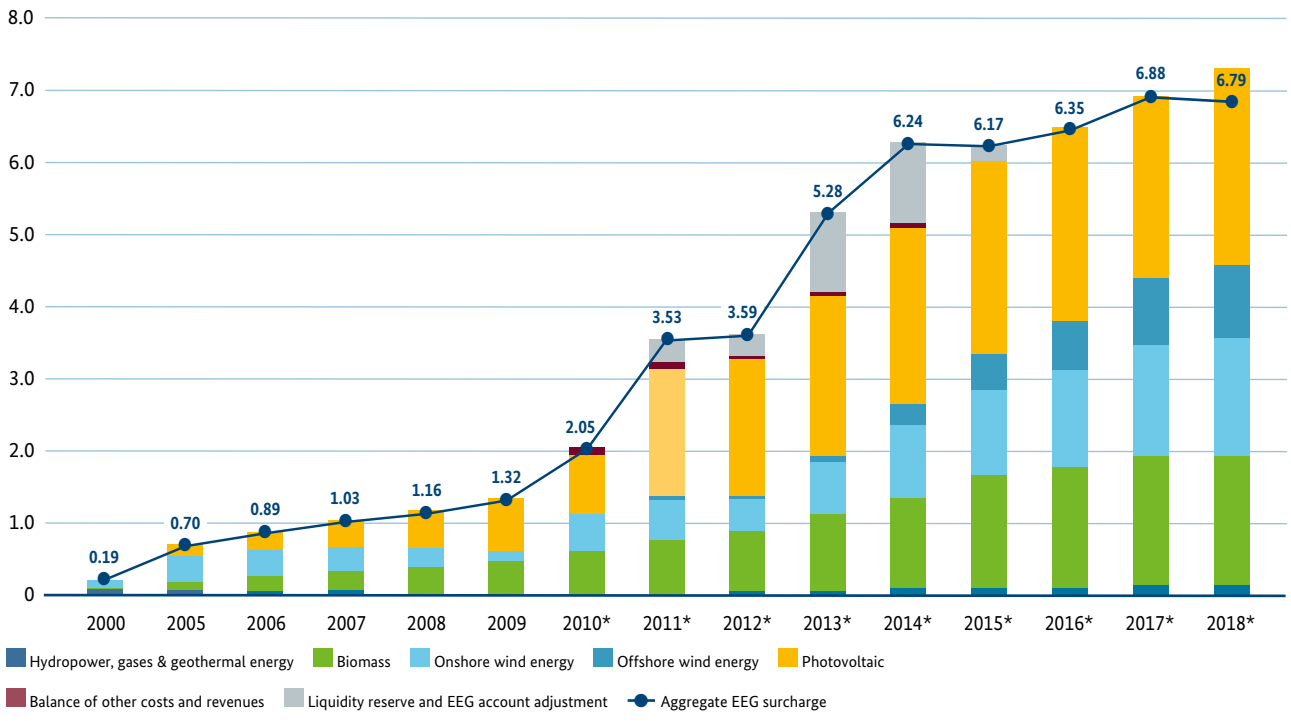
In general the RES Act requires every electricity utility and self-supplier to pay the EEG surcharge. Electricity utilities routinely pass this cost on to the final consumer. However, it is beneficial to exempt some consumers from paying the full EEG surcharge – namely, large energy-intensive companies 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.

In 2017, the scheme exempted a total of 2,092 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.

Both privileged and non-privileged businesses in Germany together (those in the industrial sector as well as commerce, trade and services) finance just under half of the aggregate EEG surcharge in 2018 [25]. However, the exemptions mean that the EEG surcharge is higher for all non-privileged final consumers. For more details, see the document "Hintergrundinformationen zur Besonderen Ausgleichsregelung" available at www.erneuerbare-energien.de (in German only).

**Figure 30: Development of the renewable energy surcharge (EEG surcharge)**

Cent per kilowatt hour (kWh)




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, published on www.netztransparenz.de.

The item 'balance of other costs and revenues' includes the revenues from the payment of the minimum surcharge due to privileged final consumption, the costs of the green electricity privilege, and expenditure by transmission system operators on profile service, exchange listing admission, trading platform connectivity and interest charges.

Source: Federal Ministry for Economic Affairs and Energy, based on data provided by the German transmission system operators; (TSOs [5]); further information at www.erneuerbare-energien.de (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 2018 amounts to €23.8 billion and the (forecast) final consumption subject to the surcharge is 350 billion kilowatt hours. This produces a 2018 EEG surcharge of 6.792 cents per kilowatt hour.

$$\text{EEG surcharge} = \frac{\text{aggregate EEG surcharge}}{\text{final consumption subject to the EEG surcharge}}$$

Payments to solar installations (40 %), biomass installations (27 %) and onshore wind energy installations (24 %) have the largest share in the EEG surcharge in 2018.

## Economic impetus from the construction and operation of renewable energy installations

### Renewable energy as an economic factor

Investments in installations for the use of renewable energy continue to play an important role for Germany's economy, since a large part of the added value is generated in the country itself. Since 2000, investment in renewable energy installations has risen almost steadily, peaking at just under €28 billion in 2010. By 2015, it had dropped to €13.9 billion, but has been increasing moderately since then to €15.7 billion in 2017.

As in previous years, investment activity was highest in the wind energy segment in 2017, which attracted €10.7 billion, or roughly two-thirds of total investment. Compared with the preceding year, investments in wind power (onshore and offshore) rose by roughly 3 %. Here, growth was driven by the expansion of onshore wind energy installations, while investment in offshore wind remained stable.

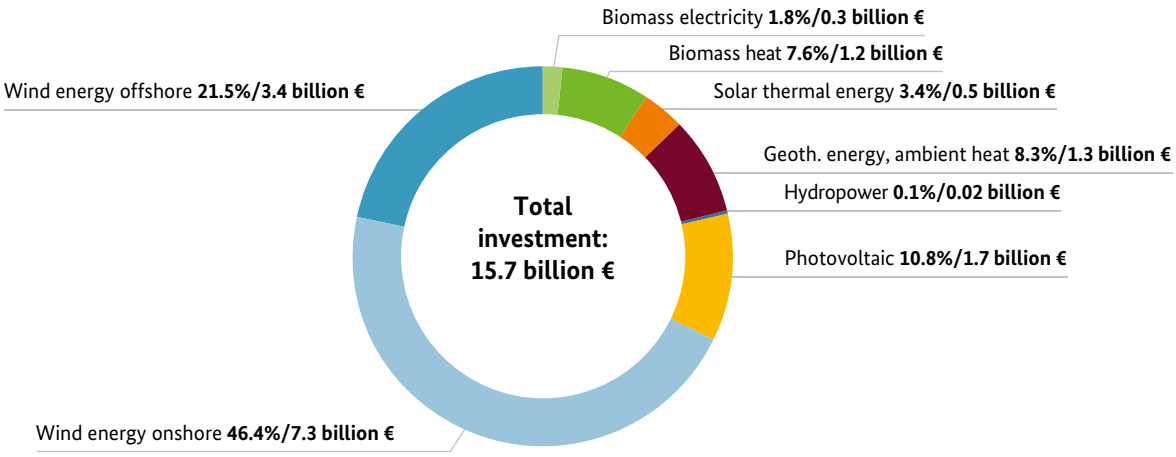
The sharp decline in total investment after 2010 is primarily due to the trend in photovoltaics, which saw installation prices fall in 2011 and 2012 while new plants continued to

**Figure 31: Investment in the building of renewable energy installations**

| | Hydropower | Wind energy onshore | Wind energy offshore | Photovoltaic | Solar thermal energy | Geoth. energy. ambient heat | Biomass electricity | Biomass heat | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | (Billion Euro) | | | | |
| **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 | 1.0 | 3.1 | 1.3 | **26.1** |
| **2012** | 0.2 | 3.6 | 2.4 | 12.0 | 1.0 | 1.1 | 0.8 | 1.5 | **22.5** |
| **2013** | 0.1 | 4.5 | 4.3 | 3.4 | 0.9 | 1.1 | 0.7 | 1.5 | **16.5** |
| **2014** | 0.1 | 7.1 | 3.9 | 1.5 | 0.8 | 1.1 | 0.7 | 1.4 | **16.4** |
| **2015** | 0.1 | 5.4 | 3.7 | 1.5 | 0.8 | 1.0 | 0.2 | 1.3 | **13.9** |
| **2016** | 0.05 | 6.9 | 3.4 | 1.6 | 0.7 | 1.2 | 0.3 | 1.2 | **15.4** |
| **2017** | 0.02 | 7.3 | 3.4 | 1.7 | 0.5 | 1.3 | 0.3 | 1.2 | **15.7** |

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, 2017**




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

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 to just under 11 % in the period from 2015 to 2017. This corresponds to an investment volume of €1.7 billion in 2017.

Investment in the other fields (electricity and heat from biomass, hydropower, solar and geothermal heat) totalled €3.4 billion in 2017, or roughly 21 % of total investment. Compared with the previous year, solar thermal, hydropower heat from biomass installations saw a decline in investment, investment in geothermal energy (including ambient heat) and biomass for electricity generation increased slightly.

Reduced costs for renewable energy installations, especially PV 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 achieved at lower investment costs than in the past.

Most investment – roughly 80 % – still goes towards electricity generation plants that qualify for payments under the RES Act. This portion rose by 1 percentage point compared to the preceding year.

## Stimulus from plant operation continues to exceed investment

In addition to plant 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 stimulates other sectors of the economy as well. The operating expenses incurred by the operator generate corresponding amounts of revenue for suppliers. The economic stimulus from plant operation has risen steadily for years in line with the increasing number of installations. For example, since 2000 revenues have risen steadily year after year, climbing from €2.0 billion to €16.2 billion in 2017. This means that economic stimulus from plant operation exceeded investment in installations, as was also the case in the previous two years.

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 stimulus resulting from plant operation. This is followed by the revenues generated by the sale of biofuels, and then the economic stimulus from the operation of wind energy and PV installations, geothermal and ambient heat plants and hydropower and solar thermal installations. The economic stimulus that is generated in the form of operating costs provides a long-term boost to the economy, as the costs are incurred continuously over the entire life of the plants (usually 20 years) and increase with every additional plant that is installed.

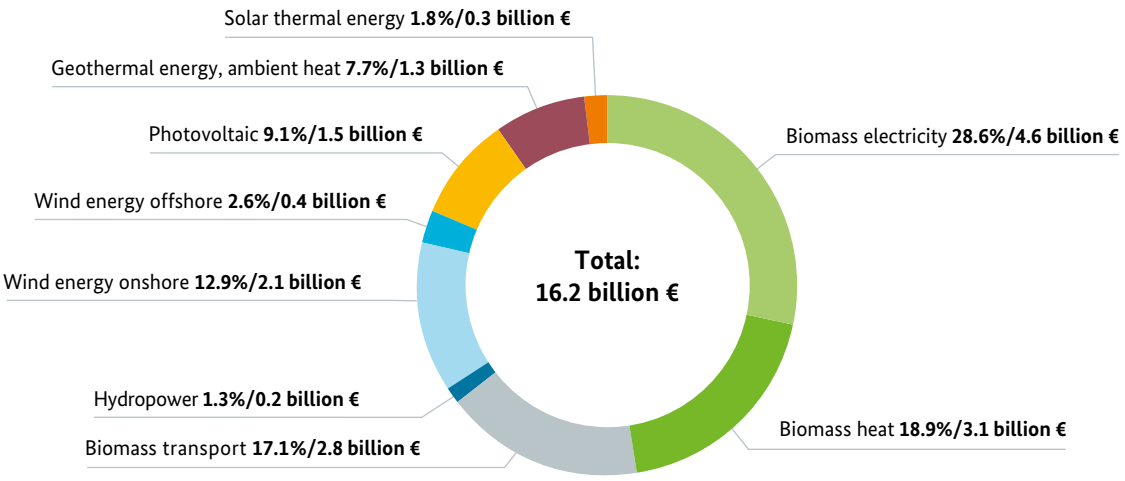
For more details on the method used in these calculations, see the "Information on methodology" section.

**Figure 33: Economic impetus from the operation of renewable energy installations**

| | Hydropower | Wind energy onshore | Wind energy offshore | Photovoltaic | Solar thermal energy | Geoth. energy, ambient heat | Biomass electricity | Biomass heat | Biomass fuels | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (billion €) | | | | | |
| **2000** | 0.1 | 0.2 | – | 0.0 | 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 | – | 0.3 | 0.1 | 0.4 | 1.6 | 1.9 | 3.8 | **8.8** |
| **2008** | 0.2 | 0.8 | – | 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 | 4.1 | 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 | **15.0** |
| **2016** | 0.2 | 1.9 | 0.4 | 1.4 | 0.3 | 1.2 | 4.6 | 3.1 | 2.6 | **15.6** |
| **2017** | 0.2 | 2.1 | 0.4 | 1.5 | 0.3 | 1.3 | 4.6 | 3.1 | 2.8 | **16.2** |

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

**Figure 34: Economic impetus from the operation of renewable energy installations in 2017**




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

## Employment in the renewable energy sector in Germany

The latest employment figures are available for 2016: approximately 338,700 individuals were employed in the renewable energy sector that year. This equates to an increase of 10,000 on the previous year and therefore the first rise since 2011, when employment in renewables peaked at 416,200. Initially, back in 2000, the sector employed 106,700 people.

Wind energy continued to be biggest employer in the renewables sector in 2016. With 160,100 workers, almost every second job in renewables was in the wind energy segment. Due to the high level of investment in onshore wind energy, more jobs were created in this sector. Together with plant maintenance and operation, 133,000 people were employed in the context of onshore wind energy. Offshore wind is also becoming an increasingly important employer, accounting for 28,200 jobs.

In the energy system, bioenergy is represented by a variety of technological options. It generates employment through the construction and operation of bioenergy plants, and through the provision of fuel for the biomass plants. A total of 105,600 people are employed in this field, accounting for roughly one job in every three in renewable energy. Fuel production and supply is a significant contributor to employment here, generating work for 69,000 people. As with jobs associated with plant operation and maintenance, these jobs are also long-term, providing employment for the lifetime of the installation.

The PV sector, by contrast, continued to consolidate, and the area of solar thermal and solar thermal installations also reported slight declines in 2016. A total of 45,300 people are employed in the solar energy sector.

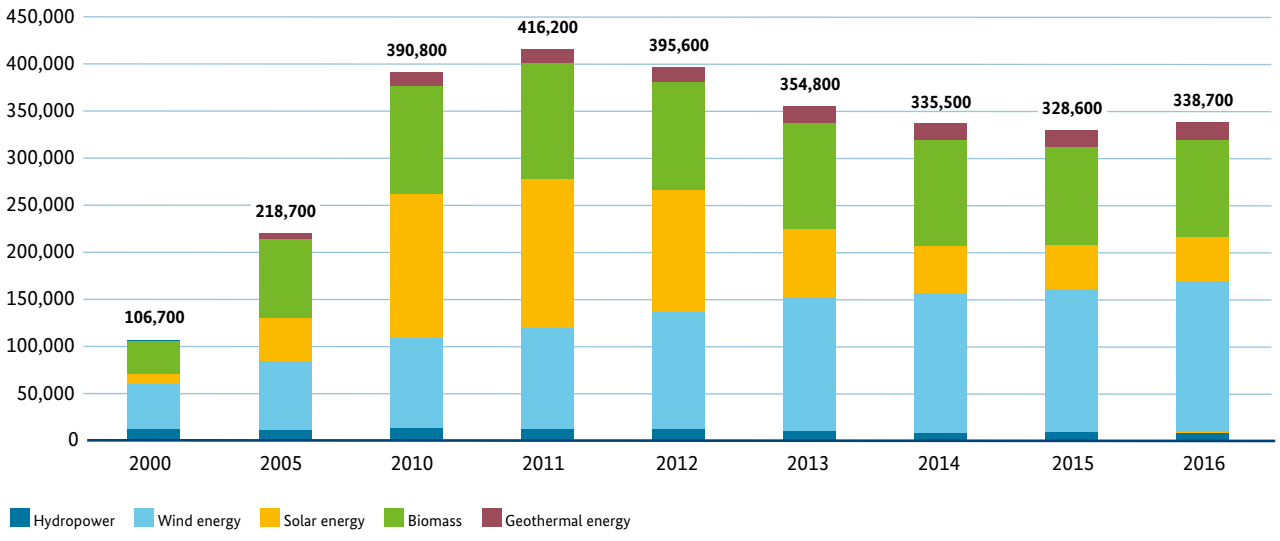
The employment numbers are calculated based on data on investments in renewable energy installations, expenditure on plant operation, estimates regarding the international trade of the industry concerned and associated inputs, and also industrial inputs of other economic sectors. Fuel input data also feed into the statistics.

The assessment conducted under the "Macroeconomic impact and distribution effects of the energy transition" project (GWS, Prognos, DLR, ISI), commissioned by the Federal Ministry for Economic Affairs and Energy, looks at gross employment in its entirety, and factors in both direct effects – e.g. in the case of plant manufacturers – and indirect effects – e.g. in the case of suppliers. A net analysis is also conducted in the project.

On the basis of the gross figures determined for the whole of Germany, [51] regional effects are identified for the individual ferdal states [52] . The data show that the expansion of renewable energy has recently contributed to increased employment in the sector, particularly in northern Germany. The renewables sector plays a more important role as an employer in the majority of the new federal states (federal states comprising former eastern Germany).

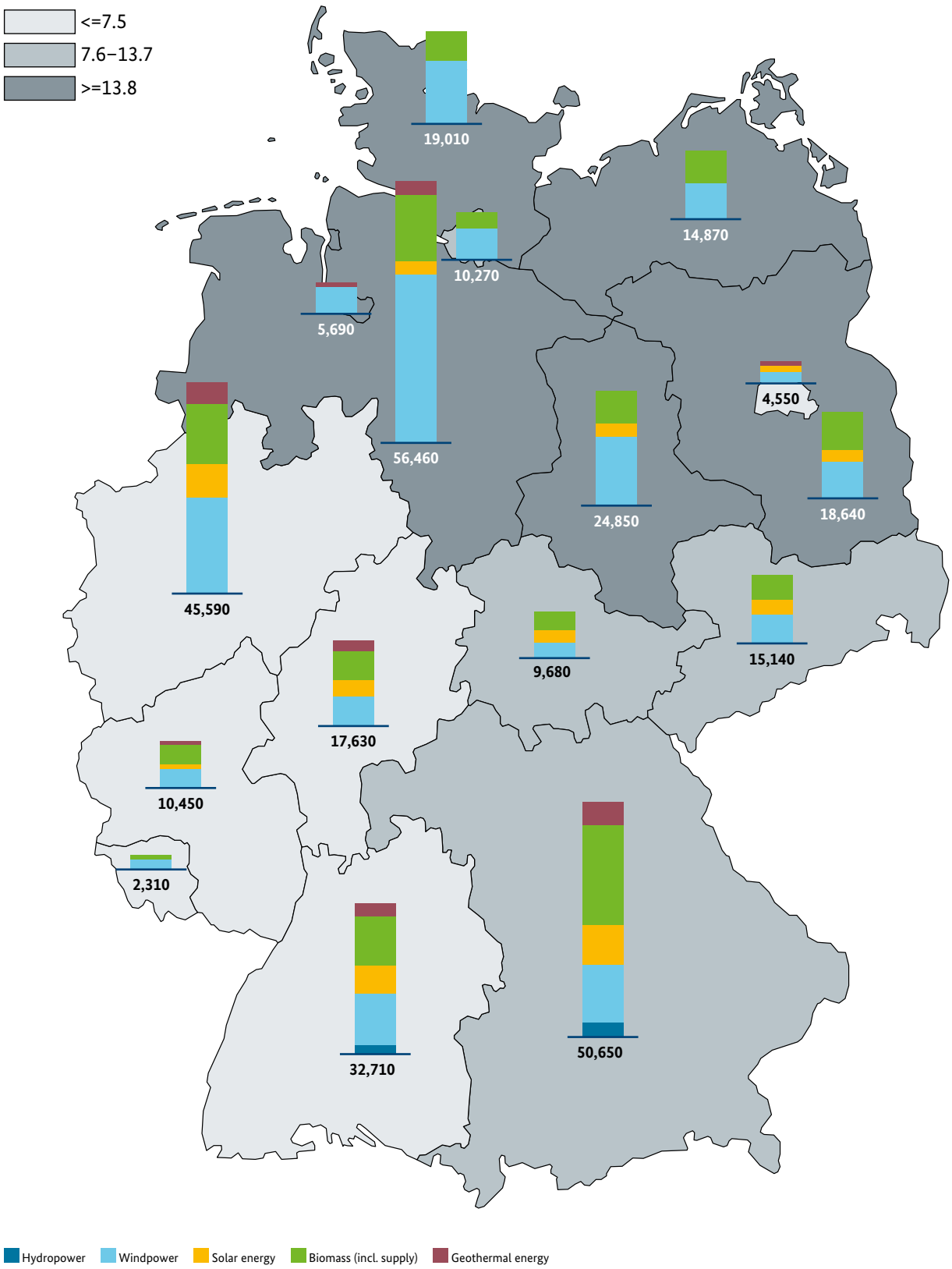
**Figure 35: Development of gross employment from renewable energy in Germany**

Number of employees




Source: GWS [51]

**Figure 36: Development of gross employment from renewable energy in Germany, 2016**




Source: GWS [52]

## Promotion of renewable energy in the heating sector

### Renewable Energies Heat Act

The Renewable Energy Heat Act entered into force on 1 January 2009 and has since been repeatedly amended. Its purpose 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 the continued development of technologies for generating heating and cooling from renewable energy sources. The Act is intended to help raise the share of renewable energy in energy consumption for heating and cooling to 14 % by 2020.

Section 3 of the Renewable Energies Heat Act addresses the obligation to use a certain proportion of renewable energy for the supply of heat to new 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 (EnEG) and the Energy Savings Ordinance (EnEV). Energy conservation law for buildings will be simplified and made less bureaucratic with the revision pending in this legislative term. The regulations of the Energy Savings Ordinance, the Energy Conservation Act and the Renewable Energies Heat Act will be merged into a new Act on Energy in Buildings, thereby transposing the requirements of EU law for public non-residential buildings with effect from 1 January 2019 and for all buildings with effect from 1 January 2021. The current energy-related requirements for existing buildings and new buildings will continue to apply [26].

### The Market Incentive Programme

The Market Incentive Programme is intended to support the attainment of the goal of the Renewable Energies Heat Act (i.e. RES to have a 14 % share in final energy consumption for heating/cooling by 2020) by further expanding the deployment of technologies to use renewable energy in the heating/cooling sector. The Programme is subject to ongoing evaluation by experts in order to assess the impact of the funding [27]. Details of funding under the Market Incentive Programme are set down in the applicable "Guidelines for the Promotion of Measures for the Use of Renewable Energy in the Heating Market", as amended on 4 August 2017 [28], and can be accessed online at www.erneuerbare-energien.de/EE/Redaktion/DE/Standardartikel/foerderrichtlinie-zum-marktanreizprogramm.html (in German only).

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. Applications for such funding 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 2017, funding under the system of investment grants (from the Federal Office for Economic Affairs and Export Control) amounted to approximately €1.46 billion in investment grants towards some 1.2 million solar thermal plants and approximately €858 million for some 435,000 small-scale biomass heating systems, e. g. pellet boilers. The resulting investment totalled about €10.64 billion in the solar segment and approximately €6.29 billion in the biomass segment.

Between 2008 and 2017, some 123,000 investment grants totalling roughly €360 million were disbursed for efficient heat-pump heating systems, which have been eligible for funding since 2008. The resulting volume of investment amounted to around €2.15 billion.

Under the second funding strand of the Market Incentive Programme, the KfW Renewable Energy Premium programme, reduced-interest loans with repayment grants were approved for 23,475 larger projects between 2000 and 2017. The total volume of loans granted came to around €3.33 billion and the volume of repayment grants totalled around €831 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 heat networks and storage facilities for heat from renewable energy sources.

The number of approvals in 2017 for the two strands of the Market Incentive Programme (Federal Office for Economic Affairs and Export Control; KfW) are presented in Figures 37 and 38.

**Figure 37: Market Incentive Programme 2017 – Investment grants, share from Federal Office for Economic Affairs and Export Control (BAFA)**

| | Number of approvals, BAFA part |
|---|---|
| Heat pumps | 25,058 |
| Biomass heating systems | 24,619 |
| Solar thermal plants | 18,206 |
| Other | 715 |
| **Total** | **68,598** |

Source: Federal Ministry for Economic Affairs and Energy

**Figure 38: Market Incentive Programme 2017 – Repayment grants, share from KfW (KfW Renewable Energy Premium programme)**

| | Number of approvals, KfW part |
|---|---|
| Heating networks | 1,054 |
| Biomass heating systems | 357 |
| Heat storage vessel | 89 |
| Solar thermal plants | 30 |
| Geothermal energy | 4 |
| Heat pumps | 1 |
| **Total** | **1,535** |

Source: Federal Ministry for Economic Affairs and Energy

The Market Incentive Programme is evaluated regularly. More information on the Market Incentive Programme is available on the websites operated by the Federal Ministry for Economic Affairs at www.bmwi.de and www.erneuerbare-energien.de/EE/Navigation/DE/Foerderung/Marktanreizprogramm/marktanreizprogramm.html (in German only).

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/EN/Home/home_node.html, and www.heizen-mit-erneuerbaren-energien.de (in German only).

Details on the KfW Renewable Energy Premium programme under the Market Incentive Programme are available on the KfW website at www.kfw.de/kfw.de-2.html.

## 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 [29] found that considerable overfunding for biofuel had occurred in 2006, as the tax refund was much higher than the difference in production costs. For this reason, biofuel funding was shifted onto a 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 [30][31]. The new biofuel quota introduced in this context required the oil industry to put on the market a minimum proportion of biofuels – in terms of a company's total annual sales of petrol, 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 and for biofuel substituting petrol were 4.4 % and 2.8 % (energy content), respectively. Since 2011, it has been possible to give certain biofuels (particularly biofuels produced from waste and residual material) a double weighting when calculating the biofuel quota.

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

As of 1 January 2015, the reference basis for the quota was switched from the energy content to the net reduction in greenhouse gas emissions. This is 3.5 % for 2015 and 2016, 4.0 % for 2017–2019, and 6.0 % from 2020 [32]. This is intended to ensure that the target for the use of biofuels and electric mobility (10 % by 2020), which applies equally to all EU Member States pursuant to Directive 2009/28/EC, will be achieved (for information on the specific requirements, including multiple counting, see the "Information on methodology" section in the Annex).

The quantitative development of the various biofuels (see Figures 23 and 24) is closely related to the changes in funding arrangements since 2004.

### Electric mobility

At the second municipal summit on 28 November 2017, the Federal Government launched a set of measures, with a financial volume of up to €1 billion, for better air quality in cities with the "Immediate Action Programme for Clean Air 2017–2020". Electric mobility is a central element of a climate-friendly transport policy, which is why just under

€400 million have been set aside for measures towards the electrification of the transport sector. Of this amount, €96 million will go towards the action area for which the Federal Ministry for Economic Affairs and Energy has responsibility (€91 million of which for commitment appropriations that are part of the measure). The Federal Ministry of Transport and Digital Infrastructure and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety are also involved in the programme with their own individual action areas.

As an immediate measure towards implementing the "Immediate Action Programme for Clean Air 2017–2020", the Federal Ministry for Economic Affairs and Energy issued a call for applications on 28 December 2017 for the "development of a charging infrastructure for electric vehicles in close association with the removal of existing grid barriers and the development of a low-cost infrastructure and mobile metering charge points". The Federal Ministry for Economic Affairs and Energy is pursuing two goals in this respect: the near-term development of charging infrastructures in municipalities, and the monitoring and examination of these measures with regard to weaknesses in grid expansion and grid stability. To this end, the charging infrastructure will be developed immediately in public areas, publicly accessible areas, non-public commercial areas and private areas, while full-load situations will be tested in "reality labs" and scientific studies conducted concurrently. The findings are to feed directly into the efficient expansion of the grid. In addition, the focus is also on charging options for vehicle owners who do not have a charging point where they park, and on charging options for business applications.

## Promotion of renewable energy research and development

The promotion of innovations in the field of renewable energy helps develop the energy transition as a necessary step towards a decarbonised, competitive industrial economy of the future, and therefore also makes an important contribution to climate change mitigation. Technical improvements in renewable energy systems aim to make renewable energy the mainstay of the energy supply system and, combined with consistent increases in energy efficiency, grid expansion and a flexible electricity market design, aim to guarantee the security of energy supply at a low cost. Technical innovations increase plant reliability, and thereby help to reduce costs and ensure a high degree of supply security with an increasing share of green electricity in the German grid.

Research and development projects on energy technology receive funding under the Federal 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 Federal Government's sustainability, energy and climate policies,
- to further 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 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 2017, the Federal Ministry for Economic Affairs and Energy approved a total of 328 new projects with a financial volume of over €260 million in the following fields: photovoltaics, geothermal energy, wind energy, system integration of renewable energy sources, low-temperature solar thermal energy, solar thermal power plants, marine energy, international cooperation and supporting ecological research (see Figure 39).

For more information, please see the Ministry's 2017 annual "Innovation through Research" report ('Innovation durch Forschung – Projekte und Ergebnisse der Forschungsförderung 2017'). The website of Jülich (www.ptj.de), the project management agency commissioned by the Federal Ministry for Economic Affairs and Energy, includes information on funding and on applications for research funding programmes for renewable energy.

## Figure 39: Newly approved projects for renewable energy technologies

| | 2014 | | | 2015 | | | 2016 | | | 2017 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | 1,000 Euro | Share in % | Number | 1,000 Euro | Share in % | Number | 1,000 Euro | Share in % | Number | 1,000 Euro | Share in % |
| Photovoltaics | 90 | 66,910 | 35.4 | 106 | 84,248 | 32 | 166 | 116,570 | 38.7 | 103 | 89,310 | 34.2 |
| Wind energy | 63 | 38,510 | 20.4 | 111 | 91,113 | 34.6 | 93 | 86,240 | 28.6 | 86 | 95,970 | 36.8 |
| Geothermal energy | 15 | 12,650 | 6.7 | 23 | 17,441 | 6.6 | 22 | 19,550 | 6.5 | 17 | 8,000 | 3.1 |
| Low-temp. Solar thermal energy | 15 | 6,500 | 3.4 | 21 | 9,675 | 3.7 | 24 | 12,900 | 4.3 | 8 | 5,870 | 2.2 |
| Solar thermal power plants | 22 | 7,440 | 3.9 | 17 | 3,845 | 1.5 | 13 | 8,900 | 2.9 | 21 | 5,620 | 2.2 |
| SystEEm[1] | 114 | 51,881 | 27.5 | 128 | 54,577 | 20.7 | 120 | 53,750 | 17.9 | 91 | 54,960 | 21.1 |
| Cross-sectoral | 12 | 2,673 | 1.4 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 0 | 0 | 0.0 |
| Other | 10 | 2,424 | 1.3 | 6 | 2,355 | 0.9 | 4 | 3,510 | 1.1 | 2 | 1,210 | 0.5 |
| **Total** | **341** | **188,988** | **100** | **412** | **263,254** | **100** | **442** | **301,420** | **100** | **328** | **260,940** | **100** |

1 Integration of renewable energy and renewable 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. The EU is now stepping up the pace of the energy transition: energy is to become cleaner and less energy is to be used. The EU has introduced new rules to deliver on these goals.**

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 laid down binding national targets for the individual Member States 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. Germany's national target is 18 %. The calculation of the shares is based on certain rules: for example, electricity generation from hydropower and wind energy, which fluctuates annually due to weather conditions, is normalised, 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 individual sources of energy. The arithmetic includes not only biofuels but also renewables-based electricity that is consumed by electric vehicles or in rail transport.

To achieve these targets, 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 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. Moreover, 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 pan-EU legal framework and a clear development path for the necessary investments and thus provides a solid foundation for the successful expansion of renewable energy capacity through to 2020.

In June 2018, the Member States of the EU, the European Commission and the European Parliament entered a trilogue agreement on the first part of the package of legislation entitled "Clean Energy for All Europeans". This first negotiation package contains the recast Renewable Energy Directive for 2021–2030, the revision of the Energy Efficiency Directive for 2021–2030 and a new Regulation on the Governance of the Energy Union. All three legal instruments are to enter into force by the end of 2018. The second sub-package of the Clean Energy Package, containing the relevant legislative acts regarding the electricity market, is to be agreed in the second half of 2018. Overall, the European Union is reshaping the EU's future legal framework for energy with the Clean Energy legislative package.

With the recast Renewable Energy Directive, the EU is defining a new support framework for renewable energy through to 2030. Under the Directive, the share of renewables in gross final energy consumption in the EU is to increase to at least 32 % by 2030. The Directive make provisions for a variety of measures in the electricity, heating and transport sector to achieve this target. Accordingly, the share of renewable energy in the heating and cooling sector is to increase annually by 1.3 percentage points from 2021 onwards. The share of renewable fuels in the transport sector is to be increased to 14 % by 2030 – particularly through the use of new technologies and fuels, such as electric mobility and "power to X" (electricity-based synthetic fuels). In contrast to the legal framework defined

in 2000, the binding EU goal of 32 % by 2030 is not broken down into binding national targets for the Member States. Instead, Member States report voluntary contributions to reaching the target as part of their National Energy and Climate Plans (see below). If these voluntary contributions are not enough to meet the goal at EU level, the Governance Regulation contains provisions for a gap-filler mechanism, which is triggered to cover the gap: if the planned contributions, combined, fall short of the target from the very beginning, the Commission will issue recommendations to less ambitious Member States to increase their contributions, based on a specific formula. If insufficient progress is made at the EU level between 2021 and 2030, only the Member States that have not made sufficient progress at national level will be required to take additional action.

Under the terms of the new Regulation on the Governance of the Energy Union, Member States are to develop an integrated 2030 National Energy and Climate Plan (NECP), including long-term strategies through to 2050. Draft copies of the NECPs must be submitted to the European Commission by the end of December 2018, while the finalised plans must be submitted by the end of December 2019. The national plans should also be consulted regionally with the respective neighboring states.

With the decisions for the package of legislation “Clean Energy for All Europeans” reached in Brussels completed the first stage of an intensive, multi-year process of agreements between Member States, the European Parliament and the European Commission.

**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.

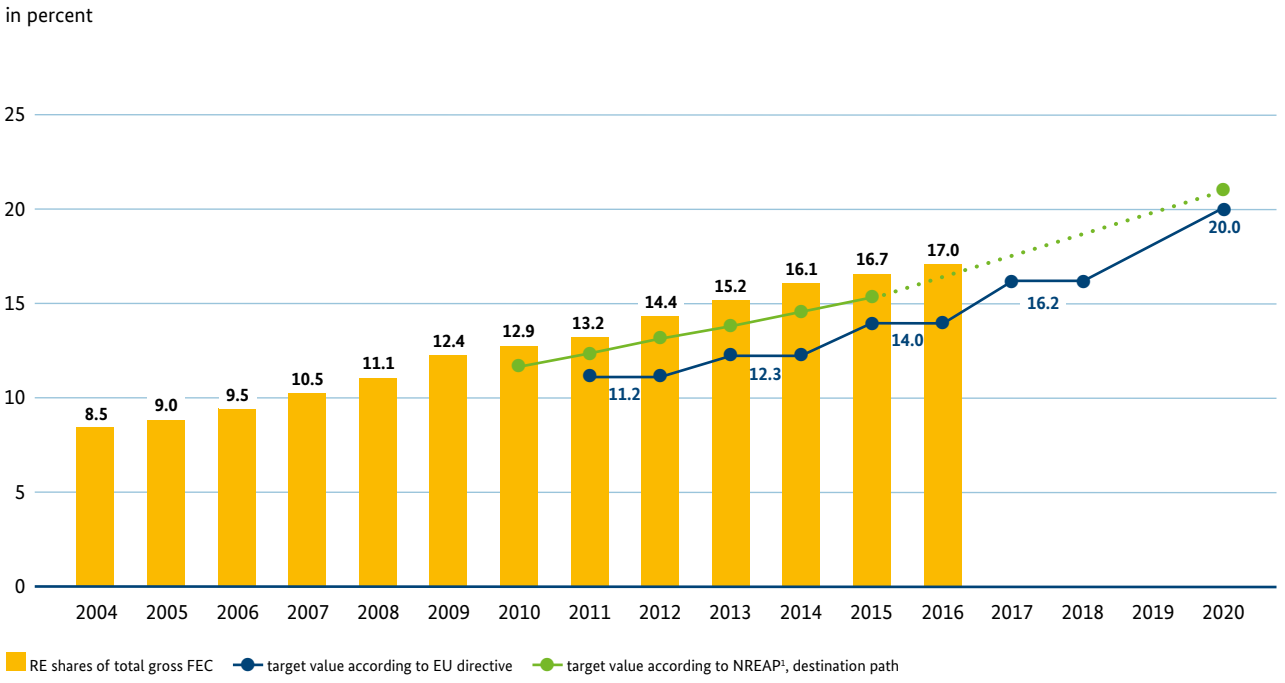
## Progress reports pursuant to Directive 2009/28/EC

On the basis of the EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC), 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 are published and available for download on the website of the European Commission at https://ec.europa.eu/energy/node/70.

According to Eurostat [2], the share of renewable energy sources used in the European Union in 2016 was 17.0 %. In 2004, this figure was just 8.5 %. Since then, 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, 14 had already reached their national targets for the year 2020 by 2016.

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 most recent (fourth) progress report in February 2017 [23]. The report is available for download at https://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports.

**Figure 40: Shares of renewable energy in gross final energy consumption in the EU and Renewable Energy Directive and National Renewable Energy Action Plan (NREAP) trajectories**




1 The Energy Research Centre of 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) [2]; ECN and Ökoinstitut [33]

## Figure 41: Shares of renewable energy in total gross final energy consumption and gross final energy consumption for electricity

| | RE shares of gross final energy consumption (%) | | | | | | RE shares of gross final energy consumption for electricity[1] (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2010 | 2014 | 2015 | 2016 | Target | 2005 | 2010 | 2014 | 2015 | 2016 |
| Austria | 23.7 | 30.2 | 33.0 | 32.8 | 33.5 | **34** | 61.9 | 65.7 | 70.1 | 70.3 | 72.6 |
| Belgium | 2.3 | 5.7 | 8.0 | 7.9 | 8.7 | **13** | 2.4 | 7.1 | 13.4 | 15.5 | 15.8 |
| Bulgaria | 9.4 | 14.1 | 18.0 | 18.2 | 18.8 | **16** | 9.3 | 12.7 | 18.9 | 19.1 | 19.2 |
| Croatia | 23.8 | 25.1 | 27.8 | 29.0 | 28.3 | **20** | 35.6 | 37.6 | 45.3 | 45.4 | 46.7 |
| Cyprus | 3.1 | 6.0 | 8.9 | 9.4 | 9.3 | **13** | 0.0 | 1.4 | 7.4 | 8.4 | 8.6 |
| Czech Republic | 7.1 | 10.5 | 15.0 | 15.0 | 14.9 | **13** | 3.7 | 7.5 | 13.9 | 14.1 | 13.6 |
| Denmark | 16.0 | 22.1 | 29.6 | 31.0 | 32.2 | **30** | 24.6 | 32.7 | 48.5 | 51.3 | 53.7 |
| Estonia | 17.5 | 24.6 | 26.3 | 28.6 | 28.8 | **25** | 1.1 | 10.4 | 14.1 | 15.1 | 15.5 |
| Finland | 28.8 | 32.4 | 38.7 | 39.2 | 38.7 | **38** | 26.9 | 27.7 | 31.4 | 32.5 | 32.9 |
| France | 9.6 | 12.7 | 14.7 | 15.1 | 16.0 | **23** | 13.7 | 14.8 | 18.3 | 18.7 | 19.2 |
| Germany | 6.7 | 10.5 | 13.8 | 14.6 | 14.8 | **18** | 10.5 | 18.2 | 28.1 | 30.8 | 32.2 |
| Greece | 7.0 | 9.8 | 15.3 | 15.3 | 15.2 | **18** | 8.2 | 12.3 | 21.9 | 22.1 | 23.8 |
| Hungary | 6.9 | 12.7 | 14.6 | 14.4 | 14.2 | **13** | 4.4 | 7.1 | 7.3 | 7.3 | 7.2 |
| Ireland | 2.9 | 5.7 | 8.7 | 9.2 | 9.5 | **16** | 7.2 | 14.6 | 22.9 | 25.2 | 27.2 |
| Italy | 7.5 | 13.0 | 17.1 | 17.5 | 17.4 | **17** | 16.3 | 20.1 | 33.4 | 33.5 | 34.0 |
| Latvia | 32.3 | 30.4 | 38.7 | 37.6 | 37.2 | **40** | 43.0 | 42.1 | 51.1 | 52.2 | 51.3 |
| Lithuania | 16.8 | 19.6 | 23.6 | 25.8 | 25.6 | **23** | 3.8 | 7.4 | 13.7 | 15.5 | 16.8 |
| Luxembourg | 1.4 | 2.9 | 4.5 | 5.0 | 5.4 | **11** | 3.2 | 3.8 | 5.9 | 6.2 | 6.7 |
| Malta | 0.1 | 1.0 | 4.7 | 5.0 | 6.0 | **10** | 0.0 | 0.0 | 3.3 | 4.2 | 5.6 |
| Netherlands | 2.5 | 3.9 | 5.5 | 5.8 | 6.0 | **14** | 6.3 | 9.6 | 10.0 | 11.1 | 12.5 |
| Poland | 6.9 | 9.3 | 11.5 | 11.7 | 11.3 | **15** | 2.7 | 6.6 | 12.4 | 13.4 | 13.4 |
| Portugal | 19.5 | 24.2 | 27.0 | 28.0 | 28.5 | **31** | 27.7 | 40.7 | 52.1 | 52.6 | 54.1 |
| Romania | 17.3 | 23.4 | 24.8 | 24.8 | 25.0 | **24** | 26.9 | 30.4 | 41.7 | 43.2 | 42.7 |
| Slovakia | 6.4 | 9.1 | 11.7 | 12.9 | 12.0 | **14** | 15.7 | 17.8 | 22.9 | 22.7 | 22.5 |
| Slovenia | 16.0 | 20.4 | 21.5 | 21.9 | 21.3 | **25** | 28.7 | 32.2 | 33.9 | 32.7 | 32.1 |
| Spain | 8.5 | 13.8 | 16.1 | 16.2 | 17.3 | **20** | 19.1 | 29.8 | 37.8 | 37.0 | 36.6 |
| Sweden | 40.6 | 47.2 | 52.5 | 53.8 | 53.8 | **49** | 50.9 | 56.0 | 63.2 | 65.8 | 64.9 |
| United Kingdom | 1.3 | 3.7 | 7.0 | 8.5 | 9.3 | **15** | 4.1 | 7.5 | 17.8 | 22.3 | 24.6 |
| **EU 28** | **9.0** | **12.9** | **16.1** | **16.7** | **17.0** | **20** | **14.8** | **19.7** | **27.4** | **28.8** | **29.6** |

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

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

Source: EUROSTAT [2]

## Figure 42: 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 | 2014 | 2015 | 2016 | 2005 | 2010 | 2014 | 2015 | 2016 | Target |
| Austria | 22.0 | 29.0 | 32.4 | 32.4 | 33.3 | 4.8 | 10.7 | 10.9 | 11.4 | 10.6 | |
| Belgium | 3.4 | 6.1 | 7.7 | 7.8 | 8.1 | 0.6 | 4.7 | 5.7 | 3.8 | 5.9 | |
| Bulgaria | 14.3 | 24.4 | 28.3 | 28.6 | 30.0 | 0.8 | 1.4 | 5.8 | 6.5 | 7.3 | |
| Croatia | 30.0 | 32.8 | 36.1 | 38.5 | 37.6 | 1.0 | 1.1 | 4.2 | 3.6 | 1.3 | |
| Cyprus | 10.0 | 18.2 | 21.6 | 22.5 | 23.0 | 0.0 | 2.0 | 2.7 | 2.5 | 2.7 | |
| Czech Republic | 10.9 | 14.0 | 19.3 | 19.6 | 19.9 | 0.9 | 5.1 | 6.9 | 6.5 | 6.4 | |
| Denmark | 22.8 | 31.0 | 38.5 | 40.1 | 41.7 | 0.4 | 1.1 | 6.7 | 6.7 | 6.8 | |
| Estonia | 32.2 | 43.3 | 45.2 | 49.6 | 51.2 | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 | |
| Finland | 39.1 | 44.2 | 52.0 | 52.5 | 53.7 | 0.9 | 4.4 | 22.0 | 22.0 | 8.4 | |
| France | 12.3 | 16.2 | 18.9 | 19.7 | 21.1 | 2.1 | 6.5 | 8.4 | 8.5 | 8.9 | |
| Germany | 6.8 | 9.8 | 12.2 | 12.9 | 13.0 | 4.0 | 6.4 | 7.2 | 6.6 | 6.9 | |
| Greece | 12.8 | 17.9 | 26.9 | 25.6 | 24.2 | 0.1 | 1.9 | 1.3 | 1.1 | 1.7 | All countries 10 % |
| Hungary | 9.9 | 18.1 | 21.2 | 21.2 | 20.8 | 0.9 | 6.0 | 6.9 | 7.0 | 7.4 | |
| Ireland | 3.5 | 4.5 | 6.6 | 6.6 | 6.8 | 0.1 | 2.5 | 5.1 | 5.7 | 5.0 | |
| Italy | 8.2 | 15.6 | 18.9 | 19.3 | 18.9 | 1.0 | 4.8 | 5.0 | 6.4 | 7.2 | |
| Latvia | 42.7 | 40.7 | 52.2 | 51.8 | 51.9 | 2.4 | 4.0 | 4.1 | 3.9 | 2.8 | |
| Lithuania | 29.3 | 32.5 | 40.6 | 46.1 | 46.5 | 0.6 | 3.8 | 4.3 | 4.6 | 3.6 | |
| Luxembourg | 3.6 | 4.7 | 7.2 | 7.1 | 7.3 | 0.1 | 2.1 | 5.4 | 6.5 | 5.9 | |
| Malta | 1.0 | 7.8 | 14.5 | 14.1 | 15.3 | 0.0 | 0.0 | 4.6 | 4.7 | 5.4 | |
| Netherlands | 2.4 | 3.1 | 5.1 | 5.5 | 5.5 | 0.4 | 3.3 | 6.2 | 5.3 | 4.6 | |
| Poland | 10.2 | 11.7 | 14.0 | 14.5 | 14.7 | 1.6 | 6.6 | 6.2 | 5.6 | 3.9 | |
| Portugal | 32.1 | 33.9 | 34.0 | 33.4 | 35.1 | 0.5 | 5.5 | 3.7 | 7.4 | 7.5 | |
| Romania | 18.0 | 27.2 | 26.7 | 25.9 | 26.9 | 1.6 | 3.8 | 4.7 | 5.5 | 6.2 | |
| Slovakia | 5.0 | 7.9 | 8.9 | 10.8 | 9.9 | 1.6 | 5.3 | 7.6 | 8.5 | 7.5 | |
| Slovenia | 18.9 | 28.1 | 32.4 | 33.9 | 34.0 | 0.8 | 3.1 | 2.9 | 2.2 | 1.6 | |
| Spain | 9.4 | 12.6 | 15.7 | 16.8 | 16.8 | 1.3 | 5.0 | 0.8 | 1.2 | 5.3 | |
| Sweden | 51.9 | 60.9 | 68.0 | 68.6 | 68.6 | 6.2 | 9.2 | 21.1 | 24.0 | 30.3 | |
| United Kingdom | 0.8 | 2.7 | 4.7 | 6.3 | 7.0 | 0.5 | 3.3 | 5.3 | 4.4 | 4.9 | |
| **EU 28** | **10.9** | **15.0** | **18.1** | **18.7** | **19.1** | **1.8** | **5.2** | **6.5** | **6.6** | **7.1** | |

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

Source: EUROSTAT [2]

## Estimate of the shares of renewable energy in Germany in 2017 according to Directive 2009/28/EC

Initial estimates and calculations indicate that renewable energy made up 15.2 % of gross final energy consumption in 2017, based on the calculation method set out in the EU Directive.

This represents an increase on the previous year (14.8 %). The level Germany reached in 2017 actually exceeded the national interim target laid down in EU Directive 2009/28/EC for 2017/2018 (13.7 %).

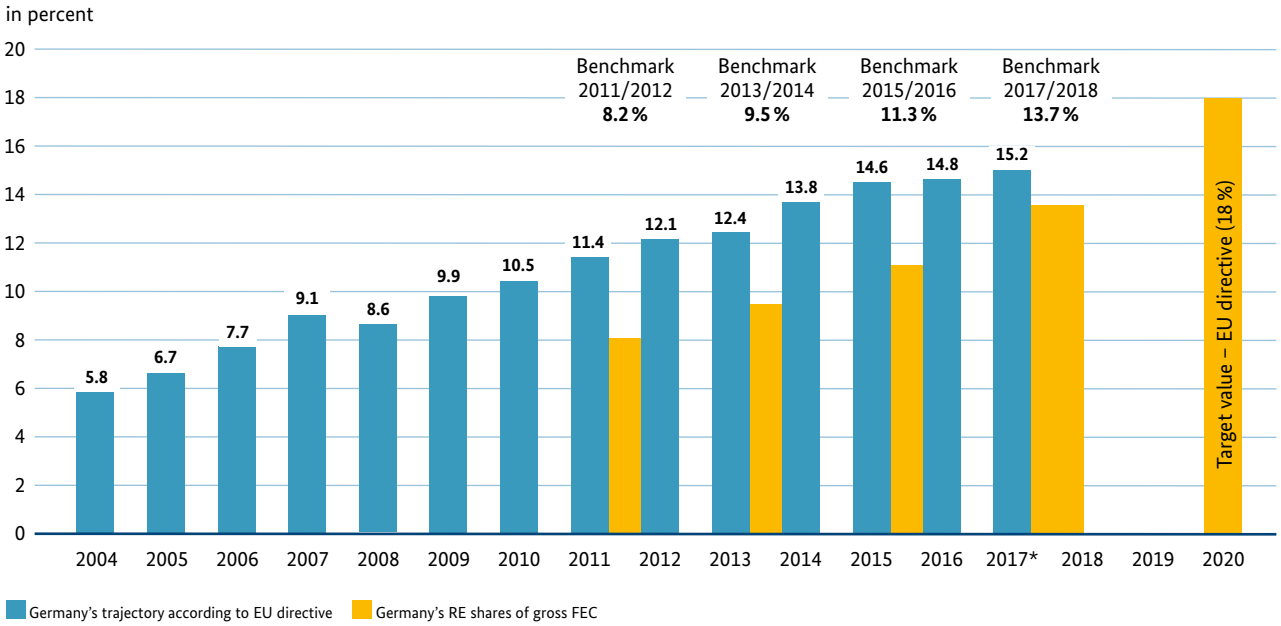
**Figure 43: Shares of renewable energy in total gross final energy consumption (GFEC) and in electricity, heat and transport in Germany**

Calculated according to the EU Directive

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (%) | | | | | | |
| RES share in GFEC electricity | 9.4 | 10.5 | 11.8 | 13.6 | 15.0 | 17.3 | 18.2 | 20.9 | 23.6 | 25.3 | 28.1 | 30.8 | 32.2 |
| RES share in GFEC 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 | 13.0 |
| RES share in FEC transport | 2.2 | 4.0 | 6.8 | 7.5 | 6.4 | 5.9 | 6.4 | 6.5 | 7.4 | 6.9 | 7.2 | 6.6 | 6.9 |
| **RES share in total gross final energy consumption** | **5.8** | **6.7** | **7.7** | **9.1** | **8.6** | **9.9** | **10.5** | **11.4** | **12.1** | **12.4** | **13.8** | **14.6** | **14.8** |

Source: EUROSTAT (SHARES) [2]

**Figure 44: Shares of renewable energy in gross final energy consumption in Germany and trajectory set out in the EU Directive**

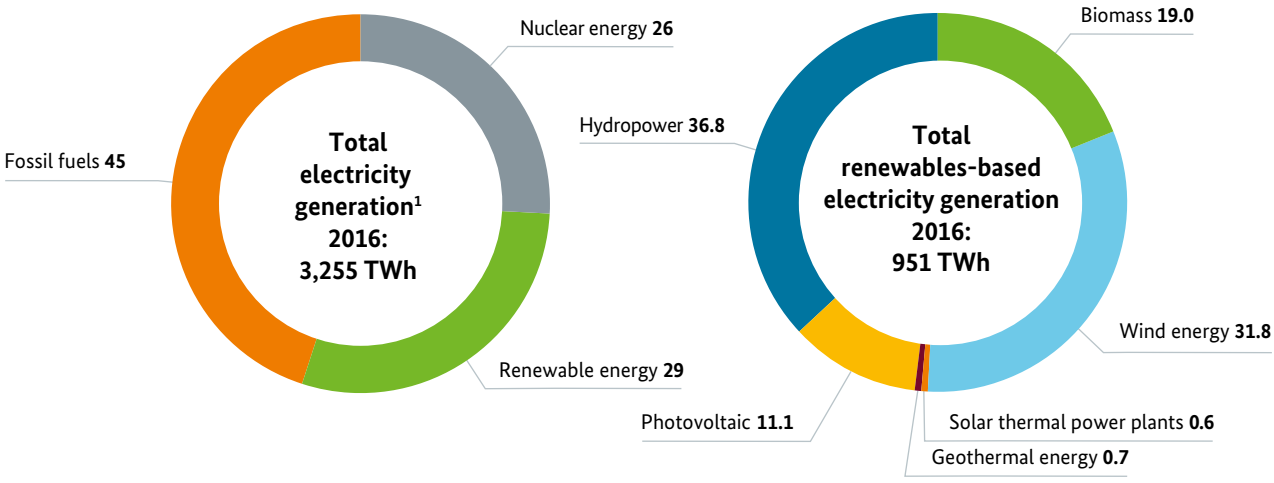



The Directive contains detailed rules on how to calculate the share of renewable energy in gross final energy consumption.
Due to the methodology set out in the EU Directive, the data shown in this figure is not comparable to data on national trends (see pages 7 ff.).
For information on the calculation method in the EU Directive, see the "Information on methodology" section.

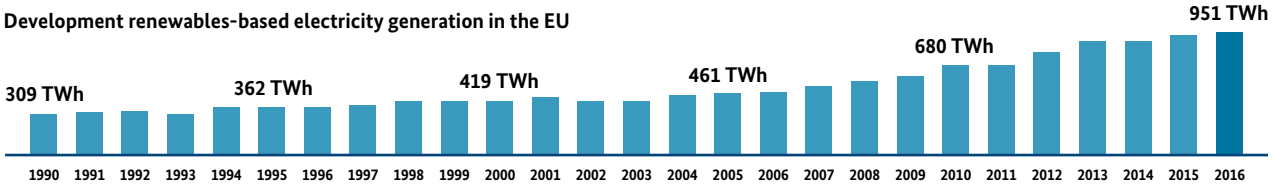
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat, ZSW; data current as at August 2018 (* provisional)

**Figure 45: Electricity generation in the EU in 2016**

in percent




**Development renewables-based electricity generation in the EU**




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

Source: EUROSTAT (supply, transformation and consumption of electricity – annual data [nrg_105a]) [34]

## Electricity generation from renewable energy sources

In 2005, the share of renewables in total gross electricity consumption in the EU was just under 14 %, i.e. more than 86 % of electricity consumption was still 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 in excess of 30 %.

In 2016, 951 billion kilowatt hours of electricity were produced in the EU from renewable energy sources, and therefore over double the amount produced in 2005 (461 billion kilowatt hours). As a result, the share of renewable energy in total gross electricity consumption in the EU rose to 29.1 % in 2016.

Back in 2005, the bulk (more than two thirds) of green electricity came from hydropower. By 2016, the share of this technology had fallen to just roughly 37 %. By contrast, the shares of wind, biomass and solar energy have increased considerably, standing at 32 %, 19 % and 12 % respectively.

At the end of 2016, total installed capacity in the EU for the generation of electricity from renewable energy amounted to 422 gigawatts, and was therefore more than twice the level in 2005 (179 gigawatts). Wind energy accounted for approximately 154 gigawatts of this figure, well ahead of hydropower (129 gigawatts) and photovoltaics (101 gigawatts).

## Figure 46: Electricity generation from renewable energy sources in the EU (TWh)

| | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | (TWh) | | | | |
| Biomass[1] | 69.8 | 124.1 | 133.0 | 148.6 | 157.4 | 167.2 | 177.8 | 180.5 | |
| Hydropower[2] | 313.3 | 376.9 | 312.2 | 335.8 | 371.6 | 375.0 | 341.1 | 350.1 | |
| Wind energy | 70.5 | 149.4 | 180.0 | 206.0 | 236.8 | 253.1 | 301.9 | 302.9 | 353.5 |
| Geoth. Energy | 5.4 | 5.6 | 5.9 | 5.8 | 5.9 | 6.2 | 6.5 | 6.6 | |
| Photovoltaics | 1.5 | 22.5 | 45.3 | 67.4 | 80.9 | 92.3 | 102.3 | 105.2 | 105.3 |
| Solar thermal energy | 0.0 | 0.8 | 2.0 | 3.8 | 4.8 | 5.5 | 5.6 | 5.6 | |
| Ocean energy | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 | 0.5 | 0.5 | |
| RE total | 460.9 | 679.7 | 678.9 | 767.8 | 857.8 | 899.8 | 935.7 | 951.4 | |
| **RE share of gross electrictiy consumption[3]** | **13.8 %** | **20.1 %** | **20.5 %** | **23.2 %** | **26.1 %** | **28.1 %** | **28.8 %** | **29.1 %** | |
| | | | | | (TWh) | | | | |
| EU-gross final electricity generation | 3,325.8 | 3,366.6 | 3,301.4 | 3,296.2 | 3,270.9 | 3,191.2 | 3,235.2 | 3,255.1 | |
| Import | 335.2 | 298.7 | 329.8 | 363.1 | 349.6 | 386.9 | 410.3 | 382.2 | |
| Export | 319.4 | 291.2 | 322.6 | 344.4 | 337.0 | 371.4 | 396.1 | 364.0 | |
| Final consumption | 2,784.6 | 2,838.2 | 2,791.6 | 2,800.4 | 2,777.4 | 2,711.8 | 2,751.9 | 2,784.2 | |

1 Including biogas, sewage gas and landfill gas, liquid and solid biogenic fuels and the renewable share of municipal waste
2 In the case of pumped storage power plants, power generation from natural inflow only
3 Gross electricity consumption = gross electricity generation plus imports minus exports; not calculated using rules in EU Directive.
This overview is based on currently available statistics (up to 2016 EUROSTAT, 2017 EurObserv'ER – data available for wind energy and photovoltaics).

Sources: EUROSTAT (supply, transformation and consumption of electricity – annual data [nrg_105a]) [34], EurObserv'ER [35], IEA [44]

## Figure 47: Electricity generation from renewable energy sources in the EU, 2016

| | Hydropower | Wind energy | Bio-mass[1] | Biogas[2] | Lioquid biogenic fuels | Photo-voltaic | Solar thermal power plants | Geo-thermal energy | Ocean energy | Total | RE share of gross electricity consumption[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (TWh) | | | | | | (%) |
| Austria | 39.8 | 5.2 | 4.0 | 0.6 | 0.01 | 1.1 | – | 0.001 | – | **50.8** | **67.3** |
| Belgium | 0.4 | 5.4 | 4.3 | 1.0 | 0.04 | 3.1 | – | – | – | **14.2** | **15.5** |
| Bulgaria | 3.9 | 1.4 | 0.2 | 0.2 | – | 1.4 | – | – | – | **7.1** | **18.3** |
| Croatia | 6.9 | 1.0 | 0.2 | 0.2 | – | 0.07 | – | – | – | **8.4** | **45.6** |
| Cyprus | – | 0.2 | – | 0.1 | – | 0.1 | – | – | – | **0.4** | **8.7** |
| Czech Republic | 2.0 | 0.5 | 2.2 | 2.6 | – | 2.1 | – | – | – | **9.4** | **13.0** |
| Denmark | 0.02 | 12.8 | 4.4 | 0.6 | – | 0.7 | – | – | – | **18.5** | **52.1** |
| Estonia | 0.04 | 0.6 | 0.8 | 0.05 | – | – | – | – | – | **1.5** | **15.0** |
| Finland | 15.8 | 3.1 | 11.1 | 0.4 | 0.004 | 0.02 | – | – | – | **30.4** | **34.7** |
| France | 60.0 | 21.4 | 5.2 | 1.9 | 0.001 | 8.2 | – | 0.004 | 0.5 | **97.2** | **18.9** |
| Germany | 20.5 | 78.7 | 16.7 | 33.7 | 0.5 | 38.1 | – | 0.18 | – | **188.4** | **31.5** |
| Greece | 5.5 | 5.1 | 0.0 | 0.3 | – | 3.9 | – | – | – | **14.9** | **24.7** |
| Hungary | 0.3 | 0.7 | 1.7 | 0.3 | – | 0.2 | – | – | – | **3.2** | **7.2** |
| Ireland | 0.7 | 6.1 | 0.5 | 0.2 | – | 0.0 | – | – | – | **7.5** | **25.3** |
| Italy | 42.4 | 17.7 | 6.5 | 8.3 | 4.7 | 22.1 | – | 6.29 | – | **108.0** | **33.1** |
| Latvia | 2.5 | 0.1 | 0.4 | 0.4 | 0.001 | – | – | – | – | **3.5** | **46.8** |
| Lithuania | 0.5 | 1.1 | 0.3 | 0.1 | – | 0.1 | – | – | – | **2.1** | **16.7** |
| Luxembourg | 0.1 | 0.1 | 0.1 | 0.1 | – | 0.1 | – | – | – | **0.5** | **5.4** |

*Continuation on page 46*

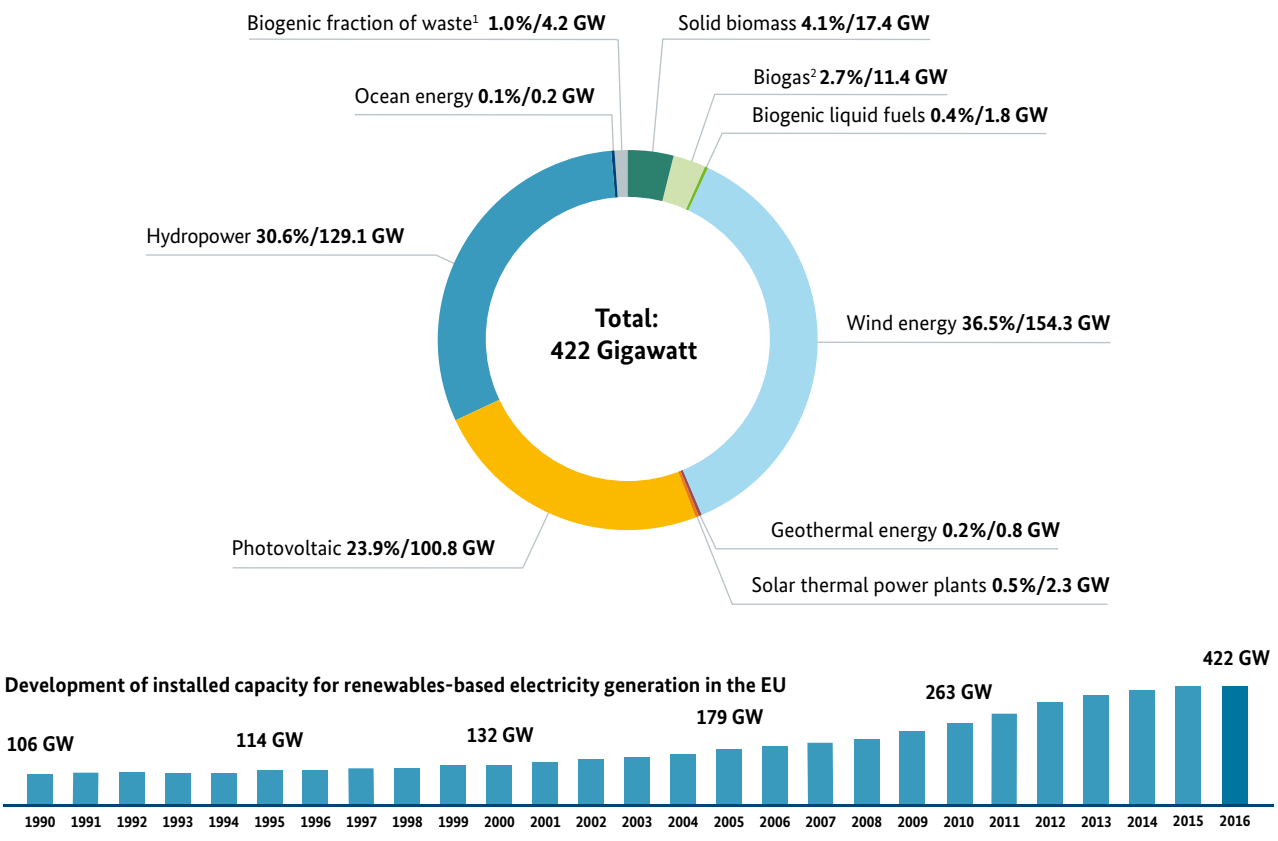
*Fortsetzung der Tabelle von Seite 45*

| | Hydropower | Wind energy | Bio-mass[1] | Biogas[2] | Lioquid biogenic fuels | Photo-voltaic | Solar thermal power plants | Geo-thermal energy | Ocean energy | Total | RE share of gross electricity consumption[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (TWh) | | | | | | (%) |
| Malta | – | – | – | 0.008 | – | 0.13 | – | – | – | **0.1** | **5.6** |
| Netherlands | 0.1 | 8.2 | 4.1 | 1.0 | 0.4 | 1.6 | – | – | – | **15.4** | **12.8** |
| Poland | 2.1 | 12.6 | 6.9 | 1.1 | 0.004 | 0.12 | – | – | – | **22.9** | **13.6** |
| Portugal | 15.7 | 12.5 | 2.8 | 0.3 | – | 0.8 | – | 0.17 | – | **32.3** | **58.5** |
| Romania | 18.0 | 6.6 | 0.5 | 0.1 | – | 1.8 | – | – | – | **27.0** | **44.9** |
| Slovakia | 4.4 | 0.01 | 1.2 | 0.6 | – | 0.5 | – | – | – | **6.6** | **22.4** |
| Slovenia | 4.5 | 0.006 | 0.1 | 0.1 | 0.003 | 0.3 | – | – | – | **5.1** | **33.0** |
| Spain | 36.4 | 48.9 | 4.8 | 0.9 | – | 8.1 | 5.6 | – | – | **104.6** | **37.0** |
| Sweden | 62.0 | 15.5 | 11.4 | 0.01 | 0.05 | 0.14 | – | – | – | **89.1** | **61.8** |
| United Kingdom | 5.4 | 37.4 | 22.3 | 7.7 | – | 10.4 | – | – | 0.002 | **83.2** | **23.3** |
| **EU 28** | **350.1** | **302.9** | **112.5** | **62.7** | **5.3** | **105.2** | **5.6** | **6.6** | **0.5** | **951.4** | **29.1** |

This overview is based on currently available statistics (see source). The data may differ from national statistics due to different methodologies used or other factors. All data are provisional; discrepancies in the totals due to rounding.
1 Including the biogenic share of municipal waste
2 Including sewage and landfill gas
3 Gross electricity consumption = gross electricity generation plus imports minus exports; not calculated using rules in EU

Source: EUROSTAT: (supply, transformation and consumption of electricity – annual data [nrg_105a]) [34]

**Figure 48: Total installed renewables-based electricity generation capacity in the EU in 2016**




1 Biogenic share of waste in waste incineration plants estimated at 50%
2 Including landfill gas and sewage gas

Source: EUROSTAT (NRG – 113a) [36]

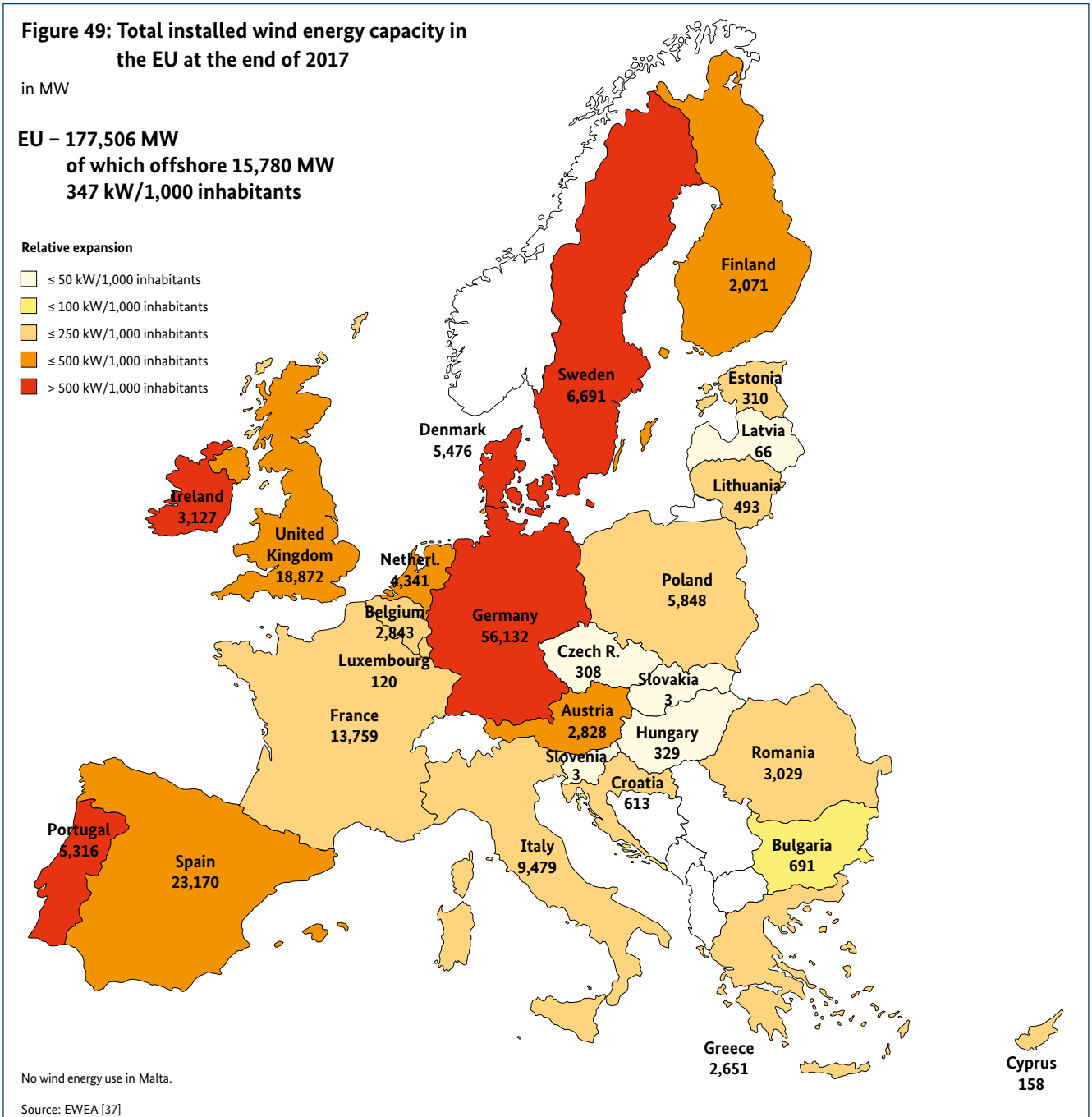
## Wind energy use

The rate of expansion in the use of wind energy across the EU reached a record level in 2017. According to the European Wind Energy Association (EWEA) [40] net expansion of capacity, at 16.2 gigawatts, was 16 % higher than the previous year (13.9 gigawatts). As in previous years, the bulk of this new capacity was installed in Germany (38 %), followed by the United Kingdom (26 %) and France (roughly 10 %). Thus, by the end of 2017 wind energy installations across the EU had a combined total capacity of 177.5 gigawatts, according to EWEA data. In terms of total capacity, Germany was able to further consolidate its leading position in the EU, accounting for roughly 32 % of the total wind energy capacity installed. In second place, Spain's share dropped to 13 %, while the United Kingdom and France increased their share to 11 % and 8 % respectively.

However, the picture is still different if the total installed capacity of the various Member States is considered in per-capita terms. At the end of 2017, the EU average stood at 347 kilowatts per 1,000 inhabitants. In terms of country rankings, Denmark was clearly in first place with 953 kilowatts per 1,000 inhabitants. Germany secured second place for the first time, with 680 kilowatts per 1,000 inhabitants, followed closely by Sweden with 669 and Ireland with 654.

**Figure 49: Total installed wind energy capacity in the EU at the end of 2017**

in MW




No wind energy use in Malta.

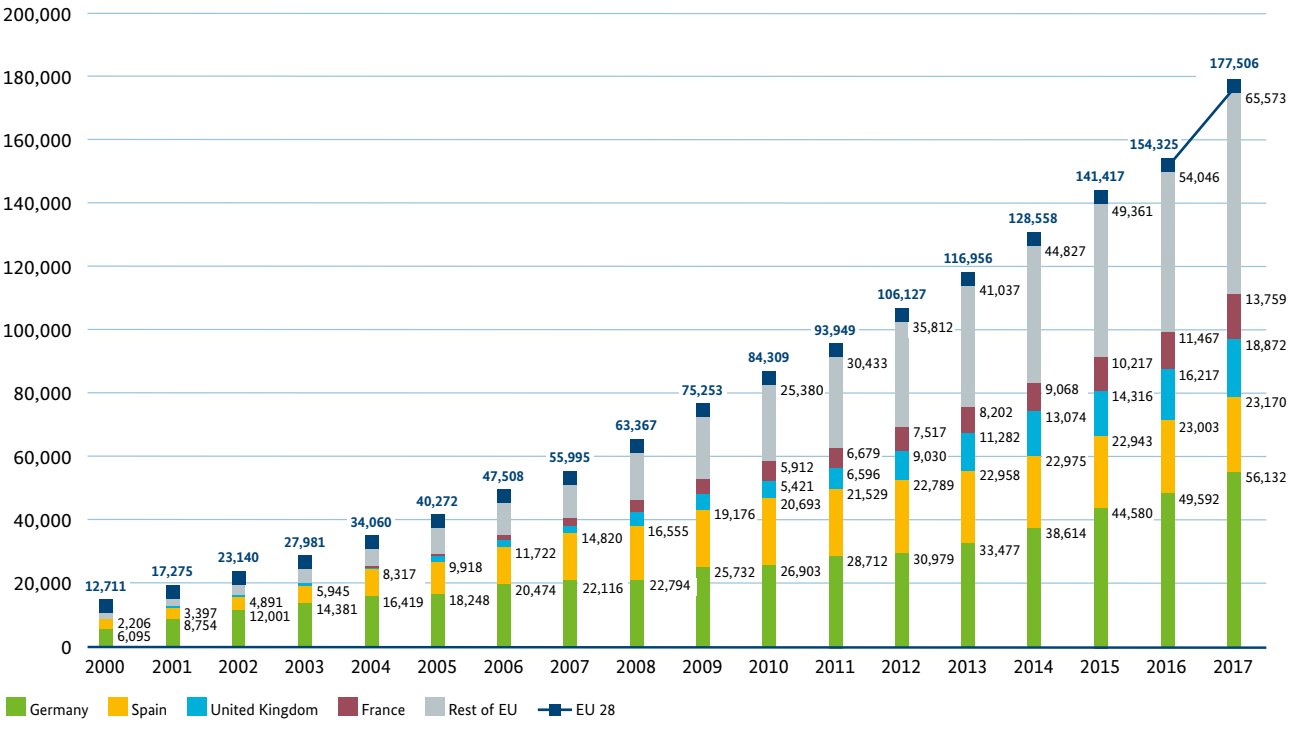
Source: EWEA [37]

If installed offshore wind energy capacity is considered on its own, the new capacity added in 2017 amounted to roughly 3,154 megawatts. This is over twice the capacity added the previous year (1,567 megawatts) and even exceeds the previous record set in 2015 (3,035 megawatts). This meant that by the end of 2017, offshore wind energy installations across the EU had a combined total capacity of 15,780 megawatts. Here, the United Kingdom led the way (43 %), ahead of Germany (34 %), while Denmark slipped to 10 % and the Netherlands to 7 %.

All the EU's wind energy installations combined generated over 353 billion kilowatt hours of electricity in 2017, which translates to an increase of approximately 17 % on the previous year [35].

**Figure 50: Development of cumulative wind energy capacity in EU Member States**

Accumulated wind energy capacity (MW)

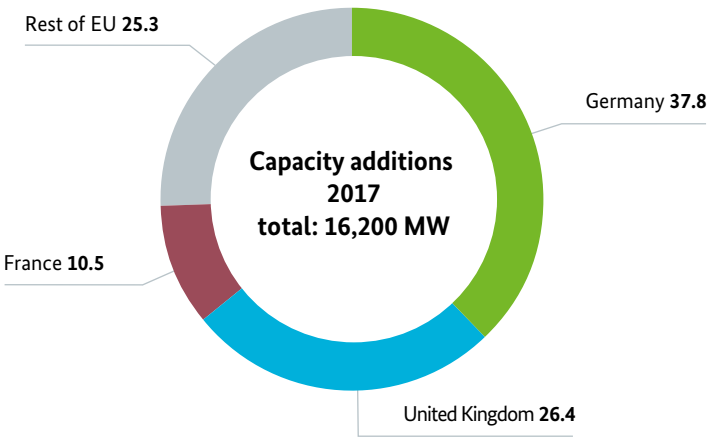



Total wind capacity in 2017 is not exactly equal to the sum of installed capacity at the end of 2016 plus new-build in 2017; this is due to the repowering and decommissioning of existing wind energy installations and the rounding of data.

Source: EUROSTAT (NRG – 113a) [36]; EWEA "Wind in Power" [37]

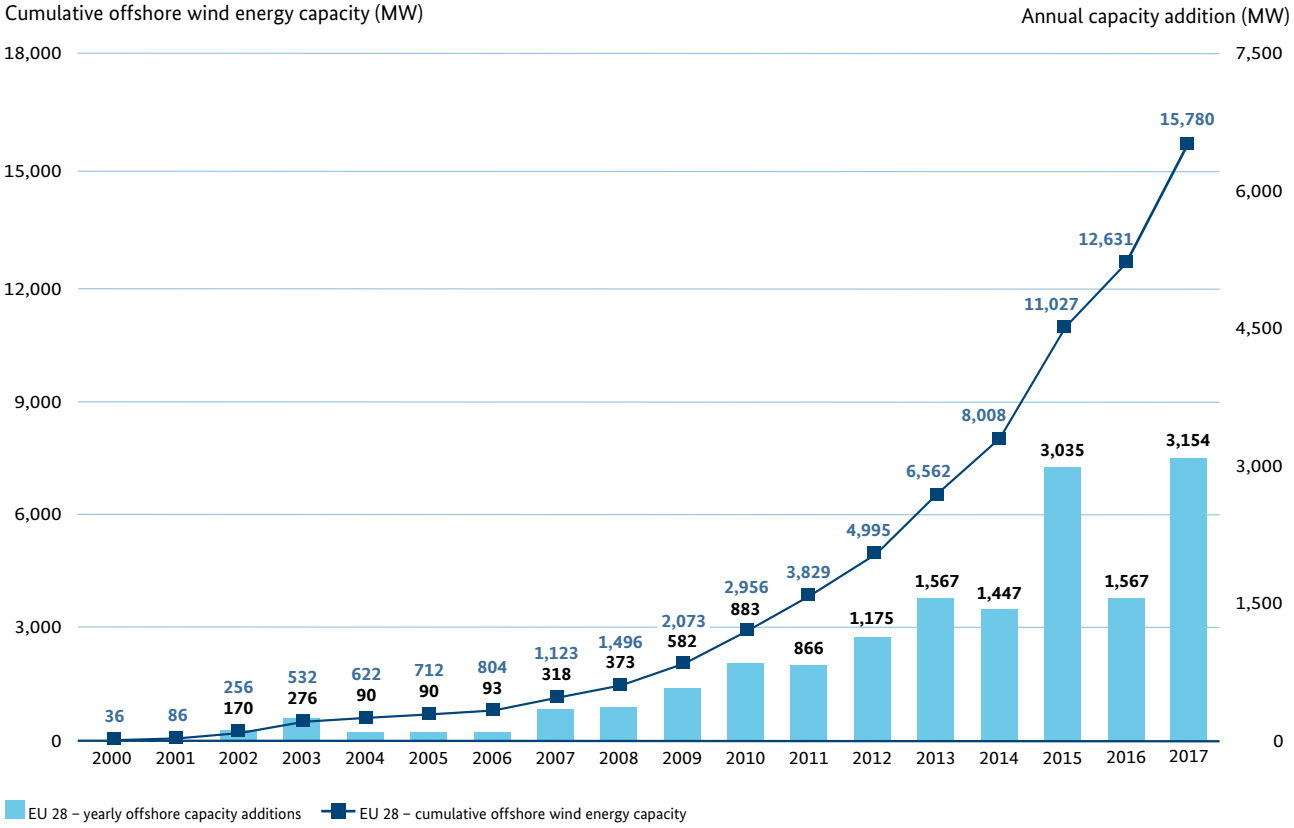
**Figure 51: Expansion of wind energy capacity in the EU Member States, 2017**

in percent




Source: EUROSTAT (NRG – 113a) [36]; EWEA "Wind in Power" [37]

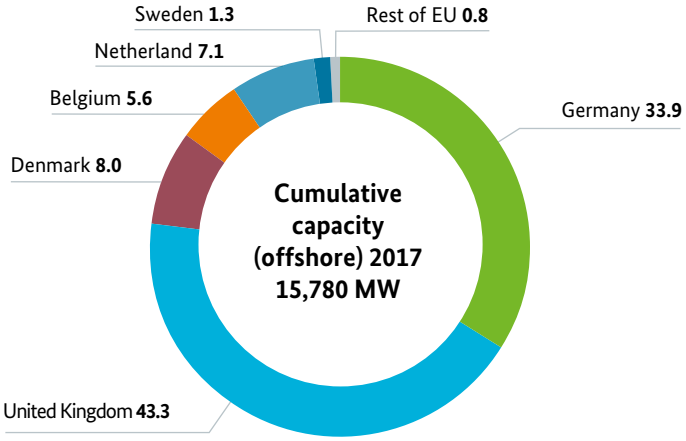
**Figure 52: Expansion and cumulative installed offshore wind capacity**




Source: EWEA "Offshore" [37]

**Figure 53: Share of total offshore wind energy capacity held by individual countries 2017**

in percent




Source: EWEA "Offshore" [37]

## Solar energy use – electricity generation

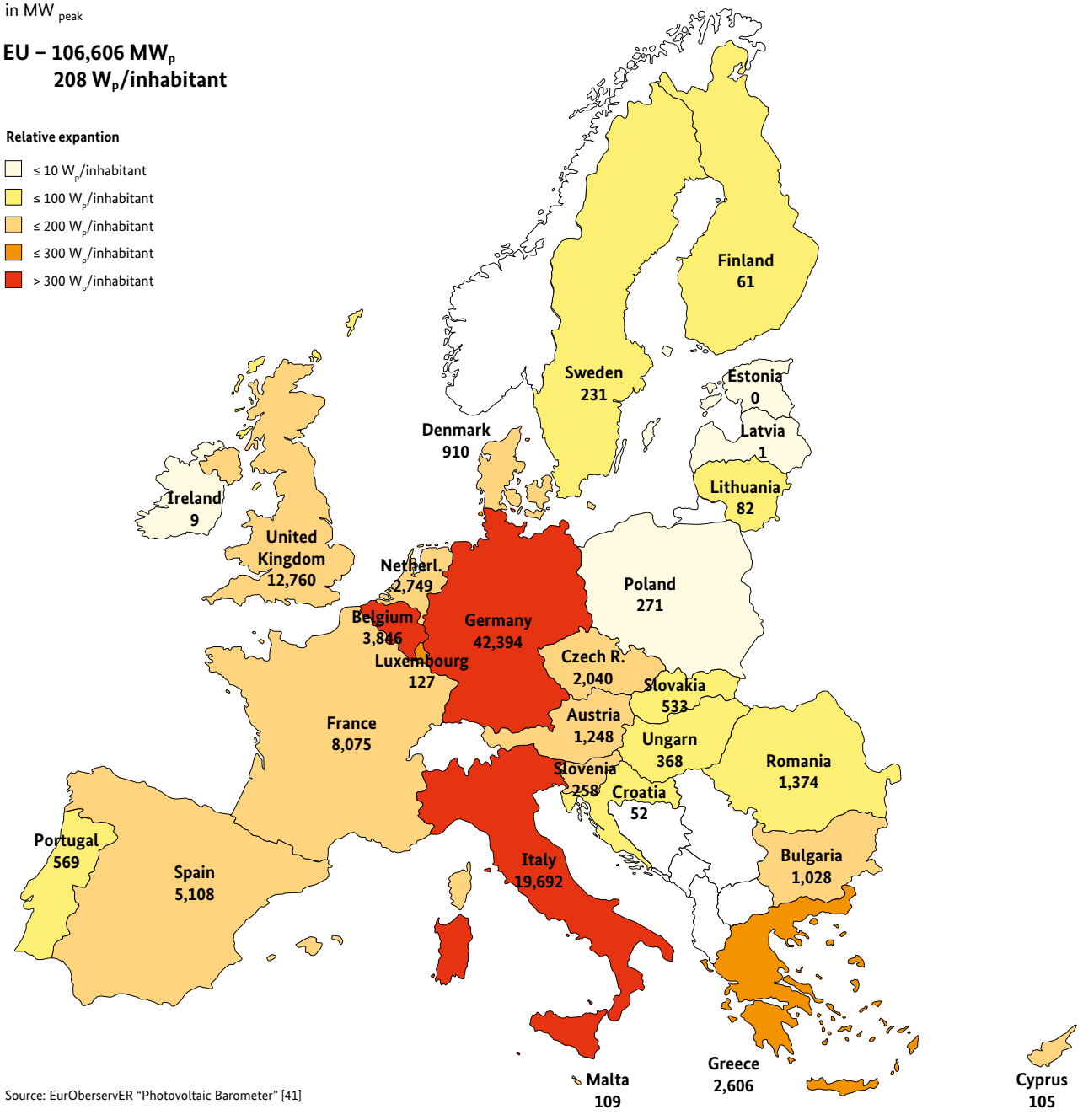
The European photovoltaic market continued on a downward trend in 2017, and with roughly 5.6 gigawatts of capacity added that year, it experienced a further decline of 11 % on the previous year [41]. Accounting for 30 % of the capacity increase, Germany moved into first place once again, taking over from the United Kingdom, whose share fell significantly in 2017 to roughly 15 % (2016: 38 %) and slipped to third place in the ranking behind France (16 %). The Netherlands followed with approx. 13 %, Italy with 7 % and Belgium 5 %.

This means that total photovoltaic capacity of 106.6 gigawatts was installed in the EU at the end of 2017. Broken down by country, by far most PV capacity was installed in Germany (approx. 40 %), followed by Italy (approx. 18 %), the United Kingdom (12 %) and France (roughly 8 %). Considered in terms of installed capacity per 1,000 inhabitants, which averaged 208 kilowatts in the EU, Germany also occupied first place with 514 kilowatts, followed by Belgium with 339 and Italy with 325 kilowatts.

All photovoltaic installations combined produced roughly 105 billion kilowatt hours of electricity in 2017 and therefore output was roughly on a par with the previous year.

**Figure 54: Total installed photovoltaic capacity in the EU at the end of 2017**

in MW $_{peak}$




Source: EurObservER "Photovoltaic Barometer" [41]

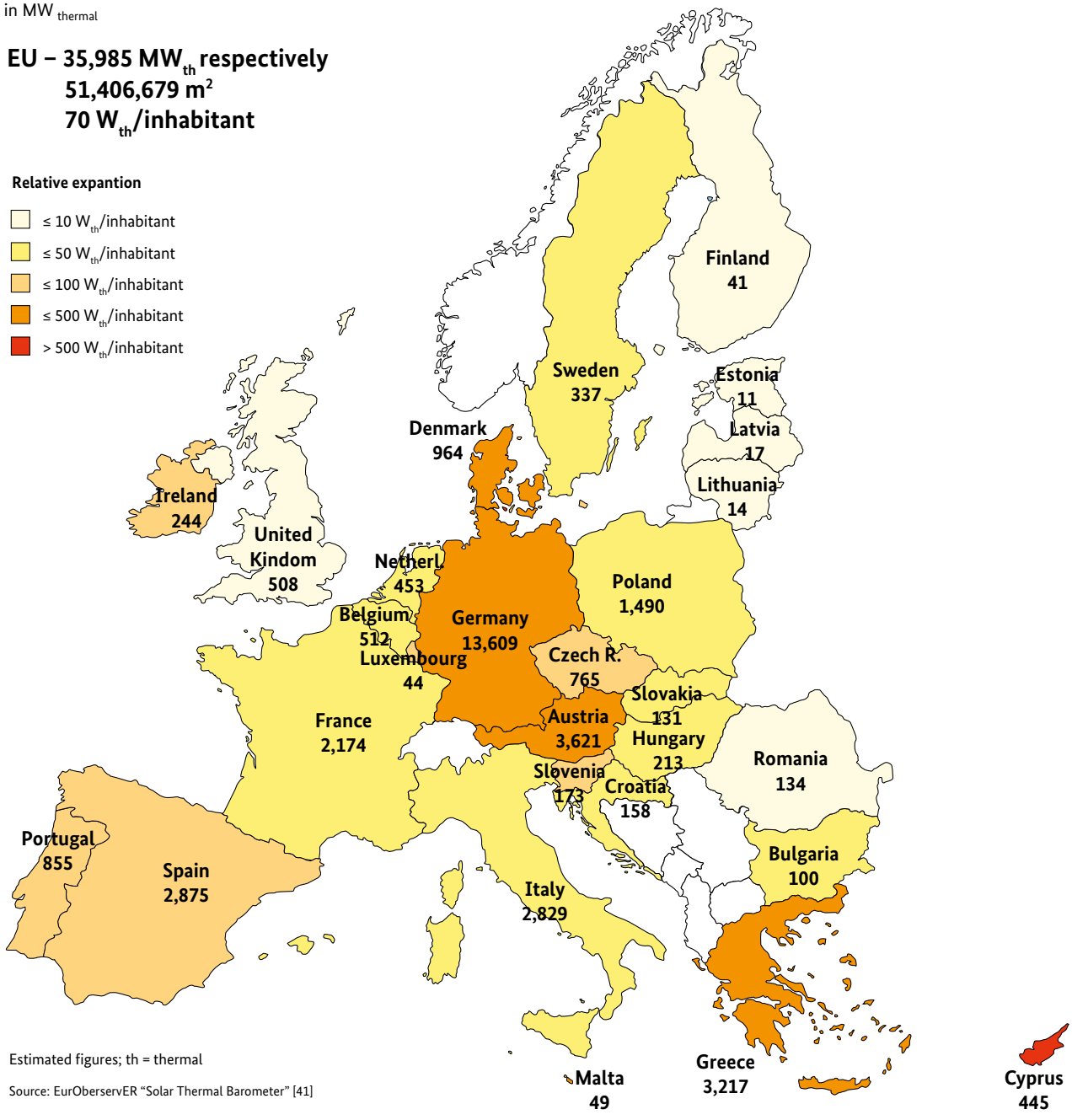
Apart from photovoltaic installations, solar thermal power plants are also used in the EU to generate electricity using solar energy. However, use of this technology is only commercially viable in the southern European countries, with Spain having been both the EU and global leader in this field for a long time – helped along by an attractive feed-in tariff. As a result, almost all of solar thermal capacity installed in the EU – amounting to roughly 2,300 megawatts – is located in Spain. Producing roughly 5 billion kilowatt hours of electricity, the installations cover around 2 % of Spanish electricity consumption each year [40].

## Solar energy use – heat supply

According to the EurObserv'ER Solar Thermal Barometer [42], the pan-EU solar thermal market shrunk by a further 24.2 % in 2017. Roughly 1.96 million square metres of new solar collector surface area was installed in the EU in 2017, corresponding to a thermal capacity of 1.37 gigawatts. This contrasts to the almost 2.6 million square metres that were newly installed the previous year, and means that solar thermal expansion in the EU declined for the ninth year in succession. By far, the biggest decline was seen in Denmark, with the market contracting by over 90 % as a result of changes in policy.

**Figure 55: Total installed solar thermal capacity in the EU, 2017**

in MW $_{thermal}$




Estimated figures; th = thermal

Source: EurOberservER "Solar Thermal Barometer" [41]

With 630,000 square meters of new glazed collector area, Germany continued to be the biggest market in Europe but did experience a significant decline compared to the previous year. Reporting an increase of 16 % on the previous year, Greece, by contrast, bucked the downward trend, and moved up to second place with 316,000 square meters of new collector surface area, followed by Spain (202,000 square metres) and Italy (151,000 square metres).

This means that at the end of 2017, the EU had a total installed collector surface area of over 51.4 million square meters, which equates to a thermal capacity of almost 36 gigawatts. Totalling 19.44 million square meters, the largest collector surface area by far was installed in Germany, followed by Austria (5.17 million), Greece (4.6 million), Spain (4.11 million) and Italy (4.04 million). In per-capital terms, Cyprus continues to top the ranking, with 0.71 square metres, ahead of Austria (0.59) and Greece (0.43).

## Renewable energy sources in the transport sector

EU Directive 2009/28/EC sets a binding target for the transport sector, namely that the share of final energy consumption from renewable sources in each EU Member State must be at least 10 % by 2020, taking multiple-counting options into consideration.

Owing to the debate surrounding the sustainability of first-generation biofuels and to increasing interest in electric mobility options, the use of both biodiesel and bioethanol declined in 2016. In 2017, however, there was already a more positive development.

By contrast, the consumption of biofuels in the EU rose in 2017 by 8 %, climbing to 180.4 TWh. Biodiesel sales rose by 7.9 % and bioethanol by 7.8 % [43].

Regional sales of electric vehicles in Europe rose by 8 % in 2017 to a total of around 300,000 vehicles. This means that Europe accounts for about a quarter of global sales of electric vehicles [43].

## Figure 56: Consumption of biofuels in the EU Member States in 2016 and 2017

| | 2016 | | | | 2017[1] | | | |
|---|---|---|---|---|---|---|---|---|
| | Bioethanol | Biodiesel[2] | Others[3] | Total | Bioethanol | Biodiesel[2] | Others[3] | Total |
| | (billion kWh) | | | | (billion kWh) | | | |
| Austria | 0.7 | 6.7 | 0.01 | 7.4 | 0.6 | 7.2 | 0.004 | 7.8 |
| Belgium | 0.5 | 4.5 | – | 5.0 | 1.0 | 4.4 | – | 5.4 |
| Bulgaria | 0.4 | 1.3 | – | 1.7 | 0.4 | 1.8 | – | 2.3 |
| Croatia | – | 0.3 | – | 0.3 | – | 0.0 | – | 0.004 |
| Cyprus | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 |
| Czech Republic | 0.6 | 2.7 | – | 3.3 | 0.9 | 2.8 | – | 3.7 |
| Denmark | – | 2.8 | – | 2.8 | 0.5 | 2.0 | – | 2.5 |
| Estonia[5] | 0.03 | – | – | 0.0 | 0.03 | – | – | 0.03 |
| Finland | 0.7 | 4.3 | 0.02 | 5.0 | 1.0 | 3.5 | 0.03 | 4.6 |
| France | 5.5 | 30.7 | – | 36.2 | 6.3 | 32.5 | – | 38.8 |
| Germany[4] | 8.8 | 20.6 | 0.3 | 29.8 | 8.5 | 21.4 | 0.4 | 30.3 |
| Greece | – | 1.7 | – | 1.7 | – | 1.8 | – | 1.8 |
| Hungary | 0.5 | 1.6 | – | 2.1 | 0.7 | 2.3 | – | 3.1 |
| Ireland | 0.4 | 1.0 | – | 1.4 | 0.4 | 1.5 | – | 1.9 |
| Italy | 0.3 | 11.7 | – | 12.0 | 0.4 | 11.9 | – | 12.3 |
| Latvia | 0.1 | 0.2 | – | 0.3 | 0.1 | 0.0 | – | 0.1 |
| Lithuania | 0.1 | 0.6 | – | 0.7 | 0.1 | 0.6 | – | 0.7 |
| Luxembourg | 0.1 | 0.9 | – | 1.0 | 0.1 | 1.2 | – | 1.3 |
| Malta | – | 0.1 | – | 0.1 | – | 0.0 | – | 0.05 |
| Netherlands | 1.4 | 1.6 | – | 3.0 | 1.5 | 2.0 | – | 3.5 |
| Poland | 1.9 | 6.3 | – | 8.2 | 1.9 | 4.9 | – | 6.8 |
| Portugal | 0.2 | 2.9 | – | 3.2 | 0.0 | 2.9 | – | 3.0 |
| Romania[5] | 0.9 | 2.0 | – | 3.0 | 0.9 | 2.0 | – | 3.0 |
| Slovakia | 0.4 | 1.4 | – | 1.7 | 0.5 | 1.6 | – | 2.0 |
| Slovenia | 0.1 | 0.3 | – | 0.3 | – | 0.4 | – | 0.4 |
| Spain | 1.6 | 9.8 | – | 11.4 | 1.6 | 13.3 | – | 15.0 |
| Sweden | 1.3 | 12.8 | 1.2 | 15.3 | 1.2 | 16.6 | 1.3 | 19.1 |
| United Kingdom | 4.5 | 6.5 | – | 11.0 | 4.5 | 6.4 | – | 10.9 |
| **Region EU 28** | **30.8** | **134.9** | **1.6** | **167.3** | **33.2** | **145.5** | **1.7** | **180.4** |

1 Data provisional

2 Value for biodiesel also contains a share of HVO

3 Biogas in Germany, Sweden and Finland; vegetable oil consumption and unspecified biofuelsin Austria

4 Value for biodiesel in Germany also includes the used proportion of vegetable oil

5 Data for 2017 were not yet available for Estonia, and Romania at the time the EurObserv'ER was published. For both countries the values of 2016 were extrapolate.

Source: EurObserv'ER [43]

# Part III: Global use of renewable energy sources

**Renewable energy plays an ever greater role in worldwide electricity generation. However, as the global population is growing at continously, the pace of renewable energy expansion must be stepped up significantly if the increasing demand is to be met in a sustainable manner.**

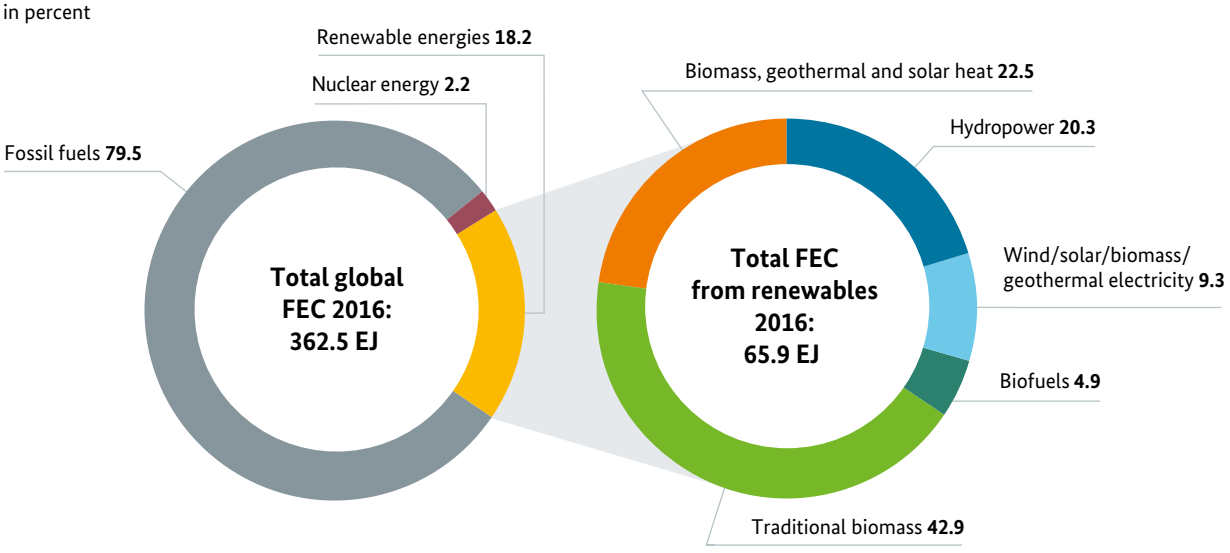
Wind and solar energy are considered to have the greatest potential for meeting the world's growing demand for energy. These are the technologies that have been posting the largest growth rates in the recent past. Geothermal energy, marine energy, and modern biomass technologies are also of importance. Modern renewable energy technologies are a key factor in combating poverty, especially in developing countries, where more than 1.1 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. 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. The following data on the global deployment of renewable energy are used based on their availability at the time this document was drafted, and therefore do not yet fully reflect all developments in the year 2017.

According to estimates by REN21 [39], renewables accounted for 18.2 % of total final energy consumption in 2016. Some 79.5 % continued to be derived from fossil fuels and 2.2 % from nuclear energy. However, modern forms of using renewable energies accounted for just 10.4 %, while the traditional use of biomass still made up a large share (7.8 %) of total final energy consumption derived from renewables. While the use of photovoltaics and wind energy continued to grow rapidly, the increase in the share of renewable energy slowed again recently. This is partly because the expansion of renewable energy can barely keep pace with the increasing global demand for energy. Furthermore, traditional biomass usage has declined in some countries, which can also be seen as a positive development from an ecological viewpoint.

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

**Figure 57: Distribution of global final energy consumption (FEC) in 2016**

in percent




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

Source: REN21: Renewables 2018 Global Status Report, REN21 Secretariat, Paris, 2018 [39]

estimates by the IEA, as many as around 2.7 billion people rely on traditional biomass use for cooking. Simple cooking 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 [44]. 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.

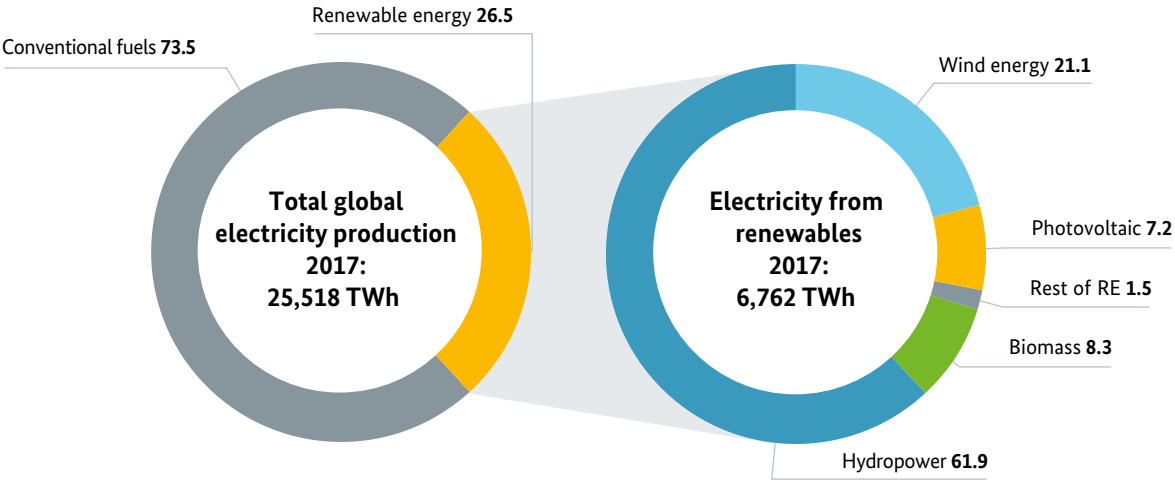
The remaining field of final energy provided from renewable energy is dominated by the generation of heat from biomass using modern combustion techniques, geothermal solar thermal, and hydropower. Power generation from sun, wind, biomass and geothermal energy only accounted for 1.7 % of global final energy consumption in 2016.

## Electricity generation from renewable energy sources

Renewable energy has also been able to make considerable headway globally, particularly with regard to its use for electricity generation. According to REN21 [39], the share of renewable energy in global electricity consumption increased to 26.5 % in 2017 (2016: 24.5 %). Hydropower still accounted for the largest share of power generation from renewable energy, at 16.4 %, slightly less than the previous year. The current growth in electricity generation from renewables is based on an increase in the shares of wind energy and photovoltaics, which climbed from 4.0 % to 5.3 % and from 1.5 % to 1.9 %, respectively.

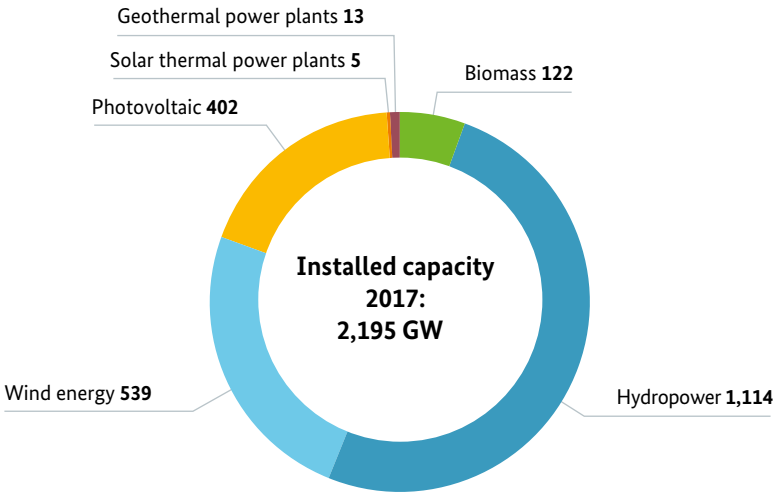
In 2017, a further 178 gigawatts of power generation capacity from renewables were added around the world, representing an increase of 17 gigawatts on the previous year. Of this amount, photovoltaics clearly led the way, accounting for 98 gigawatts, followed by wind energy (52 gigawatts). By the end of 2017, 402 gigawatts of PV capacity and 539 gigawatts of wind energy capacity were connected to the grid worldwide. With 1,114 gigawatts of capacity installed, however, hydropower continued to enjoy a clear lead and remained firmly in first position.

**Figure 58: Distribution of global electricity generation in 2017**
in percent




Source: REN21: Renewables 2018 Global Status Report; REN21 Secretariat, Paris, 2018 [39]

**Figure 59: Total installed power generation capacity based on renewables at the end of 2017**
Gigawatt (GW)




Source: REN21: Renewables 2018 Global Status Report; REN21 Secretariat, Paris, 2018 [39]

Excluding hydropower, the world's power generation capacity based on renewables therefore totalled 1,081 gigawatts at the end of 2017. China has further extended its lead, with a current total of 334 gigawatts, followed by the United States (161 gigawatts) and Germany (106 gigawatts). With 61 gigawatts, India moved up to fourth place, ahead of Japan (57 gigawatts) [39].

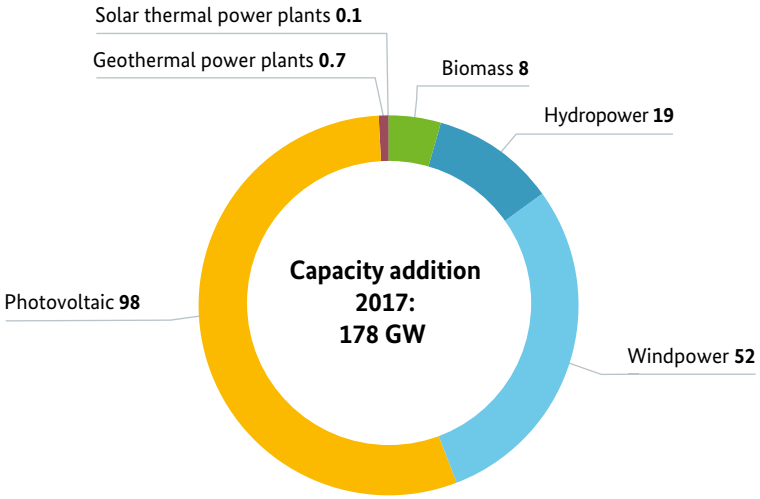
With 52 gigawatts, the rate of expansion in the use of **wind energy** in 2017 was only slightly behind that of the preceding year (54 gigawatts). Accounting for 19.7 gigawatts of this installed capacity, China retained its lead for new installations, despite the further contraction of the Chinese wind energy market. As in 2016, the United States occupied second place (7 gigawatts), followed by Germany with 6.1 gigawatts. India also remained on course for growth and secured fourth place with 4.1 gigawatts. The same ranking applies for total installed wind energy capacity, with China again clearly ahead of other countries with 189 gigawatts of installed wind energy capacity. The expansion of offshore wind set a new record in 2017 with 4.3 gigawatts of new capacity installed. As a result, installed offshore wind power capacity amounted to 18.8 gigawatts worldwide in 2017.

2017 was also a record year for **photovoltaics** with 98 gigawatts of capacity added worldwide, an increase of almost one third on the previous year. China accounted for over 50 % of global growth in this field, with 53 gigawatts. The United States was a distant second adding 10.6 gigawatts, followed closely by India (9.1 gigawatts). Thus, a total of 402 gigawatts of photovoltaics capacity was installed worldwide at the end of 2017, with over 130 gigawatts located in China alone.

In 2017, total installed power generation capacity from **biomass** increased by about 7 %, rising to 122 gigawatts worldwide. The majority of this capacity was added in the United States, followed by Brazil and China. Around 0.7 gigawatts of new power generation capacity from **geothermal** energy was added worldwide in 2017, with Indonesia again accounting for the largest share (275 megawatts), followed by Turkey (243 megawatts). Total power generation capacity based on geothermal energy amounted to 14.2 gigawatts, with the United States occupying first place, followed by the Philippines and Indonesia.

**Figure 60: Expansion of power generation capacity based on renewables, 2017**

Gigawatt (GW)




Discrepancies due to rounding.

Source: REN21: Renewables 2018 Global Status Report; REN21 Secretariat, Paris, 2018 [39]

## Renewable energy sources in heat and transport sector

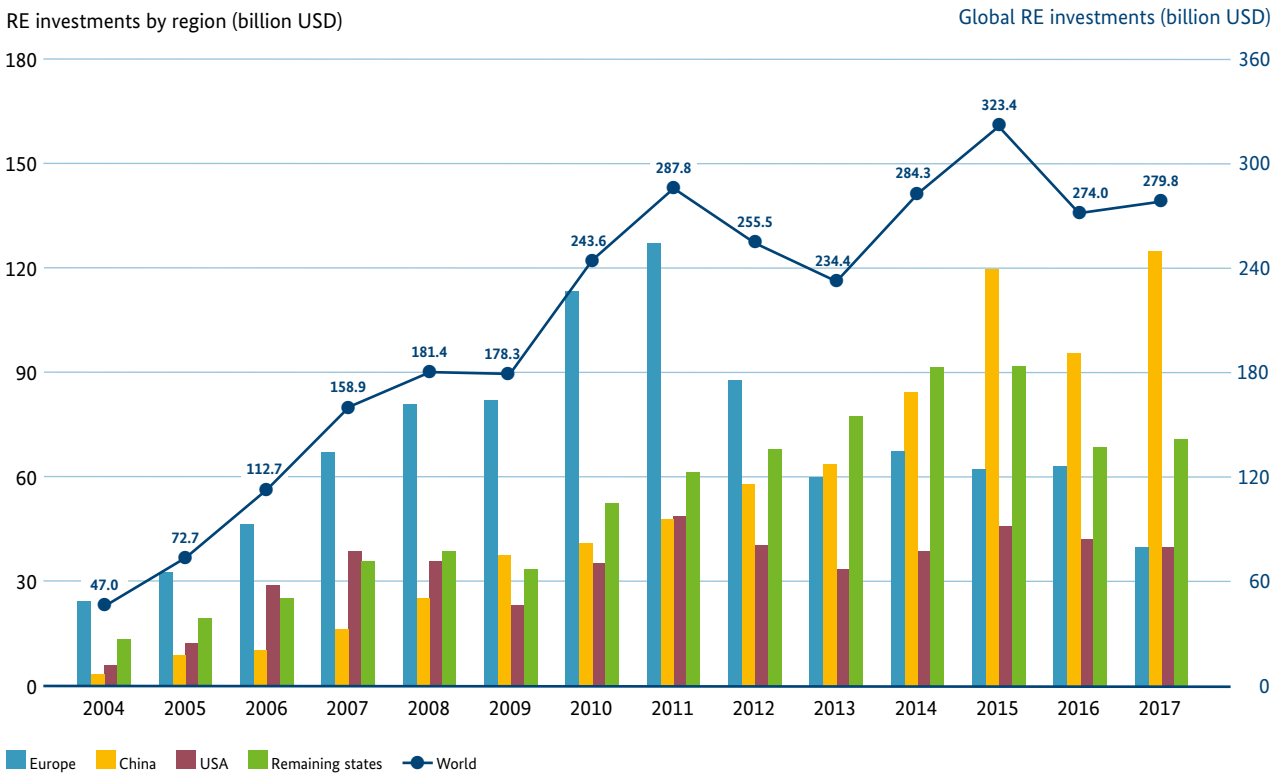
In 2017, 26.7 % of global final energy consumption for heating was covered by renewable energy. While the share provided by modern technologies has grown significantly to 10.3 %, most of this heating is still based on traditional biomass use and therefore cannot be considered sustainable [39].

Owing to a number of factors including the low price of oil, the slowdown in the expansion of solar thermal capacity continued in 2017 and, at 16 gigawatts (net), reached its lowest value ever in ten years. The solar thermal capacity of 472 gigawatts installed worldwide at the end of 2017 would be able to provide 388 billion kilowatt hours of solar-based heat annually. At over 71 %, the vast majority of the collector surface area was installed in China, with the United States a very distant second accounting for 4 %, followed by Turkey and Germany accounting for approximately 3 % each. Since 2000, final energy consumption in the transport sector has risen globally by 39 %. This sector now accounts for 32 % of total final energy consumption worldwide. Renewable energy covers 3.1 % of this consumption, mostly (2.8 %) in the form of biofuels. In 2017, global production of bioethanol increased by 2.5 % on the previous year while the production of biodiesel remained stable. The largest producer of biofuel was the United States, followed by Brazil [39].

## Investment in renewable energy sources and employment

A closer look at global investment in electricity generation capacities reveals that investments in renewable energy technologies have surpassed investments in fossil power capapicity since some years now. For example over 65 % of investments in the power sector in 2017 went to renewables. In terms of investment volume, following a significant decrease in 2016 global investment in renewable energy (excluding large-scale hydropower) saw modest growth again in 2017, increasing by 2 % to roughly USD 280 billion. This was driven by the record installation numbers, particularly in the photovoltaics sector [45].

**Figure 61: Investment in renewable energy sources by region**




Source: Frankfurt School-UNEP Centre/BNEF [45]

**Figure 62:**
**Investment in 2016 and 2017 disaggregated by renewable energy sector**

| Sector | RE-Investment billion USD | | Growth rate 2016/2017 |
|---|---|---|---|
| | 2016 | 2017 | % |
| Wind energy | 121.6 | 107.2 | -12 |
| Solar energy | 136.5 | 160.8 | 18 |
| Biofuels | 2.1 | 2.0 | -5 |
| Biomass[1] | 7.3 | 4.7 | -36 |
| Hydropower[2] | 3.9 | 3.4 | -13 |
| Geothermal power | 2.5 | 1.6 | -36 |
| Ocean energy power | 0.2 | 0.2 | 0 |
| **Total** | **274.0** | **279.8** | **2** |

1 Including waste
2 Only hydropower plants < 10 MW

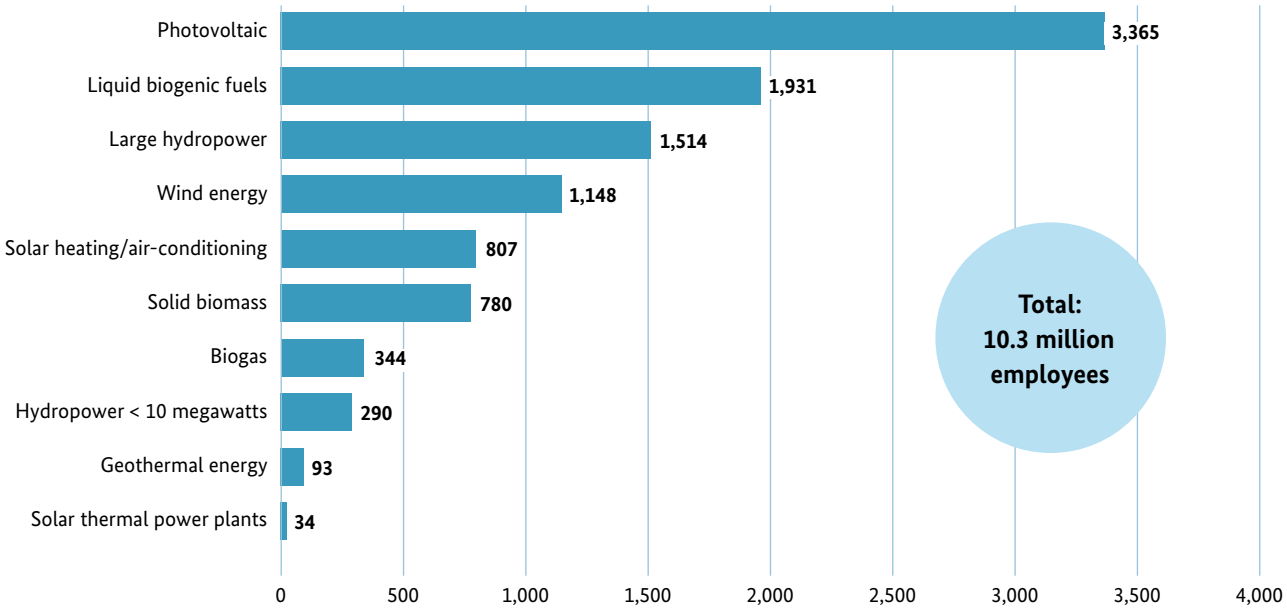
Source: Frankfurt School-UNEP Centre/BNEF [45]

Most of this investment – just under USD 127 billion – was concentrated in China, a development which is particularly driven by a current boom in photovoltaics in the country. By contrast, investment in Europe fell by 36 % to just under USD 41 billion. This is due in large part to the slowdown in investment in the United Kingdom. The most notable increases in investment in 2017 were concentrated in Mexico, Australia and Sweden.

Disaggregated by technology, most investment in 2017 was directed into photovoltaics, at USD 161 billion, which equates to an 18 % increase on the previous year. By contrast, investment in wind energy fell 12 % to USD 107 billion. Due to the lower technology costs, this decrease was more pronounced than the curve for new installed capacity. These two technologies combined accounted for some 95 % of total investment in renewable energy (excluding large-scale hydropower).

**Figure 63: Persons employed in the renewable energy sectors in 2017**

in 1,000 employees




Source: IRENA [46]

In global terms, the number of persons employed in the renewables sector increased by a further 5.3 % in 2017. According to an estimate by the International Renewable Energy Agency – IRENA [46], this sector gave employment to around 10.3 million in 2017, with around one-third (3.4 million) working in the photovoltaics sector, followed by around 2 million in the biofuel industry. Most of these jobs (43 %) were created in China. Disaggregated by RES sector, China had the highest percentage of jobs in the solar thermal sector (83 %), photovoltaics sector (66 %) and wind energy sector (44 %).

# Annex

## International networks for renewable energy sources

### 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 158 members, with another 24 states currently in the accession process. IRENA is headquartered in Abu Dhabi, United Arab Emirates. The IRENA Innovation and Technology Centre (IITC), one of its three core divisions, is based in Bonn. Director-General Adnan Z. Amin from Kenya has headed the IRENA Secretariat since 2011. IRENA currently employs over 100 people.

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

The current work programme (2018/2019) is divided into six thematic programme areas:

1. Centre of Excellence for Energy Transformation
2. Global Voice of Renewables
3. Network Hub
4. Source of Advice and Support
5. International Cooperation and Strategic Engagement
6. Efficient, Transparent and Innovative Management

An annual budget of around USD 22 million per year is available for these areas. Voluntary contributions are also made.

In recent years, IRENA has made a name for itself particularly with the analysis of progress towards the goal of the UN's "Sustainable Energy for All" initiative to double the share of renewable energy sources in the global energy mix 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. Building on this, in the context of Germany's G20 presidency in 2017 IRENA collaborated with the IEA to develop perspectives for 2050, which map out the global transition of the energy sector in line with the Paris climate goals and estimate the investment framework this requires. The modelling analysis conducted by IEA and IRENA comes to the conclusion that a global energy transition is technically feasible and can be achieved at reasonable cost.

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

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

### Main bodies and structure

IRENA is composed of three main governing bodies. The Assembly, 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.

For more information, please visit: www.irena.org

## The International Energy Agency (IEA)

The International Energy Agency (IEA) is one of the world's central energy organisations. An autonomous institution within the OECD, it acts as a voice for the energy-consuming industrialised countries, and currently consists of 30 OECD member countries. Given the strong growth in energy demand outside the OECD, the IEA is also expanding and deepening 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. Since then, Brazil, India, Morocco and Singapore have also activated Association status with the IEA.

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 agree 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 World Energy Outlook (WEO), a comprehensive international reference publication on energy policy with forecasts currently through 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 around the world.

The IEA issues numerous publications on renewable energy, most recently the Renewable Energy Market Report in 2017, with a forecast extending through to 2022. Investment in the global expansion of renewable energy also plays a central role in the joint IEA/IRENA "Perspectives for the energy transition – investment needs for a low-carbon energy system" study which the two organisations conducted on behalf of the German presidency of the G20 in 2017. The IEA and IRENA work closely together on the basis of a partnership agreement signed 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 was 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 working group has focused more sharply on the central role of the energy sector in the implementation of the Paris Climate Agreement and on the 2030 Agenda on Sustainable Development and has adopted a Climate and Energy Action Plan for Global Growth. The Action Plan can be accessed at: https://www.g20germany.de/Content/DE/_Anlagen/G7_G20/2017-g20-climate-and-energy-en_nn=2186596.html. Dialog on energy policy is continuing in the "Energy Transitions Working Group" in 2018 as part of Argentina's G20 presidency.

### 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: The more than 100 participating countries agreed that renewable energy would play a central role in an energy system of the future and committed to national or regional targets and actions. To maintain this momentum, the Renewable Energy Policy Network for the 21st Century (REN21) was then founded. REN21 publishes the Global Status Report each year, a publication which informs policy debate on renewable energy. After 2004, follow-up conferences took place in China, the United States, India, the United Arab Emirates and Mexico (see below); the next follow-up conference is scheduled for October 2019 in Korea.

### 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, which also opened the third session of the IRENA Assembly and hosted the annual World Future Energy Summit. The 6th International Renewable Energy Conference was held in Cape Town, South Africa, in early October 2015 (SAIREC). 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.

Mexico became the first Latin American country to host the event, with the 7th International Renewable Energy Conference (MEXIREC) held in Mexico City in September 2017 as part of "Energy Week". MEXIREC was attended by numerous ministers and high-level participants from the field of energy policy and the business community, with talks centering particularly on the framework conditions and factors that are key to the successful expansion of renewable energy in Central and South America.

### 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 founded on the initiative of Germany after the renewables2004 conference. The network has developed into the most important global multi-stakeholder network dedicated to promoting policy measures aimed at accelerating the expansion of renewable energy. It plays a key role in the provision of strategic and organisational support to the countries hosting International Renewable Energy Conferences (IRECs). REN21 comprises representatives from government, international organisations, civil society, the scientific community and private-sector stakeholders from the fields of energy, the environment and development.

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 was published in 2017.

In 2013, REN21 published the Global Futures Report for the first time. The second edition of the report followed in 2017. This publication contains an overview of possible directions and expectations for the future growth of renewable energy. Based on scenarios and interviews with experts, the report describes the expectations of various players for the future of renewables, key issues and important policy options. The report was published for the first time 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.

For more information, please visit: 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 aims at intensifying international exchange of experiences, challenges and opportunities associated with the global energy transition. The event is co-organised by the Federal Ministry for Economic Affairs and Energy and the Federal Foreign Office.

In 2018, the event was attended by more than 2,000 domestic and foreign decision-makers from the political sphere, from business, science and academia, civil society, and world-leading energy experts from almost 100 countries. This also included numerous foreign and energy ministers, as well as high-ranking delegations from all over the world. Against the backdrop of the Paris climate agreements, the aim of the conference was to continue international dialogue on a secure, environmentally compatible and affordable global energy transition. Parallel to the event, attendees were also offered an extensive side programme. The excursions, which were provided in cooperation with the German Energy Agency, enabled those attending to experience the German energy transition directly on location.

The 5th Berlin Energy Transition Dialogue is scheduled for 9/10 April 2019. For more information, please visit: www.energiewende2018.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 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 a variety of working groups in which Member States usually focus on specific individual technologies. There are also short-term ‘campaigns’ which often include players from the private sector and civil society. This cooperation builds on 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 Federal Ministry for Economic Affairs and Energy) co-leads the multilateral working group on solar and wind energy, which is currently working on long-term scenarios for the energy transition and to increase the flexibility of electricity systems. Germany is also involved in the initia-

tives focussing on energy-efficient electrical appliances, energy management systems in industry, electric mobility, investment in the energy transition, and smart grids. The various ministers involved meet on an annual basis to decide on new areas of work under the initiatives. The latest meeting was held on 24 May 2018 in Copenhagen, Denmark and was co-hosted by Denmark, Sweden, Finland, Norway and the European Commission.

For more information, visit
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 through to 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.

For more information, please visit: 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.

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

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 final energy consumption on this basis.

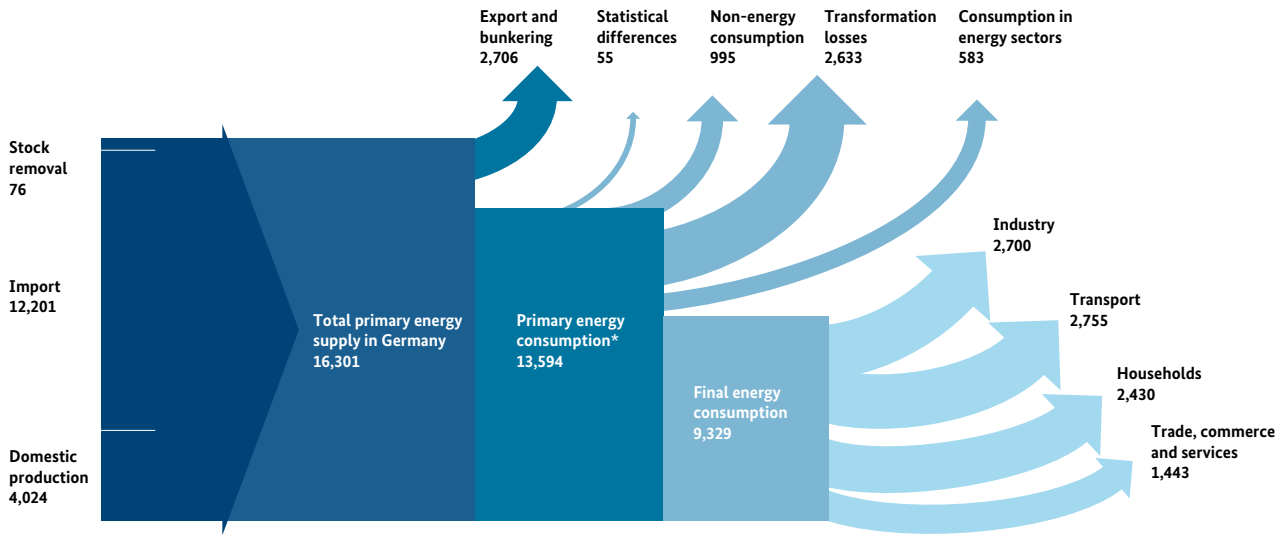
### Changes in methodology

#### Changes in the methodology applied for electricity and heat

The AGEE-Stat has held a series of expert discussions over the past 12 months. This sharing of knowledge with experts in a variety of fields has given AGEE-Stat new insight into ways to improve the data for the production of electricity and heat from renewable energy sources. The resulting methodological changes aim to ensure that renewable energy statistics can be updated over the long term, while also providing a uniform and consistent data base to meet national and international reporting obligations. An overview of the methodological changes that have been implemented is provided below:

**Figure 64: Schematic diagram of energy flows in Germany in 2017**

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 13.6%.
* All figures preliminary/estimated
29.3 Petajoule (PJ) ≙ 1 million tonnes of coal equivalent

Source: Arbeitsgemeinschaft Energiebilanzen 07/2018

## Electricity generated and consumed onsite in the case of wind energy installations

In line with the approach taken for offshore wind energy installations, with effect from February 2018 electricity generated and consumed onsite by onshore wind energy installations is also taken into consideration in the time series from 1990 onwards. Based on the information currently available, in the case of onshore wind energy installations this share is estimated at 2 % relative to the volume of electricity fed into the grid with entitlement to remuneration under the RES Act, and at 1.5 % in the case of offshore wind energy installations.

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

The time series for the final energy consumption of solid biomass used for the generation of heat in private households has been switched, as of 2005, to the data determined by the Thünen Institute for International Forestry and Forest Economics as part of its project to recalculate fellings [54]. The representative surveys on the use of wood for energy purposes in private households, conducted regularly as part of the wood monitoring project (Rohstoff-Monitoring Holz [55]), provide the empirical basis [56]. An AGEE-Stat conversion approach approved by experts was applied at the “wood type”-level to convert the mass balance data to energy units.

## Fuel input of liquid biomass to generate electricity and heat

The previous model to estimate the fuel input of liquid biomass for CHP-based electricity and heat generation with entitlement to remuneration under the RES Act has been replaced, from 2013 onwards, by new data available from the Federal Ministry of Food and Agriculture (BLE) in line with the Biomass Energy Sustainability Ordinance [21].

## Fuel input of biomethane to generate electricity and heat in CHPs and for non-cogeneration heat production from biomethane

As insufficient data had been available so far on the biomethane used outside the scope of the RES Act in private households and in the commerce, trade and services sector for the purpose of heat generation, this biomethane was not included in the balance up to now. This data gap has now been closed thanks to an expert report by the German Energy Agency (dena) [64], which analysed the dena biogas register, inter alia. In addition, the model to determine the consumption of biomethane for electricity and heat production with entitlement to remuneration under the RES Act has also been refined further.

### Separate reporting of electricity generation and heat production from biogas and biomethane

The dena expert report mentioned above provided a long-desired separate account of the biomethane used in the electricity sector and that used in heating sector.

### Fuel input of landfill gas for CHP heat generation

The model used up to now to estimate the fuel input of landfill gas for CHP-based heat generation has been replaced by official data on landfill gas use from waste statistics supplied by the Federal Statistical Office [57].

### Final energy consumption of solar thermal for heat generation

In future, calculations of the final energy consumption of solar thermal for heat generation will be based on a "mortality curve" for flat-plate and evacuated tube collectors. The average service life will continue to be estimated at 20 years. The progression of the mortality curve over a period of 10 years is based on an expert knowledge after consulting researchers and business reresentatives, and represents a more realistic life expectancy for solar thermal installations than the fixed-lifetime approach used until now. Furthermore, new findings regarding the new installation and dismantling of absorber systems for swimming pools are considered in the time series from 2003 onwards. This information is based on a short expert report compiled by the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW).

### Final energy consumption of ambient heat for heating and cooling

The time series for final energy consumption of ambient heat is based on the second update to the "Analysis of the German Heat Pump Market – Current Situation and Trends" study by the Bochum Geothermal Centre (GZB) [10]. On the basis of new data, the time series was recalculated from 1990 onwards. In the latest study, sales figures have been updated, underlying seasonal performance factors and full hours of use have been recalculated and a transparent life cycle curve has been applied to the installed base.

### 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 capacity expansion.

Bioliquids and biofuels must fulfil specific sustainability criteria to be able to count towards the overall target and the target in the transport sector.

In the transport sector, a factor of 2.5 is applied to the contribution made by electricity that is generated from renewable energy sources and used in electric rail transport, while a factor of 5 applies to the contribution made by electricity that is generated from renewable energy sources and used in road vehicles with an electric drive. Furthermore, biofuels made from feedstock as defined in Annex IX of Directive 2009/28/EC (particularly used cooking oil) are double-counted towards the decarbonisation goal.

Gross final consumption of energy is defined as follows in Article 2 (f) of Directive 2009/28/EC:

"'Gross final consumption of energy' means the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission."

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

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

The Federal Government's Energy Concept 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.

### 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. In the case of installations whose construction takes place over a period of several years, investments are assigned to the appropriate period. This particularly concerns offshore wind installations, installations that use deep geothermal energy, large hydropower plants, and large biomass CHP plants and biogas plants. This approach prevents the incorrect assignment of investment, i.e. investment is not solely assigned to the year the plant was completed or went into operation.

The economic stimuli arising from plant operation include not only the costs of operation and maintenance, especially personnel costs 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 (including the research reports on the Renewable Energy Sources Act Progress Report, for example [47] and the final report on the monitoring of power generation from biomass [48]), the evaluations of the Market Incentive Programme [49], and the evaluations of KfW funding for renewable energy sources [50].

The calculation of the costs arising from supplying fuel for heat and power generation also includes the costs of solid and liquid fuels and of the substrates used to produce biogas. The relevant solid biomass fuels include waste wood, residual wood from forestry and industry, wood pellets, wood chips, wood briquettes, and commercially traded firewood. The main components of substrates for biogas production are maize silage, grass silage, whole-crop silage and inferior grain. In total, the economic stimulus from the supply of biogenic fuels for heat and power is estimated at €4.7 billion.

# Conversion factors

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

| 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 millionen 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 |
| $SF_6$ | Sulphor hexafluoride |
| H-FKW | Hydrofluorocarbons |
| FKW | Perfluorocarbons |

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

# List of abbreviations

| | |
|---|---|
| AusglMechV | Ordinance on the equalisation mechanism (Ausgleichsmechanismus-Verordnung) |
| 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 |
| 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 |
| iLUC | Indirect land use change |
| KWKG | Combined Heat and Power Act (Kraft-Wärme-Kopplungsgesetz) |
| MAP | Market Incentive Programme (Marktanreizprogramm) |
| N/A | Not available |
| NQ | Not quantified |
| NREAP | National Renewable Energy Action Plan |
| PEC | Primary energy consumption |
| PP | Power plant |
| PV | Photovoltaic |
| R&D | Research and development |
| RE/RES | 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 |

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

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