Federal Ministry
for Economic Affairs
and Energy

Energie wende
Switch to the Future

# Renewable energy sources in figures

*National and International Development, 2020*

bmwi.de

**Imprint**

**Publisher**
Federal Ministry for Economic Affairs and Energy
Public Relations
11019 Berlin
www.bmwi.de

**Expert support**
Centre for Solar Energy and Hydrogen Research
Baden-Württemberg (ZSW), Stuttgart,
German Environment Agency (UBA), Department V 1.5,
Dessau-Roßlau

**Current as at**
October 2021

This publication is available for download only.

**Design**
PRpetuum GmbH, D-80801 Munich

**Image credit**
Adobe Stock / Günter Albers / title

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# Table of contents

# List of figures

# Introduction

Dear reader,

With the new 2021 edition of the publication "Renewable Energy Sources in Figures – National and International Development", the Federal Ministry for Economic Affairs and Energy once again presents you with the latest data on the use of renewable energy in Germany, the EU and the world.

The detailed data on the development of renewable energy in Germany in 2020 contained in this publication are an important basis for monitoring the Federal Government's goals for the energy transition. These data lay a foundation for future decisions on framework conditions and measures for further expansion of renewable energy.

The year 2020 was strongly influenced by the Covid 19 pandemic. The resulting drop in energy consumption has impacted the areas of electricity, heat and transport. In summary, the following picture emerges:

**Electricity**

Electricity generation from renewable energy rose by almost 4% in 2020 to 250 Terawatt-hours. The renewables-based share of gross electricity consumption increased significantly from 41.8 to 45.3% due to the pandemic induced overall decrease in electricity consumption.

**Heat**

The use of heat from renewable energy sources in 2020 remained level to the previous year. As total heating consumption fell due to the weather and the pandemic, the share of renewable energy sources rose from 15.1 to 15.6%.

**Fuel**

The increase in the greenhouse gas reduction quota led to a significant rise in sales of biodiesel, while at the same time overall fuel consumption fell due to the pandemic. As a result, the share of renewable energy sources in transport climbed from 5.6 to 7.5%.

The use of renewable energy is associated with positive ecological and economic effects:

**Renewable energy use cuts greenhouse gases**

Increasing shares of renewable energy led to fewer greenhouse gas emissions resulting from the combustion of fossil fuels. In 2020, a total of around 230 million metric tons of $CO_2$-equivalent greenhouse gas emissions were thereby avoided.

**Investment and economic stimulus**

Renewable energy sources continue to represent an important economic factor for Germany. In 2020, €11 billion were invested in renewable energy plants. The economic impetus from the operation of the installations rose to €18.3 billion.

The most important data for this publication are the results of the Working Group on Renewable Energy Statistics (AGEE-Stat), which compiles the balance of renewable energy sources for Germany on behalf of the BMWi. Furthermore, data from the German Environment Agency, the Federal Statistical Office, the Federal Network Agency, the Working Group on Energy Balances, and many other sources are included.

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

Alongside information about developments in Germany, also presented here are extensive data on the use of renewable energy in the European Union. The EU has set ambitious renewable energy targets, thus providing an overall framework for their expansion. Finally, the status of the global use of renewable energy is covered.

All the data represent snapshots from the editorial deadline of September 2021 – they are therefore provisional in some places. Parallel to this brochure, the BMWi regularly publishes on its website updated time series and a wide range of charts and complete data sets on the development of renewable energy sources in Germany from 1990 onwards. The data in this brochure are primarily in abridged form for the sake of clarity, see: www.erneuerbare-energien.de/EE/ee-in-zahlen-zeitreihen (in German only) and www.erneuerbare-energien.de.

A wide range of additional information on renewable energy and the energy transition in Germany can be found on the BMWi sites www.bmwi.de and www.erneuerbare-energien.de (in German only).

Your Federal Ministry for Economic Affairs and Energy,

Berlin, October 2021

# Working Group on Renewable Energy Statistics

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

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

The following institutions are currently AGEE-Stat members:

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

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

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

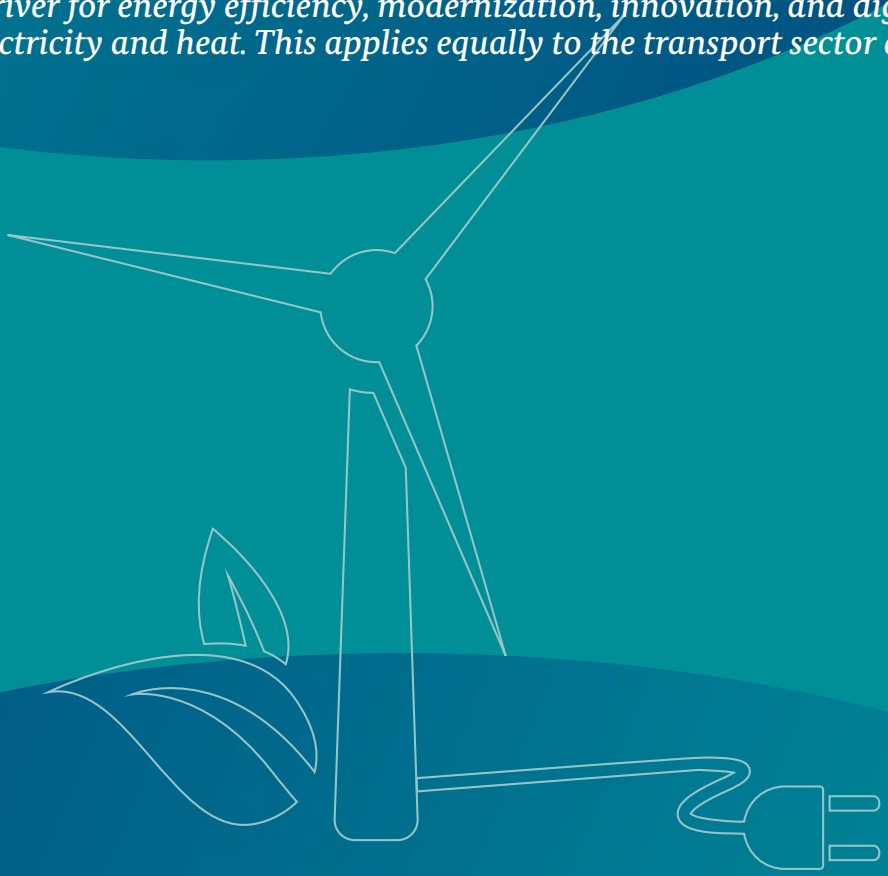
- creating a basis for meeting the Federal Government's various national, EU and international reporting obligations on renewable energy and
- providing the public with information on renewable energy data and development.

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

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

# Part I: The energy transition in Germany

*The energy transition is of central importance for Germany's path to a secure, environmentally compatible, and economically successful future. That is why we are fundamentally transforming the energy supply from nuclear and fossil fuels to renewable energy sources and more energy efficiency. We have already achieved a great deal along this path – in 2020, more than 45% of our electricity consumption came from wind, solar, biomass and hydropower. Renewable energy sources have thus become Germany's most important source of electricity. However, the Government has also set itself for the goal of making the energy transition the driver for energy efficiency, modernization, innovation, and digitization in the supply of electricity and heat. This applies equally to the transport sector and agriculture.*



Over the past two decades, the share of renewable energy sources in electricity consumption has grown steadily: from around 6% in 2000 to over 45% in 2020. The expansion target of 35% in 2020 set out in the 2010 energy concept was achieved three years in advance. The target corridor of the Renewable Energy Sources Act (EEG) of 2017, which envisaged a renewable share of 40-45% by 2025, was also exceeded last year.

However, the Government is still aiming for a further significant increase in the share of renewables in the power sector. Before 2045, all electricity generated and consumed in Germany is to be climate neutral. To achieve this, a further determined, efficient, grid-synchronized, and increasingly market-oriented expansion of renewable energy sources is necessary. This is the only way to reliably replace coal-fired power and meet additional power demand from renewables so that climate protection targets can be achieved in transport, buildings and industry.

## Further development of the successful Renewable Energy Sources Act

The foundation for the successful expansion of the use of renewable energy is the Renewable Energy Sources Act, which came into force in 2000 and has since been revised several times. The Act originally aimed to facilitate market access for what were then still young electricity generating technologies from sun, wind, biomass, and geothermal energy to enter the market by guaranteeing their purchase at fixed rates. Over the past twenty years, the EEG has brought these technologies out of their niche existence and allowed them to grow into a mainstay of Germany's electricity supply.

And the successful work has included not only the expansion of renewable energy, but also its market integration through the EEG. For example, since the 2014 revision of the EEG, the remuneration rates for renewable electricity have no longer been set by the government, as was previously the case, but have been subject to auctions on the market. The only exception was made for small plants with a capacity of up to 750 kW, so that stakeholder diversity is maintained, particularly in photovoltaics. In addition to bringing renewable energy closer to the market, the auctions under the EEG serve to control the volume of new installations.

The last comprehensive amendment took place with the EEG 2021, which came into force on January 1, 2021. With it, the long-term goal of reaching greenhouse gas neutrality in the electricity sector before the year 2050 was anchored. At the same time, an ambitious trajectory for a 65% share of renewables-based gross electricity consumption by 2030 was established. Furthermore, for the first time, connection regulations were made for plants no longer supported under the EEG. In order to adapt the EEG in 2021 to stricter climate protection law, as well as to developments at the EU level (measures still to be adopted to implement the Green Deal, Fit for 55 package), the expansion target and paths must be increased accordingly.

The growing shares of renewable energy sources mean new challenges for the grid because electricity must sometimes be transported over long distances from power generators in the north to consumers in the south. This requires good coordination of the further expansion of renewable energy with the expansion of the power grid. For this reason, the EEG 2021 also introduced a "southern quota" for wind energy and biomass plants. Better integration with the electricity system also results from stronger incentives for new plant technologies and improved controllability. In addition, the Federal Requirements Plan Act defines those grid expansion projects for which there is an urgent need regarding the energy transition.

## Impetus for photovoltaic and offshore wind

To further support the recent positive development of the expansion figures for photovoltaics, the so-called 52 GW cap, which was intended to limit the promotion of photovoltaics under the EEG, was removed in the summer of 2020. With the amendment of the Offshore Wind Energy Act (WindSeeG), the framework conditions for the further development of offshore wind energy were also adjusted at the end of 2020. In essence, the expansion target for this important pillar of the energy transition was increased from 15 to 20 GW by 2030 and a long-term target of 40 GW by 2040 was set for the first time.

## Reorganization in the heating sector

While great successes have already been achieved in the expansion of renewable energy sources in the electricity sector, efforts in the heating sector as well as in transport must be further intensified in the future. To better align the requirements for building energy efficiency and the use of renewable energy for heat generation, the Building Energy Act (GEG) came into force on November 1, 2020, bringing together the Energy Conservation Act (EnEG), the Energy Conservation Ordinance (EnEV) and the Renewable Energy Sources Heat Act (EEWärmeG). This will facilitate the application and enforcement of the statutory regulations. The GEG implements the European requirements on the energy performance of buildings and integrates the regulation of requirements for ultra-low-energy buildings into a unified energy-saving legislation. In addition, the Market Incentive Program (MAP), which was until then the central support program for renewable energy sources in the heating sector, has been replaced by the Federal Support for Efficient Buildings (BEG) at the beginning of 2021. The obligation under the EEWärmeG to partially heat newly constructed buildings with renewable energy has also been retained in the BEG. At 15.6%, the milestone target originally set in the EEWärmeG for covering 14% of Germany's heating requirements with renewable energy by 2020 has been exceeded.

By contrast, the use of renewable energy sources in the transport sector has to date fallen short of the targets. According to the EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources, a 10% share of renewable energy in final energy consumption in the transport sector, calculated according to special rules (in particular, multiple counting of the use of electricity from renewable energy sources for electromobility), was to have been reached by 2020. At the time this brochure was published, there was still no reliable information as to whether Germany was able to achieve the target value. To further strengthen the share of renewable energies in transport, the Government has once more stepped up its efforts – inter alia, also by means an electromobility strategy, as electric vehicles are an important component of the energy transition for transport. For a limited period until the end of 2021, the environmental bonus incentive to buy electric cars will be increased by an innovation premium to a total of €9,000. This measure has given the German market for electric cars an additional boost and led to a sharp rise in registrations. The transport sector is also an important part of the National Hydrogen Strategy (NWS) with which the Government has created a coherent action framework for future production, transport, use and increased use of hydrogen, including corresponding innovations and investments.

## Federal Climate Change Act strengthened

On June 24, 2021, the German Bundestag passed an amendment to the Federal Climate Change Act (entry into force on 18 December 2019) to both implement the requirements of the Federal Constitutional Court and become the first member state to transpose the increased EU climate target for 2030. With the amendment (entry into force on 31 August 2021), greenhouse gas emissions are now to be reduced by 65% of 1990 levels by 2030, instead of 55%. In addition, Germany should reach climate neutrality five years earlier, by 2045. The Government is thus placing climate protection on a new, ambitious footing and is also sending a clear signal to our European partners to achieve the EU's climate protection targets.

With its draft of the 2022 Federal Budget from 23 June 2021, the Federal Cabinet approved the Immediate Action Program 2022, which provides for an additional €8 billion in investments to support the tighter targets of the Federal Climate Change Act. The measures to achieve the (old) targets formulated in the Climate Change Act are contained in the Climate Protection Programme 2030 and the Future Package of the Economic Stimulus Programme 2020. A key measure here is the phase-out of coal-fired power generation by 2038 at the latest. In the transport sector, a higher aviation tax has been in force since 2020, while at the same time rail travel has become cheaper thanks to a reduction in the VAT rate from 19 to 7%. A $CO_2$ price was also introduced on 01 January 2021, so that gasoline and diesel, as well as heating oil and natural gas, will gradually become more expensive. The additional revenue from the $CO_2$ pricing will benefit further support measures of the climate protection programme or be returned to citizens in the form

of relief. For example, parts of the revenue will be used to reduce the EEG surcharge in order to ease the burden on electricity prices. This also provides incentives for increasing electrification and drives forward sector coupling. Low-income households and long-distance commuters will also benefit from higher rates of housing benefit and commuter allowances, respectively. In this way, climate protection is implemented in a socially responsible manner as a task for society as a whole.

## Monitoring the energy transition

The Government's "Energy of the Future" monitoring process continuously accompanies the development of the energy transition. It tracks where we stand in the energy transition, which measures have been implemented, and what effects they are having. The task of the monitoring process is to condense the large amount of available energy statistics and to present them in a comprehensible way. Measures that have already been implemented are examined, as is the question of where further efforts will be required in the future.

The regular monitoring report is the core of the monitoring process. It condenses the large amount of available energy statistics into a manageable number of selected key figures (indicators) and thus makes them comprehensible. The data provide a fact-based overview of the progress made in implementing the energy transition. As retrospective documentation, the report focuses on the respective reporting period. In this way, it also serves to fulfill the reporting obligations of the Government in accordance with the requirements of the Energy Industry Act and the Renewable Energy Sources Act.

In principle, every three years the Government presents a more detailed progress report on the energy transition into which the respective monitoring report is integrated; most recently the 2nd progress report (also the 7th monitoring report). The progress reports contain in-depth analyses over a longer period and provide an outlook on the foreseeable further development of important indicators. In addition, they propose measures, if necessary, that can be used to remove obstacles to the achievement of the goals.

The BMWi is responsible for monitoring the energy transition. The regular reports are approved by the federal cabinet and forwarded to the Bundestag and the Bundesrat. An independent commission of four renowned energy experts accompanies the process and comments on the respective monitoring and progress reports on a scientific basis. Most recently, the Government's 8th monitoring report was published together with the expert commission's statement on 03 February 2021. It documents the status of the implementation of the energy transition in 2018 and 2019 and assesses progress in achieving the 2020 targets.

### Figure 1: Renewable energy targets of the Federal Government and the status quo

| | 2020 Status Quo | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| | share of renewable energy [%] | | | | |
| Share of gross final energy consumption | 19.6 | 18 | 30 | 45 | 60 |
| Share of gross electricity consumption | 45.3 | min. 35 | 65* | | ** |
| Share of gross final energy consumption in heating / cooling | 15.6 | 14 | | | |

* The prerequisite for this is a further determined, efficient, grid-synchronized and increasingly market-oriented expansion of renewable energy sources in the coming years. The further expansion of the electricity grids is central to this.

** The EEG 2021 stipulates that before the year 2050, all electricity generated or consumed in Germany must be generated in a greenhouse gas-neutral manner. In order to adapt the EEG 2021 to the climate protection law, which will be tightened up thereafter, and to developments at EU level (measures still to be adopted to implement Green Deal, Fit for 55 package), the expansion target and paths must be increased accordingly.

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

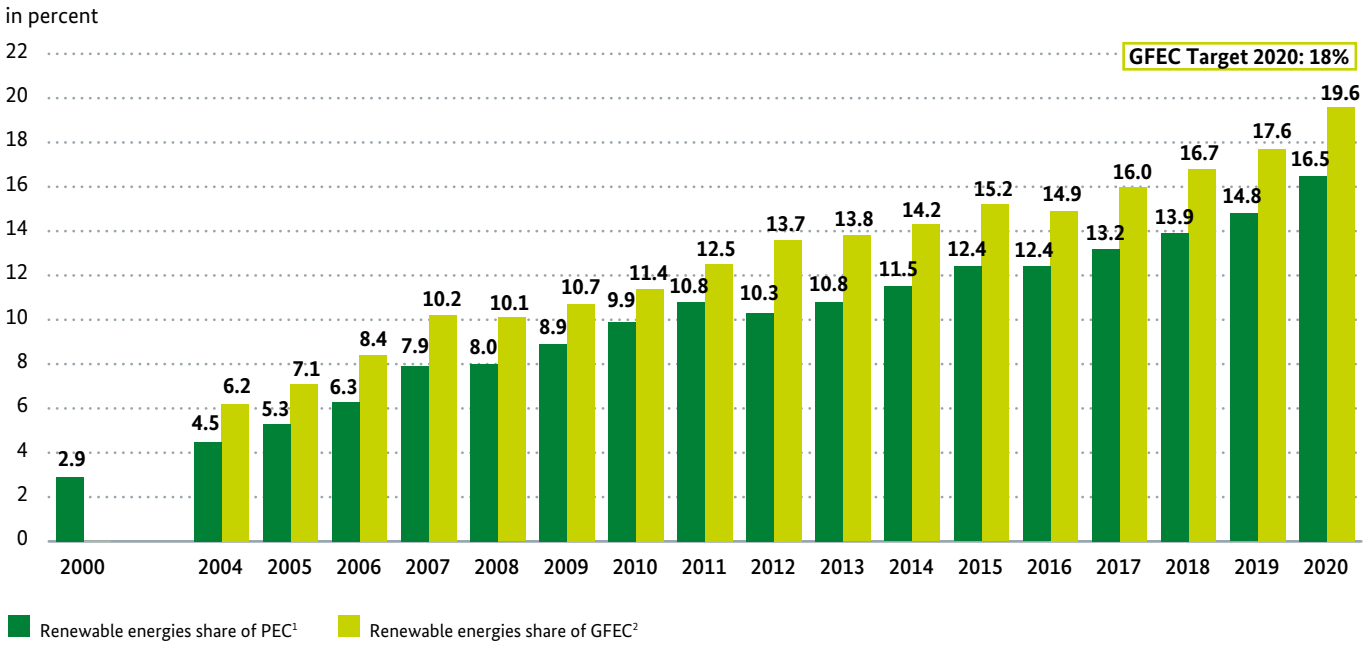
The figures contained in this brochure are the essential data basis for monitoring progress in the expansion of renewable energy sources. They also serve the monitoring process described above as well as numerous other reporting obligations of the Federal Republic at national, European and international levels.

## Figure 2: Renewable energy in Germany: Status quo

| Categories | 2019 | 2020 |
|---|---|---|
| **Renewable energy share [%]** | | |
| of gross final energy consumption | 17.6 | 19.6 |
| of gross electricity consumption | 41.8 | 45.3 |
| of final energy consumption in heating /cooling | 15.1 | 15.6 |
| of final energy consumption in transport | 5.6 | 7.5 |
| of primary energy consumption | 14.8 | 16.5 |
| **Avoidance of greenhouse gas emissions through the use of renewable energy sources** | | |
| Total greenhouse gas avoidance | 221.0 million t $CO_2$-eq. | 230.4 million t $CO_2$-eq. |
| of which through electricity with remuneration under the RES Act | 150.5 million t $CO_2$-eq. | 156.9 million t $CO_2$-eq. |
| **Economic impetus through the use of renewable energy sources** | | |
| Investment in the construction of renewable energy plants | 10.5 billion € | 11.0 billion € |
| Costs/Revenues from the operation of renewable energy plants | 17.3 billion € | 18.3 billion € |

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

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




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

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

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

# Expansion of renewable energy

## Electricity

### Share of renewable energy rises to 45.3%

At 250.2 terawatt-hours, almost 4% more electricity was generated from renewable energy sources in 2020 than in the previous year (240.3 terawatt-hours). This increase was driven in roughly equal parts by wind energy and photovoltaics. For the first time, solar, wind, biomass et alia were able to provide more electricity than all fossil fuels (coal, gas and oil) combined (2020: 231.0 terawatt-hours). Due to the pandemic, total electricity consumption fell by just under 4% to 552.2 terawatt-hours (2019: 574.6 terawatt-hours), enabling the share of renewable energy sources in gross electricity consumption to leap by over 3 percentage points to a new record level of 45.3% (2019: 41.8%).

### Onshore wind energy expansion recovers slightly

After reaching its lowest point in 20 years, the net addition of wind power capacity (859 megawatts in 2019) recovered slightly in 2020. However, at 1,227 megawatts, it remained at a comparatively low level, and far from the expansion targets. At the end of 2020, onshore wind power connected to the grid totaled 54,417 megawatts. Good wind conditions ensured that electricity generation from onshore wind power increased slightly compared with the previous year, reaching 104.8 terawatt-hours (2019: 101.2 terawatt-hours).

At sea (offshore), only individual wind farms were completed in 2020 and therefore comparatively little new wind power capacity was connected to the grid at 219 megawatts (2019: 1,111 megawatts). At the end of the year, offshore capacity totaling 7,747 megawatts was thus connected to the grid. The significantly stronger expansion of the previous year made itself felt in electricity generation so that at

### Figure 4: Renewables-based gross electricity generation in 2019 and 2020

| | Renewable energy sources 2019 | | Renewable energy sources 2020 | |
|---|---|---|---|---|
| | Gross electricity generation (GWh)[4] | Share of gross electricity consumption[5] (%) | Gross electricity generation (GWh)[4] | Share of gross electricity consumption[5] (%) |
| Hydropower[1] | 19,731 | 3.4 | 18,322 | 3.3 |
| Onshore wind energy | 101,150 | 17.6 | 104,796 | 19.0 |
| Offshore wind energy | 24,744 | 4.3 | 27,306 | 4.9 |
| Photovoltaic | 44,383 | 7.7 | 48,641 | 8.8 |
| Biogenic solid fuels[2] | 11,038 | 1.9 | 11,228 | 2.0 |
| Biogenic liquid fuels | 330 | 0.1 | 308 | 0.1 |
| Biogas | 28,225 | 4.9 | 28,757 | 5.2 |
| Biomethane | 2,859 | 0.5 | 2,914 | 0.5 |
| Sewage gas | 1,581 | 0.3 | 1,578 | 0.3 |
| Landfill gas | 287 | 0.05 | 247 | 0.04 |
| Biogenic fraction of waste[3] | 5,806 | 1.0 | 5,829 | 1.1 |
| Geothermal energy | 197 | 0.03 | 231 | 0.04 |
| **Total** | **240,331** | **41.8** | **250,157** | **45.3** |

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

2 Including sewage sludge

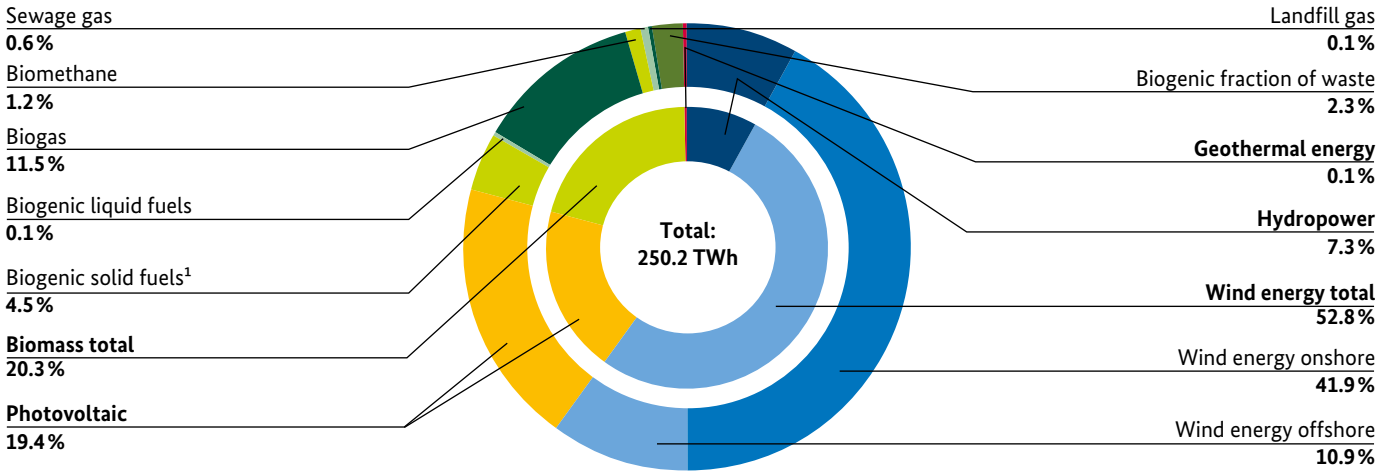
3 Biogenic share of waste estimated at 50% in waste incineration plants

4 1,000 GWh = 1 TWh

5 Based on gross electricity consumption, 2020: 552.2 TWh; 2019: 574.6 TWh, there from fossil based gross electricity production according to AGEB [1]

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

## Figure 5: Renewables-based gross electricity generation in 2020




1 Including sewage sludge

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

## Figure 6: Electricity generation from renewable energy sources

| | Hydropower[1] | Onshore wind energy | Offshore wind energy | Biomass[2] | Photovoltaics | Geoth. 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 | 61 | 0 | **36,227** | **6.3** |
| **2005** | 19,638 | 27,774 | 0 | 14,706 | 1,308 | 0 | **63,426** | **10.3** |
| **2006** | 20,031 | 31,324 | 0 | 18,934 | 2,265 | 0 | **72,554** | **11.7** |
| **2007** | 21,170 | 40,507 | 0 | 24,616 | 3,137 | 0 | **89,430** | **14.3** |
| **2008** | 20,443 | 41,385 | 0 | 28,014 | 4,508 | 18 | **94,368** | **15.2** |
| **2009** | 19,031 | 39,382 | 38 | 30,886 | 6,715 | 19 | **96,071** | **16.5** |
| **2010** | 20,953 | 38,371 | 176 | 33,924 | 11,963 | 28 | **105,415** | **17.1** |
| **2011** | 17,671 | 49,280 | 577 | 36,891 | 19,991 | 19 | **124,429** | **20.4** |
| **2012** | 21,755 | 50,948 | 732 | 43,203 | 26,744 | 25 | **143,407** | **23.6** |
| **2013** | 22,998 | 51,819 | 918 | 45,513 | 30,621 | 80 | **151,949** | **25.1** |
| **2014** | 19,587 | 57,026 | 1,471 | 48,287 | 34,558 | 98 | **161,027** | **27.2** |
| **2015** | 18,977 | 72,340 | 8,284 | 50,326 | 37,171 | 133 | **187,231** | **31.3** |
| **2016** | 20,546 | 67,650 | 12,274 | 50,928 | 36,670 | 175 | **188,243** | **31.5** |
| **2017** | 20,150 | 88,018 | 17,675 | 50,917 | 37,893 | 163 | **214,816** | **35.9** |
| **2018** | 17,693 | 90,484 | 19,467 | 50,794 | 43,459 | 178 | **222,075** | **37.5** |
| **2019** | 19,731 | 101,150 | 24,744 | 50,126 | 44,383 | 197 | **240,331** | **41.8** |
| **2020** | 18,322 | 104,796 | 27,306 | 50,861 | 48,641 | 231 | **250,157** | **45.3** |

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 1,000 GWh = 1 TWh

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

27.3 terawatt-hours, an increase of around 10% was recorded compared to 2019 (24.7 terawatt-hours).

## Wind energy further expands position as most important source of electricity

All onshore and offshore wind turbines combined generated around 132.1 terawatt-hours of electricity in 2020, almost 5% more than in the previous year (2019: 125.9 terawatt-hours). Wind energy thus set a record again, accounting for 23.9% of gross electricity consumption. It was also able to further expand its position as the most important source of electricity in the German mix ahead of lignite.

## Installation figures for photovoltaics continue to rise

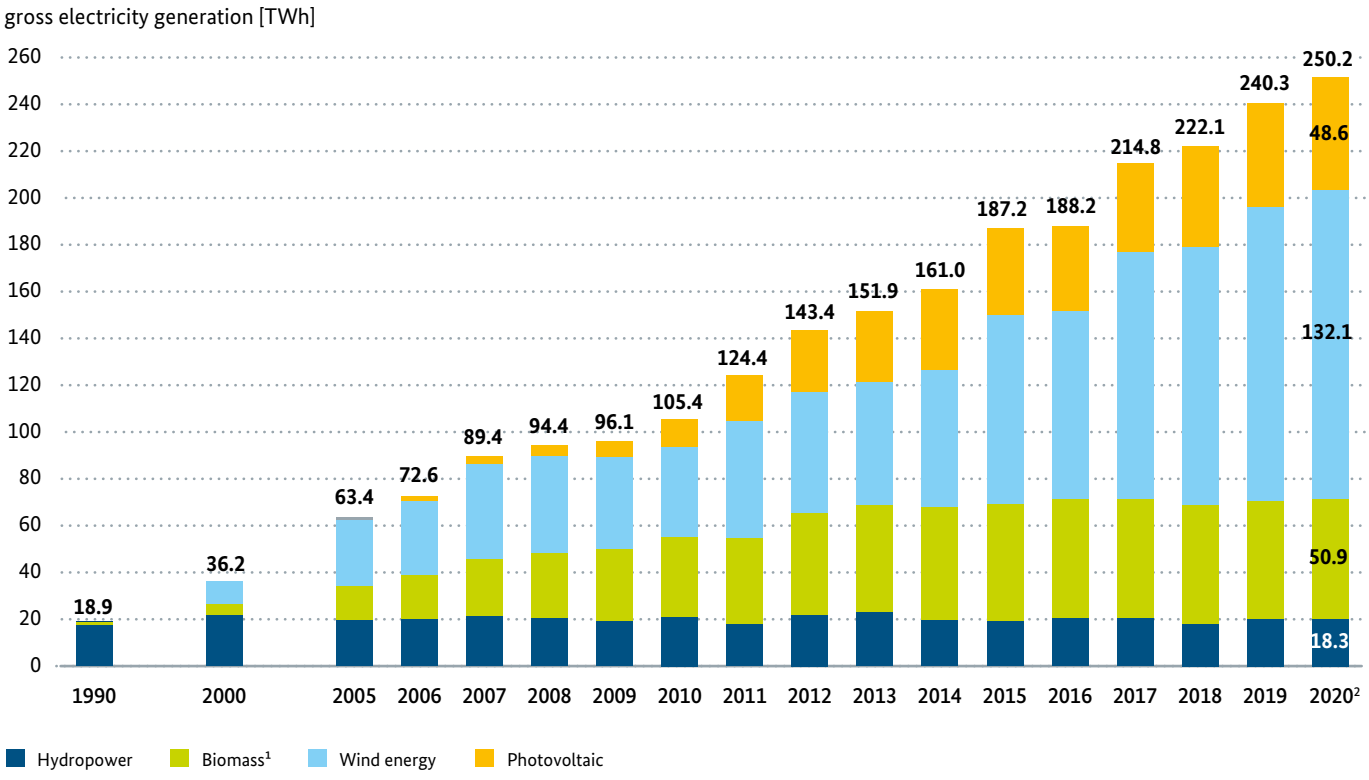
Photovoltaics has been on an upward trend since 2015, one which continued strongly in 2020. Supported by a further drop in prices for photovoltaic modules and battery storage, new photovoltaic capacity of 4,807 megawatts was installed, 28% more than in the previous year (2019: 3,756 megawatts). At the end of 2020, photovoltaic systems with a total capacity of 54,414 megawatts were connected to the grid in Germany. Thus, the so-called "PV cap" of 52 gigawatts, which was intended for photovoltaic promotion and has since been removed, was also exceeded during the year.

The significant expansion and extended periods of good weather, particularly in the first half of the year, ensured that electricity generation also increased by almost 10% year-on-year to 48.6 terawatt-hours (2019: 44.4 terawatt-hours). Photovoltaics ranked second among renewable electricity sources, accounting for 8.8% of total gross electricity consumption.

## Further flexibilisation of biogas and biomethane

Compared to the previous year, 414 megawatts of capacity were added to generate electricity from biogas and biomethane (2019: 329 megawatts). As

### Figure 7: Gross electricity generation from renewable energy sources



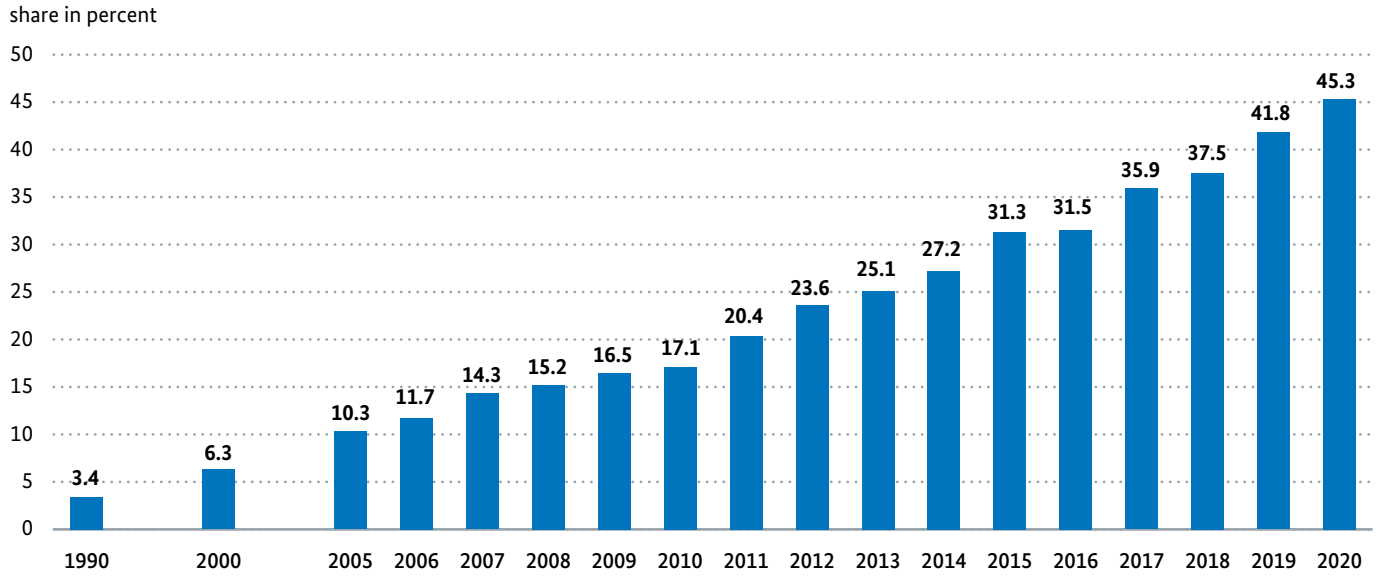

1 Solid and liquid biomass, biogas, biomethane, landfill gas and sewage gas, sewage sludge and biogenic share of waste

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

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

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




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

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

in previous years, most of the new capacity was from an increased output of existing plants. This so-called overbuilding enables more flexible and demand-driven power generation. Accordingly, electricity generation from biogas and biomethane in 2020 was only slightly above the previous year's level at 31.7 terawatt-hours (2019: 31.1 terawatt-hours).

As in previous years, 2020 saw hardly any changes in installed capacity in the solid and liquid biomass sectors. As a result, total electricity generation of 50.9 terawatt-hours from biomass, including the use of landfill and sewage gas, as well as the biogenic share of municipal solid waste, was only slightly higher in 2020 than the previous year's level (2019: 50.1 terawatt-hours). Electricity generation from all forms of biomass combined was just above generation from photovoltaics and covered 9.2% of Germany's gross electricity consumption.

### Hydropower remains low due to reduced precipitation levels

2020 was another year characterized by drought, which is why electricity generation from hydropower remained at a low level and, at 18.3 terawatt-hours, even fell short of the previous year's figure (2019: 19.7 terawatt-hours). Due to the drop in gross electricity consumption, the share of hydropower remained constant at 3.3%.

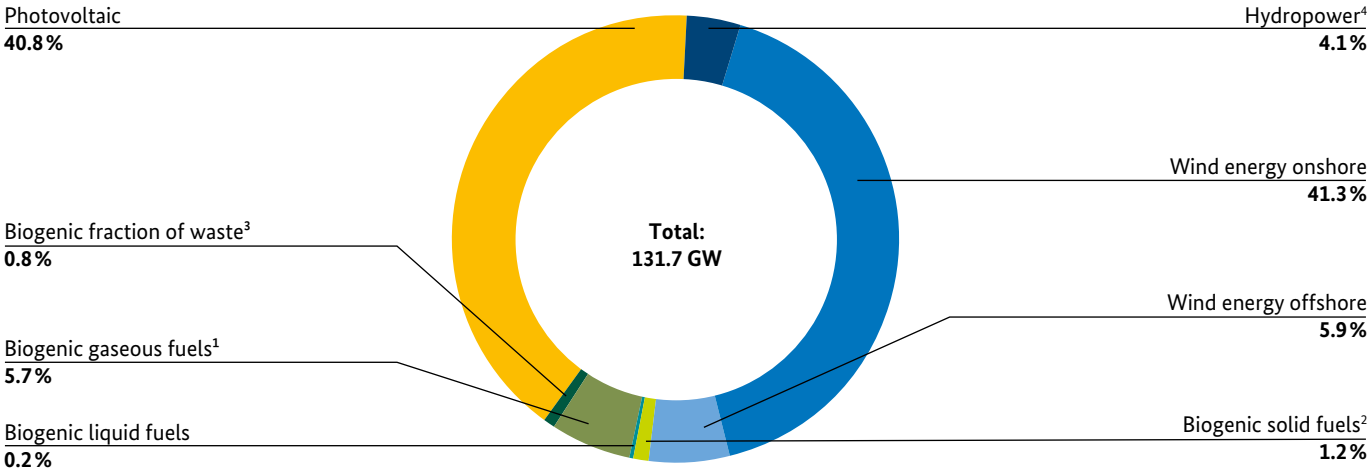
Although electricity generation from geothermal energy increased by 15% compared with the previous year, its importance for the German electricity mix remained low at 0.2 terawatt-hours.

## Heat

### Heat from renewables remains at previous year's level – relative share of total consumption rises slightly

Final energy consumption for heating and cooling from renewables in 2020 remained almost at the previous year's level at 181.7 terawatt-hours (2019: 182.1 terawatt-hours). Total final energy consumption for heating and cooling was influenced by pandemic effects and by very mild weather. At around 1,165 terawatt-hours in 2020, there was a decrease of more than 3% compared with 2019 (2019: 1,205 terawatt-hours). The final calculation showed an increase in the share of renewable energy in total final energy consumption for heating and cooling from 15.1 to 15.6%. As in previous years, the Government's target of achieving a 14%

## Figure 9: Installed power generation capacity based on renewable energy source, 2020




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

1 Biogas, biomethane, landfill gas and sewage gas

2 Incl. sewage sludge, excluding biogenic share of waste

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

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

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

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

| | Hydropower[1] | Onshore wind energy | Offshore wind energy | Biomass[2] | Photovoltaics | Geoth. energy | Total capacity |
|---|---|---|---|---|---|---|---|
| | | | | (MW)[3] | | | |
| **1990** | 3,982 | 55 | 0 | 404 | 2 | 0 | **4,443** |
| **2000** | 4,831 | 6,097 | 0 | 996 | 114 | 0 | **12,038** |
| **2005** | 5,210 | 18,248 | 0 | 2,939 | 2,056 | 0 | **28,453** |
| **2006** | 5,193 | 20,474 | 0 | 3,647 | 2,899 | 0 | **32,213** |
| **2007** | 5,137 | 22,116 | 0 | 4,006 | 4,170 | 3 | **35,432** |
| **2008** | 5,164 | 22,794 | 0 | 4,371 | 6,120 | 3 | **38,452** |
| **2009** | 5,340 | 25,697 | 35 | 5,593 | 10,566 | 8 | **47,239** |
| **2010** | 5,407 | 26,823 | 80 | 6,222 | 18,006 | 8 | **56,546** |
| **2011** | 5,625 | 28,524 | 188 | 7,162 | 25,916 | 8 | **67,423** |
| **2012** | 5,607 | 30,711 | 268 | 7,467 | 34,077 | 19 | **78,149** |
| **2013** | 5,590 | 32,969 | 508 | 7,966 | 36,710 | 30 | **83,773** |
| **2014** | 5,580 | 37,620 | 994 | 8,204 | 37,900 | 33 | **90,331** |
| **2015** | 5,589 | 41,297 | 3,283 | 8,429 | 39,224 | 34 | **97,856** |
| **2016** | 5,629 | 45,283 | 4,152 | 8,659 | 40,679 | 38 | **104,440** |
| **2017** | 5,627 | 50,174 | 5,406 | 8,982 | 42,293 | 38 | **112,520** |
| **2018** | 5,329 | 52,328 | 6,393 | 9,662 | 45,158 | 42 | **118,912** |
| **2019** | 5,378 | 53,187 | 7,555 | 9,994 | 48,914 | 47 | **125,075** |
| **2020** | 5,438 | 54,414 | 7,774 | 10,344 | 53,721 | 47 | **131,738** |

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

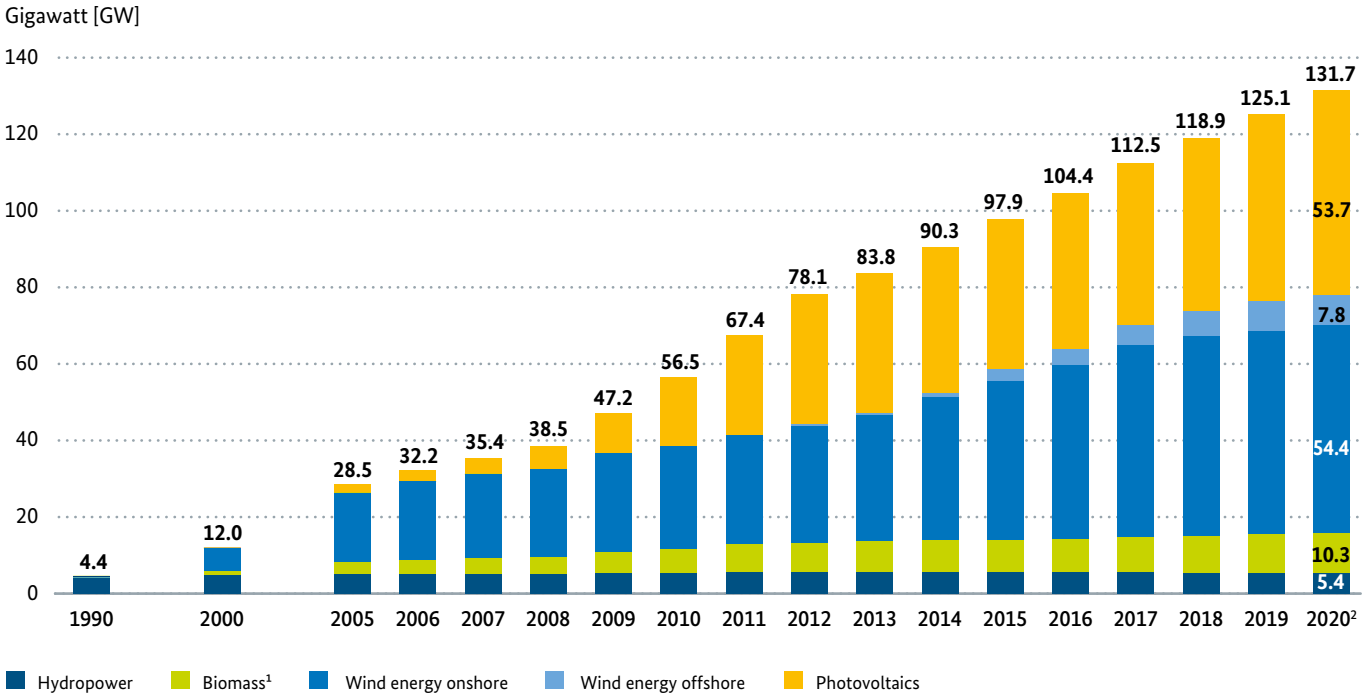
1 Installed hydropower capacity includes pumped-storage power plants with natural inflow.

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

3 1,000 MW = 1 GW

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

## Figure 11: Installed power generation capacity based on renewables




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

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

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

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

share of renewable energy sources in final energy consumption for heating and cooling by 2020 was exceeded. Thus, a first milestone has been reached in the heating sector for Germany's medium- and long-term energy and climate targets.

If we look at the various renewable energy sources in the heating sector, we see that there were some contradictory developments in 2020. While there were minor, weather related declines in heat generation from most forms of biomass and biogenic waste, there were clear upward trends in solar thermal energy, geothermal energy and environmental heat.

### Slight decline in heat generation from biomass

In the area of biomass, which accounts for a total of around 86% of the consumption of renewable energy sources for heating and cooling, the data is still largely based on model calculations. This applies to wood consumption in private households for which a decline of around 5% compared with the previous year is assumed, resulting in consumption of 67.9 terawatt-hours. In addition to logs and wood chips, this figure also includes wood pellets. Their consumption has risen in 2020 compared with the previous year to 2.33 million metric tons (2019: 2.30 million metric tons). This is mainly related to the sharp increase in the number of wood pellet furnaces. In 2020, a total of 61,350 new systems were installed, about three-quarters more than in the previous year (2019: 34,650). About two-thirds of these were central heating systems, with the remainder being stoves. The total stock has thus grown to 546,000 systems of which 322,000 are central heating systems [13].

### Upward trend in solar thermal energy, geothermal energy and environmental heat

A trend reversal was recorded for solar thermal energy in 2020: After installation figures had been declining for many years, an increase of more than 20% compared to the previous year was registered with 643,500 square meters of newly installed col-

lector area (2019: 511,000). Overall, considering the dismantling of old systems, just under 19.5 million square meters of solar collector area were installed at the end of 2020, or around 130,000 square meters more than a year earlier. Higher solar irradiation resulted in the provision of 8.7 terawatt-hours of solar heat, almost 3% more than in the previous year.

In the case of heat generation from near-surface geothermal energy and environmental heat, the upward trend of recent years continued and even strengthened significantly compared with the previous year: At 120,000 systems, around 40% more heating heat pumps were sold (2019: 86,000). Air-source heat pumps accounted for most of the growth, with 95,500 systems now accounting for 80% of new installations. At 24,500 systems, ground-source heat pumps accounted for only 20%. In addition, 20,500 new heat pumps were installed for domestic hot water heating, 24% more than in the previous year (2019: 16,500). At the end of the year, a total of 1.29 million heat pumps with a thermal output of 12.3 GW were installed in Ger-

## Figure 12: Final energy consumption for heat generation based on renewable energy sources in 2019 and 2020

| | Renewable energy sources 2019 | | Renewable energy sources 2020 | |
|---|---|---|---|---|
| | Final energy consumption heat (GWh)[8] | Share of final energy consumption for heat[9] (%) | Final energy consumption heat (GWh)[8] | Share of final energy consumption for heat[9] (%) |
| Biogenic solid fuels (households)[1] | 71,354 | 5.9 | 67,897 | 5.8 |
| Biogenic solid fuels (TCS sector)[2] | 19,052 | 1.6 | 18,953 | 1.6 |
| Biogenic solid fuels (industry)[3] | 23,784 | 2.0 | 24,029 | 2.1 |
| Biogenic solid fuels (HP/CHP)[4] | 6,121 | 0.5 | 6,267 | 0.5 |
| Biogenic liquid fuels[5] | 2,383 | 0.2 | 3,207 | 0.3 |
| Biogas | 13,295 | 1.1 | 13,549 | 1.2 |
| Biomethane | 3,765 | 0.3 | 4,045 | 0.3 |
| Sewage gas | 2,402 | 0.2 | 2,381 | 0.2 |
| Landfill gas | 102 | 0.01 | 89 | 0.01 |
| Biogenic fraction of waste[6] | 15,308 | 1.3 | 15,160 | 1.3 |
| Solar thermal energy | 8,483 | 0.7 | 8,707 | 0.7 |
| Deep geothermal energy | 1,369 | 0.1 | 1,370 | 0.1 |
| Near-surface geoth. energy, ambient heat[7] | 14,655 | 1.2 | 16,049 | 1.4 |
| **Total** | **182,073** | **15.1** | **181,703** | **15.6** |

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 1,000 GWh = 1 TWh

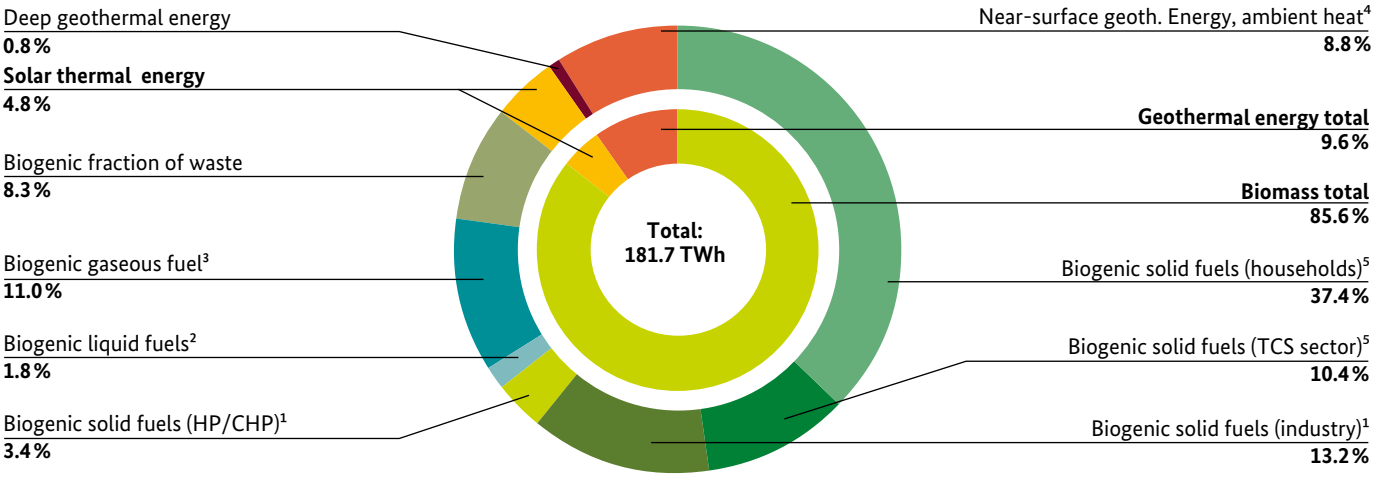
9 Relates to final energy consumption for space heating, hot water, process heat, air conditioning and process cooling, 2020: 1,165 TWh; 2019: 1,205.4 TWh according to AGEB [1] and AGEE-Stat, without electricity consumption for heating and cooling

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

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

many. Together with deep geothermal and balneological systems (pools), a total of 17.4 terawatt-hours of heat were provided from geothermal and environmental heat, around 9% more than in the previous year (2019: 16.0 terawatt-hours) and just under 10% of the total heat generated from renewable energy sources.

## Figure 13: Final energy consumption for heat generation based on renewable energy sources, 2020




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
The term "final energy consumption for heat" also includes final energy consumption for cooling applications.

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

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

| | Solid biomass[1] | Liquid biomass[2] | Gaseous biomass[3] | Solar thermal energy | Near-surface geoth. energy, ambient heat[4] | Total FEC heat | RE share of FEC of heat |
|---|---|---|---|---|---|---|---|
| | (GWh)[5] | | | | | (GWh)[5] | (%) |
| **1990** | 30,573 | 0 | 0 | 131 | 1,812 | **32,516** | **2.1** |
| **2000** | 53,604 | 8 | 1,355 | 1,292 | 2,170 | **58,429** | **4.4** |
| **2005** | 92,425 | 1,219 | 3,126 | 3,028 | 2,815 | **102,613** | **8.0** |
| **2006** | 103,952 | 1,778 | 3,413 | 3,547 | 3,272 | **115,962** | **8.8** |
| **2007** | 110,874 | 2,834 | 5,727 | 3,934 | 3,961 | **127,330** | **10.8** |
| **2008** | 121,293 | 3,409 | 5,678 | 4,474 | 4,783 | **139,637** | **10.8** |
| **2009** | 117,082 | 3,660 | 7,325 | 5,250 | 5,719 | **139,036** | **11.7** |
| **2010** | 139,945 | 3,366 | 10,078 | 5,590 | 6,627 | **165,606** | **12.4** |
| **2011** | 130,005 | 2,572 | 11,871 | 6,388 | 7,540 | **158,376** | **13.0** |
| **2012** | 144,980 | 2,104 | 11,819 | 6,638 | 8,571 | **174,112** | **14.2** |
| **2013** | 149,381 | 2,206 | 13,214 | 6,700 | 9,596 | **181,097** | **14.2** |
| **2014** | 128,080 | 2,372 | 15,139 | 7,204 | 10,695 | **163,490** | **14.2** |
| **2015** | 131,976 | 2,189 | 16,914 | 7,705 | 11,479 | **170,263** | **14.1** |
| **2016** | 128,595 | 2,188 | 17,822 | 7,691 | 12,554 | **168,850** | **13.7** |
| **2017** | 131,386 | 2,194 | 18,325 | 7,852 | 13,576 | **173,333** | **14.0** |
| **2018** | 133,328 | 2,291 | 19,123 | 8,875 | 14,812 | **178,429** | **15.0** |
| **2019** | 135,619 | 2,383 | 19,564 | 8,483 | 16,024 | **182,073** | **15.1** |
| **2020** | 132,306 | 3,207 | 20,064 | 8,707 | 17,419 | **181,703** | **15.6** |

1 Including the biogenic share of waste (estimated at 50% in waste incineration plants), sewage sludge and charcoal.

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

3 Biogas, biomethane, sewage gas and landfill gas

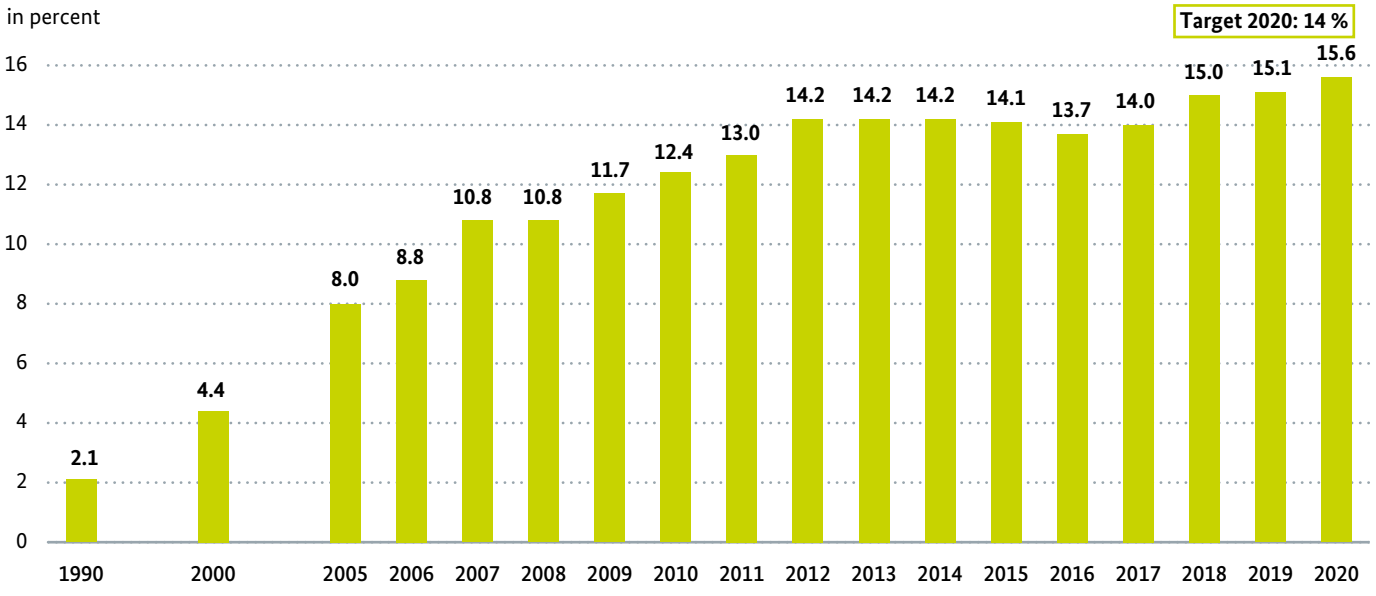
4 Including heat from deep geothermal energy and renewable heat from heat pumps (air/water, water/water and brine/water heat pumps as well as hot water heat pumps and gas heat pumps)

5 1,000 GWh = 1 TWh

The term “final energy consumption for heat” also includes final energy consumption for cooling applications.

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; AGEB [1], [14]; StBA [2], [15]; ZSW [6]; DENA [7]; Thünen Institute [12], [16]; GZB [17]; IEA/ESTIF [18]; FNR [19]; UNI HH [20]; DBFZ; BDH; BSW; DEPV; BWP; some figures are provisional

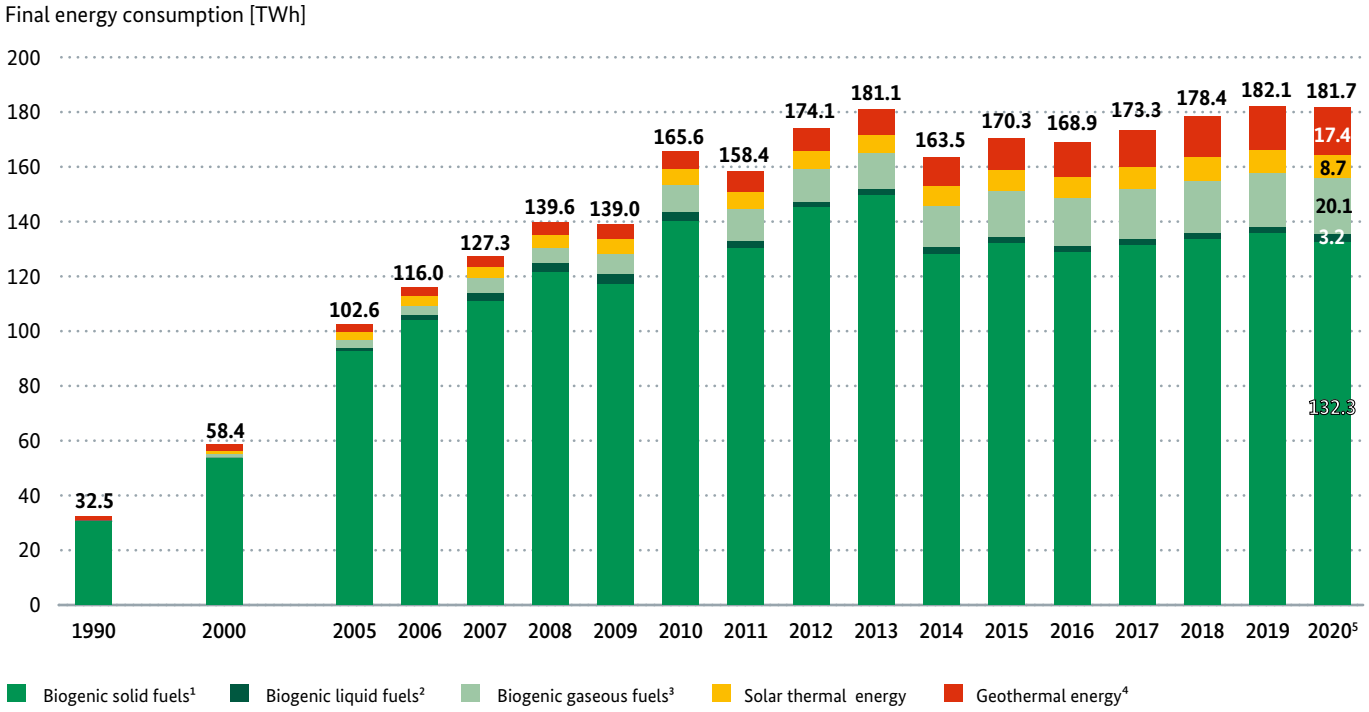
## Figure 15: Share of renewables in final energy consumption for heat generation




Under the Renewable Energies Heat Act, renewable energy must make up 14% of final energy consumption for heating and cooling by 2020.
The term “final energy consumption for heat” also includes final energy consumption for cooling applications.

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

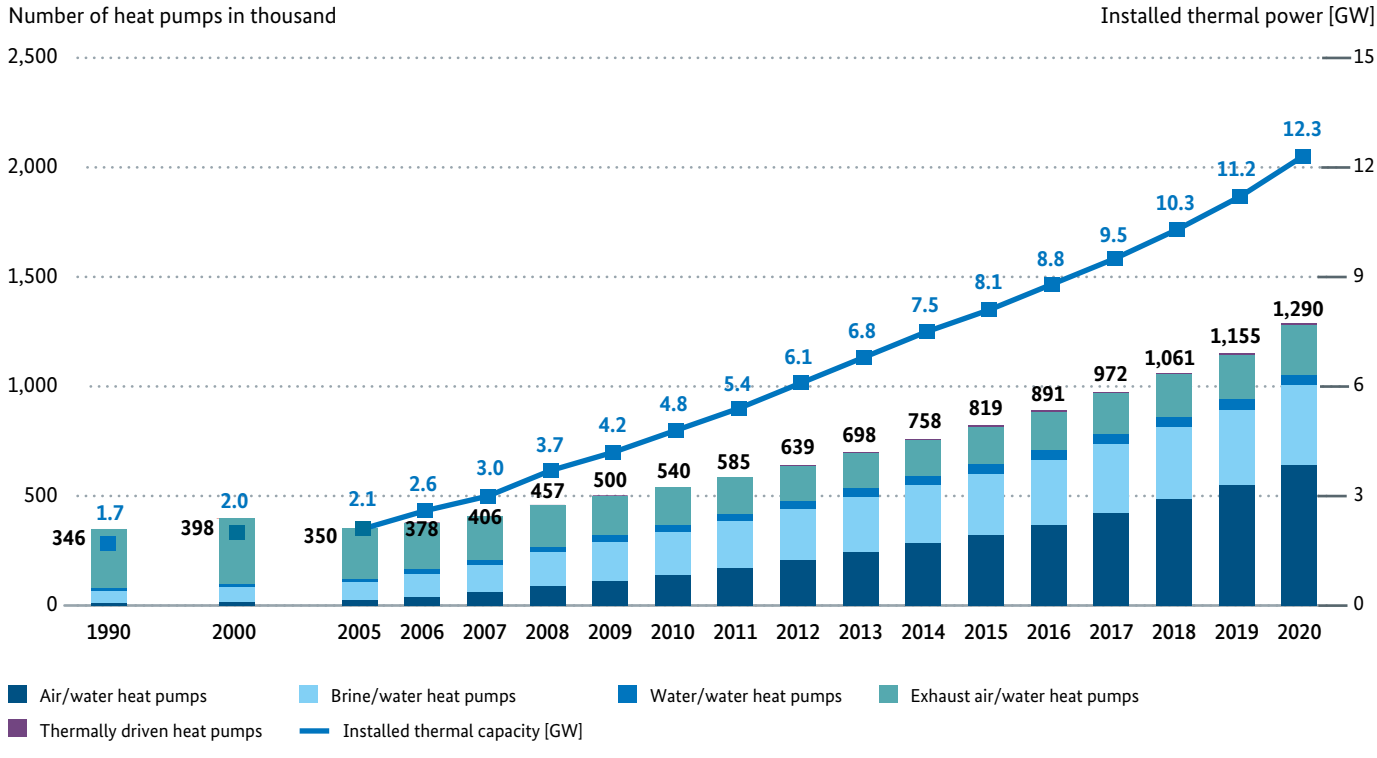
## Figure 16: Final energy consumption for heat generation based on renewable energy sources




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

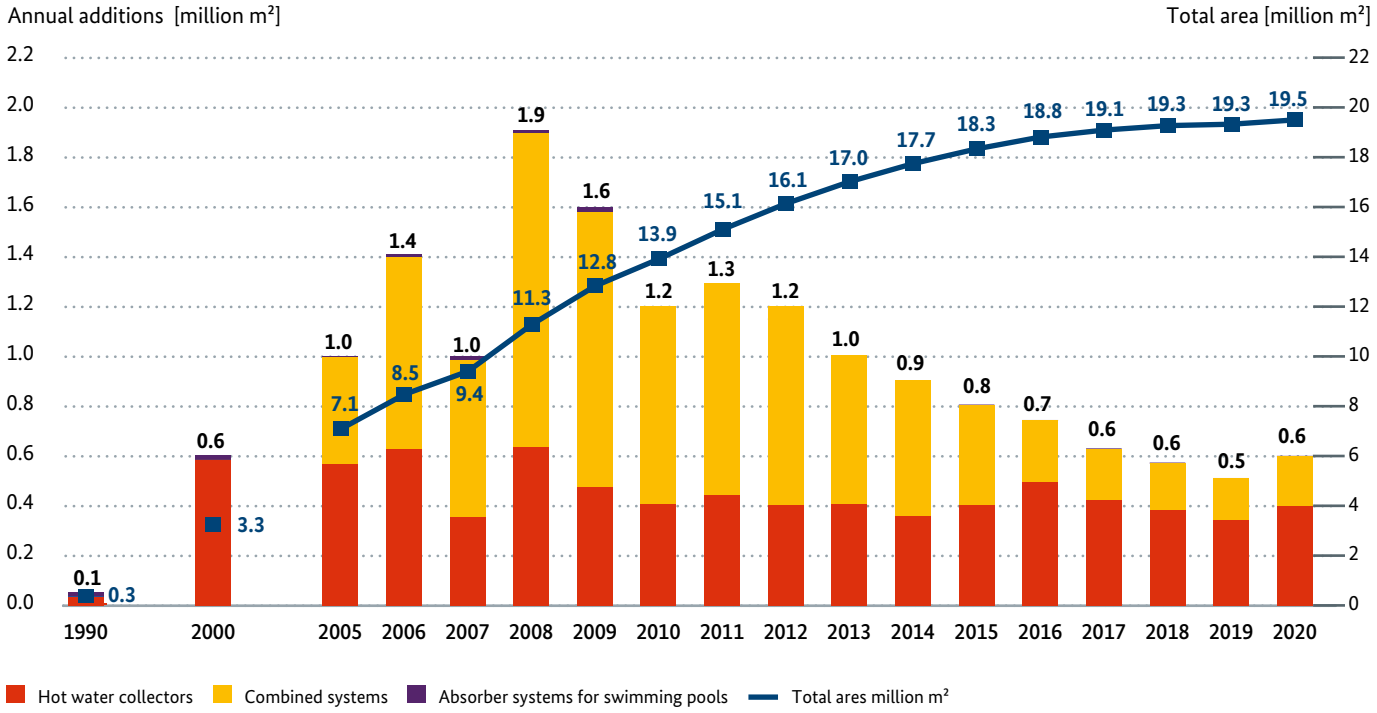
Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat and other sources: see Figure 14, some figures are provisional

## Figure 17: Development of heat pump stock




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

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




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

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; ZSW; BDH; BSW; IEA/ESTIF [18]

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

| | 1990 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative area (1,000 m²) | 348 | 3,250 | 7,085 | 13,914 | 15,100 | 16,140 | 17,020 | 17,746 | 18,339 | 18,812 | 19,091 | 19,269 | 19,326 | 19,455 |
| Cumulative output (MW) | 244 | 2,275 | 4,959 | 9,740 | 10,570 | 11,298 | 11,914 | 12,422 | 12,837 | 13,169 | 13,364 | 13,489 | 13,528 | 13,618 |

Figures take account of old installations taken out of service.

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

# Transport

## Sales of biofuels increase significantly

Biofuel sales in 2020 totalled just under 4 million tonnes, around 19% higher than in the previous year. This was due to a 30% increase in sales of biodiesel to 2.8 million tonnes (2019: 2.1 million tonnes), while sales of bioethanol fell by 4% to just under 1.1 million tonnes. Of significance for the increased use of biodiesel and so-called HVO ("Hydrotreated Vegetable Oils") was an increase in the greenhouse gas reduction quota from 4 to 6%.

Due to improved economic conditions, the use of biomethane in transport also increased significantly by one third to 884 GWh (2019: 660 GWh), while the use of pure vegetable oils remained insignificant.

In addition to biofuels, the increasing share of renewable energy sources in the electricity mix, combined with a growing number of electric drives in transport, are contributing ever more to the increased share of renewable energy sources in transport. Although rail transport is still responsible for around 95% of electricity consumption, pri-

vate motorised transport is now growing significantly. According to the Federal Motor Transport Authority, a total of 394,940 newly registered passenger cars with electric drive were registered in 2020, which was 13.5% of all new registrations. 194,163 of those vehicles were purely electric, the rest plug-in hybrids. Total electricity consumption in transport increased by 5% to almost 5.1 terawatt-hours compared to the previous year.

The growth in renewable energy sources in the transport sector contrasts with a significant decline in energy consumption in transport due to the pandemic. Compared to the previous year, it fell by 9% to 585 TWh. The final calculation shows that the share of renewable energy sources in transport climbed significantly to 7.5% (2019: 5.6%), thus surpassed the previous peak value from 2007.

## Figure 20: Consumption of renewable energy sources in the transport sector in 2019 and 2020

| | Renewable energy sources 2019 | | Renewable energy sources 2020 | |
|---|---|---|---|---|
| | Final energy consumption of transport (GWh)[3] | Share of FEC of transport[4] (%) | Final energy consumption of transportr (GWh)[3] | Share of FEC of transport[4] (%) |
| Biodiesel[1] | 22,120 | 3.4 | 29,647 | 5.1 |
| Vegetable oil | 21 | 0.003 | 21 | 0.004 |
| Bioethanol | 8,360 | 1.3 | 8,021 | 1.4 |
| Biomethane | 660 | 0.1 | 884 | 0.2 |
| RE electricity consumption in transport[2] | 4,874 | 0.8 | 5,131 | 0.9 |
| **Total** | **36,035** | **5.6** | **43,704** | **7.5** |

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

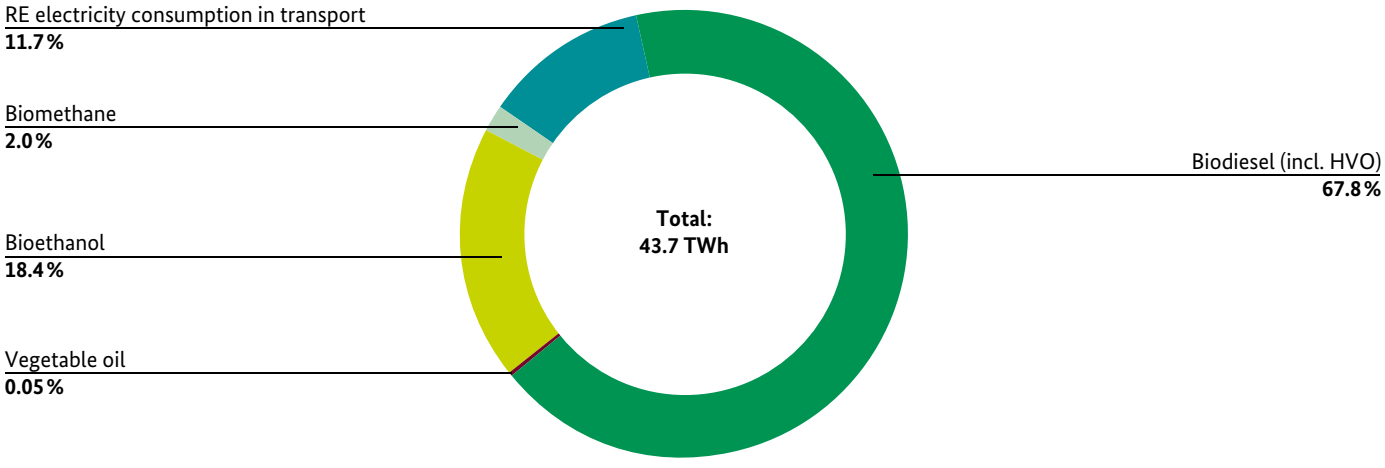
2 Calculated from total electricity consumption in the transport sector according to AGEB [1] and the share of renewable energy in gross electricity consumption according to AGEE-Stat (see Figure 6)

3 1,000 GWh = 1 TWh

4 Based on final energy consumption in transport in 2019: 585.0 TWh; 2020: 643.8 TWh, according to AGEB [1] and AGEE-Stat, without energy consumption for international air traffic

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

## Figure 21: Consumption of renewable energy sources in the transport sector, 2020




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

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

| | Biodiesel[1] | Vegetable oil | Bioethanol | Biomethane | RE electricity consumption[2] | Final energy consumption of transport | Share of FEC of transport |
|---|---|---|---|---|---|---|---|
| | | | (GWh)[3] | | | (GWh)[3] | (%) |
| **1990** | 0 | 0 | 0 | 0 | 465 | **465** | **0.1** |
| **2000** | 2,583 | 167 | 0 | 0 | 1,002 | **3,752** | **0.5** |
| **2005** | 17,666 | 1,828 | 1,780 | 0 | 1,353 | **22,627** | **3.6** |
| **2006** | 27,938 | 7,206 | 3,828 | 0 | 1,471 | **40,443** | **6.4** |
| **2007** | 32,282 | 8,533 | 3,391 | 0 | 1,750 | **45,956** | **7.3** |
| **2008** | 25,873 | 4,042 | 4,608 | 4 | 1,688 | **36,215** | **5.9** |
| **2009** | 22,966 | 961 | 6,576 | 13 | 1,902 | **32,418** | **5.3** |
| **2010** | 24,359 | 574 | 8,537 | 75 | 2,054 | **35,599** | **5.8** |
| **2011** | 23,545 | 188 | 9,031 | 92 | 2,470 | **35,326** | **5.7** |
| **2012** | 24,628 | 251 | 9,149 | 333 | 2,826 | **37,187** | **6.0** |
| **2013** | 21,934 | 0 | 8,832 | 483 | 2,993 | **34,242** | **5.4** |
| **2014** | 22,676 | 52 | 9,002 | 449 | 3,157 | **35,336** | **5.6** |
| **2015** | 20,829 | 10 | 8,589 | 345 | 3,512 | **33,285** | **5.2** |
| **2016** | 20,896 | 31 | 8,604 | 379 | 3,709 | **33,619** | **5.2** |
| **2017** | 21,354 | 31 | 8,464 | 445 | 4,305 | **34,599** | **5.3** |
| **2018** | 22,329 | 10 | 8,692 | 389 | 4,569 | **35,989** | **5.6** |
| **2019** | 22,120 | 21 | 8,360 | 660 | 4,874 | **36,035** | **5.6** |
| **2020** | 29,647 | 21 | 8,021 | 884 | 5,131 | **43,704** | **7.5** |

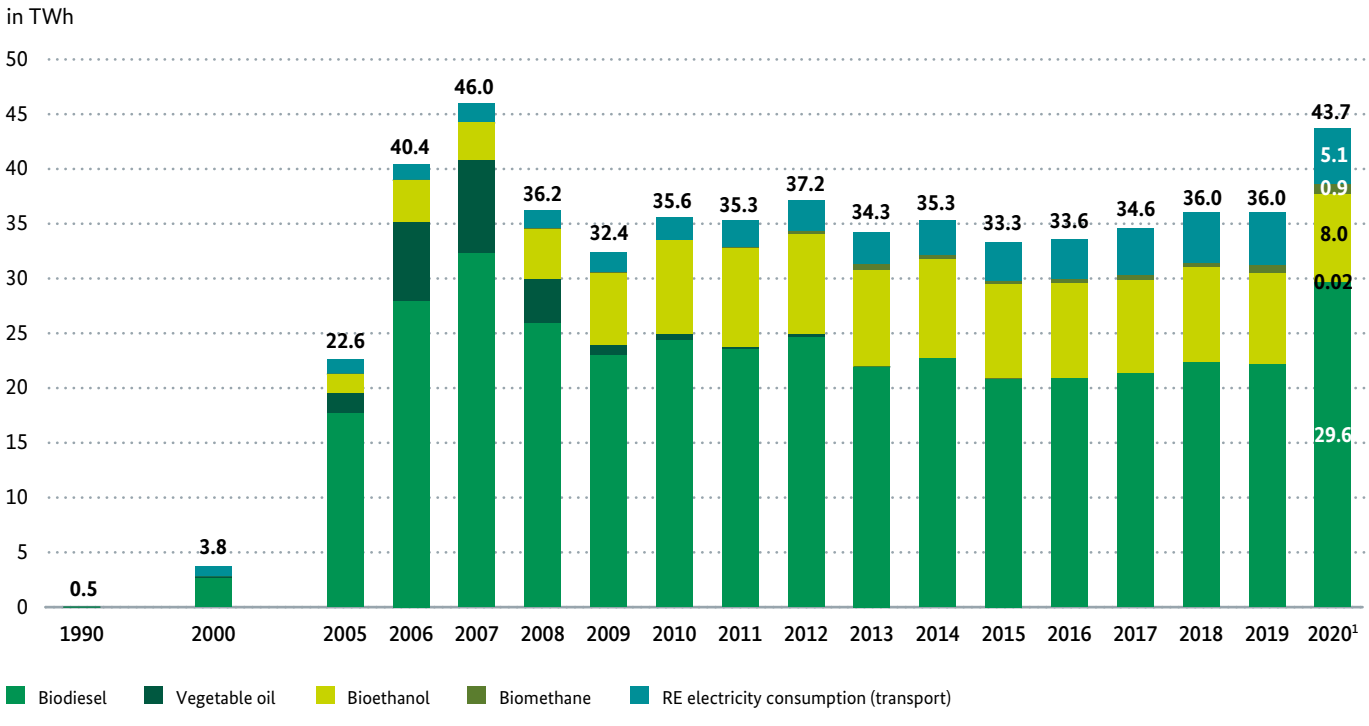
1 Consumption of biodiesel (incl. HVO) in the transport sector, excluding use in agriculture, forestry, construction and military

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

3 1,000 GWh = 1 TWh

Sources: Federal Ministry for Economic Affairs and Energy based on data from AGEE-Stat; BAFA [21]; BLE [22], [23]; FNR; ZSW; BMF [24]; Fed Govt. [25], [26], [27], [28]; StBA [29]; DBFZ; AGQM; UFOP; some provisional figures

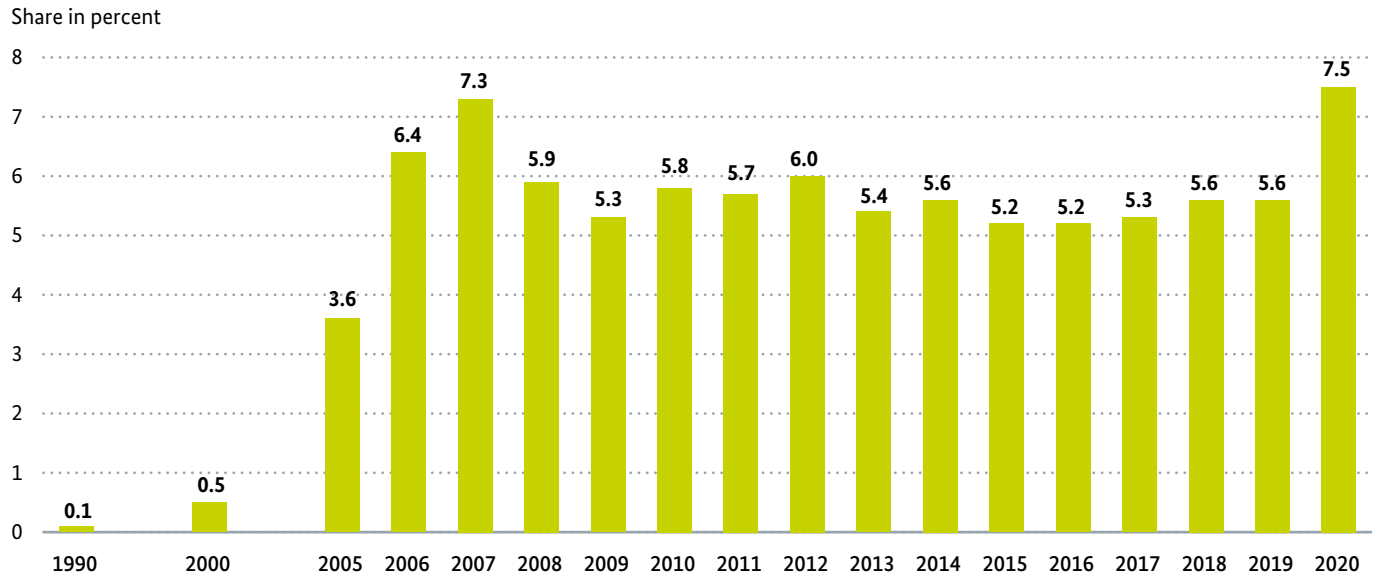
## Figure 23: Consumption of renewable energy sources in the transport sector




1 Final energy consumption of the respective technologies for transport in previous years see Figure 22

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

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




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 "Information on methodology" section of this publication.

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

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

| | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1,000 tons) | | | | | | | | | | | | |
| Biodiesel[1] | 250 | 1,720 | 2,361 | 2,257 | 2,322 | 2,058 | 2,148 | 1,998 | 2,005 | 2,073 | 2,169 | 2,146 | 2,799 |
| Vegetable oil | 16 | 175 | 55 | 18 | 24 | 0 | 5 | 1 | 3 | 3 | 1 | 2 | 2 |
| Bioethanol | 0 | 238 | 1,158 | 1,225 | 1,241 | 1,198 | 1,221 | 1,165 | 1,167 | 1,148 | 1,179 | 1,134 | 1,088 |
| Biomethane[2] | 0 | 0 | 6 | 7 | 25 | 36 | 33 | 25 | 28 | 33 | 29 | 49 | 65 |
| **Total** | **266** | **2,133** | **3,580** | **3,507** | **3,612** | **3,292** | **3,407** | **3,189** | **3,203** | **3,257** | **3,378** | **3,331** | **3,954** |

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

2 Calculated using a calorific value of 48.865 MJ/kg

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

## Emissions prevented through the use of renewable energy

The expansion of renewable energy contributes significantly to achieving climate protection targets. In 2020, greenhouse gas emissions totalling around 230 million tonnes of $CO_2$ equivalents were eliminated. Again, most greenhouse gas emissions were avoided thanks to electricity generation from wind-turbines (100 million tons of $CO_2$ equivalents). The overall electricity sector accounted for over 179 million tonnes of these savings. Emissions of around 41 million tonnes were eliminated in the heating sector, and through the use of biofuels in transport, some 11 million fewer tonnes of $CO_2$ equivalents were emitted (see Figure 26).

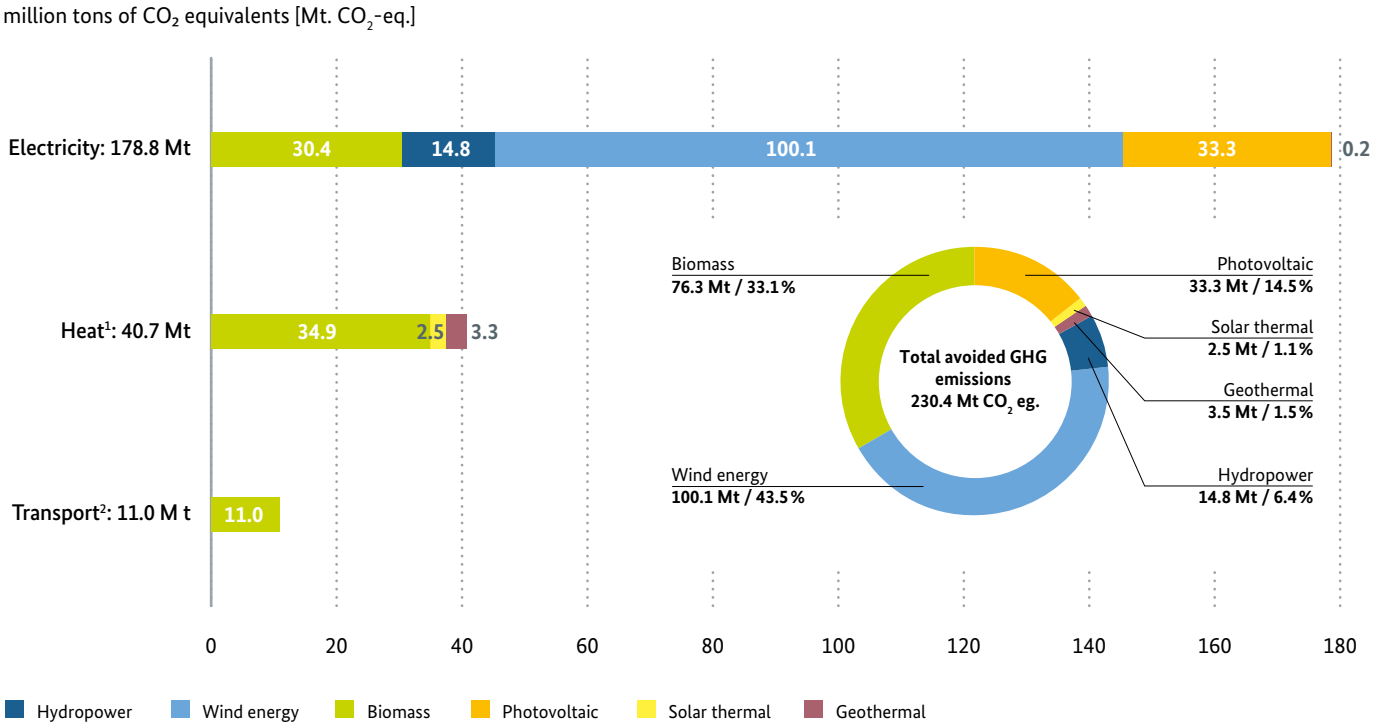
The calculations of the emissions savings arising from the use of renewable energy sources are based

on net figures[1]. This is done by setting off the volume of emissions caused by the use of renewables (final energy supply) against the volume of gross emissions that are no longer being released thanks to the substitution of fossil energy sources with renewables. Most upstream process chains involved in the production and supply of the various energy sources, as well as for plant construction and operation, are also taken into account.

In the electricity and heat sectors, technology-specific substitution factors were used. The underlying model for the electricity sector gives special consideration to the increasing interconnection of the European electricity market. The substitution factors are determined by comparing the real development of the European electricity generation sector with a plausible development path, disregarding the German expansion of renewable energy [30]. In addition, the balance for the heat sector takes account of the difference in efficiency between renewables-based heating installations and those based on conventional energy sources.

The emissions balance for the use of biomass depends on the type and origin of the raw materials. The life cycle was also modelled to ascertain the environmental footprint for the purpose of balancing [31]. If the raw materials are not residual biogenic materials or waste, land use changes resulting from the cultivation of energy crops must be taken into account. However, it is difficult to quantify indirect land use changes. Therefore, these changes have not yet been taken into account in emissions accounting. Various model-based calculations conclude that indirect land use changes can lead to considerable greenhouse gas emissions, which partially or completely offset the greenhouse gas emission savings of individual biofuels.

## Figure 26: Net balance of greenhouse gas emissions avoided through the use of renewable energy sources, 2020




1 Does not include charcoal consumption
2 Exclusively biogenic fuels in the transport sector (excluding agriculture, forestry, construction and the military and excluding electricity consumption by the transport sector), based on provisional data from the Federal Office for Agriculture and Food (BLE) for 2020 and the fossil baseline values pursuant to § 3 and § 10 of the 38th Federal Immission Control Ordinance (BImSchV)

Sources: German Environment Agency [32] – based on the sources quoted therein, provisional figures

1 Detailed documentation of the methodological principles of emissions accounting for renewable energy sources can be found in the German Environment Agency (UBA) publication “Emissionsbilanz erneuerbarer Energieträger – Bestimmung der vermiedenen Emissionen 2020” [32] (in German only).

The emissions calculation of biofuels[2] is based on the greenhouse gas emissions (including the raw material basis) accounted for or applied in the course of the GHG quota itself, as published by the Federal Office for Agriculture and Food (BLE) in its annual evaluation and experience report on the Biofuel/Biomass Electricity Sustainability Ordinance [22], as well as the fossil baseline values of the 38th BlmSchV (Regulation Implementing the Federal Immission Control Act) in accordance with § 3 and § 10.

The emissions of the individual greenhouse gases and air pollutants resulting from the use of biofuels were roughly derived by the German Environment Agency (UBA) based on total greenhouse gas emissions. For this purpose, findings from the "BioEm" research project [30] and other expert reports were included, and various assumptions and analogical conclusions were made.

Figure 27 contains the results for the balanced greenhouse gases and air pollutants. The greenhouse gas avoidance is particularly high for electricity generation. This can be explained, among other reasons, by the low emissions from the production and operation of the renewable technologies used compared to the emission-increasing fossil power generation. Negative balance values again occur for the precursor substances for ground-level ozone. This is mainly due to the use of biogas. In the heating sector, emissions of some air pollutants increase due to the combustion of wood, especially in older tiled stoves and fireplaces. However, these must be

## Figure 27: Net emissions balance for renewable energy sources used in electricity, heat and transport, 2020

| | | Renewables-based electricity generation total: 250,157 GWh | | Renewables-basedheat consumption total: 181,703 GWh[5] | | Renewables-based consumption for transport total: 38,573 GWh[6, 7] | | Total |
|---|---|---|---|---|---|---|---|---|
| **Greenhouse gas/Air pollutant** | | **Avoidance factor** | **Avoided emissions** | **Avoidance factor** | **Avoided emissions** | **Avoidance factor** | **Avoided emissions** | **Avoided emissions** |
| | | (g/kWh) | (1,000 t) | (g/kWh) | (1,000 t) | (g/kWh) | (1,000 t) | (1,000 t) |
| Greenhouse effect[1] | $CO_2$ | 706 | 176,550 | 230 | 41,524 | 303 | 11,689 | 229,764 |
| | $CH_4$ | 0.56 | 140.8 | -0.04 | -6.47 | -0.10 | -3.72 | 131 |
| | $N_2O$ | -0.02 | -4.2 | -0.01 | -2.3 | -0.05 | -2.06 | -9 |
| | $CO_2$-Equivalent | 715 | 178,775 | 226 | 40,676 | 285 | 10,982 | 230,432 |
| Acidification[2] | $SO_2$ | 0.22 | 53.9 | 0.07 | 12.4 | -0.12 | -4.69 | 62 |
| | $NO_X$ | 0.42 | 103.9 | -0.19 | -34.1 | 0.48 | 18.36 | 88 |
| | $SO_2$-Equivalent | 0.50 | 125.1 | -0.06 | -11.3 | 0.21 | 8.05 | 122 |
| Ozone[3] Particles[4] | CO | -0.30 | -75.0 | -1.90 | -343.0 | 0.88 | 33.88 | -384 |
| | NMVOC | 0.02 | 5.5 | -0.16 | -28.8 | 0.16 | 6.16 | -17 |
| | Staub | 0.004 | 1.0 | -0.09 | -16.4 | -0.01 | -0.45 | -16 |

1 Other greenhouse gases (SF6, CFCs, HCFCs) are not included.

2 Other air pollutants with acidification potential (NH3, HCl, HF) are not included.

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

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

5 Does not include charcoal consumption

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

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

Source: German Environment Agency (UBA) [32] based on the sources quoted therein

2 Overall, it can be estimated that the emission reductions from biofuel use are somewhat overstated. The reasons for this are the use of the official, regional NUTS2 values for biomass cultivation according to RED and the official specifications used for the substitution of fossil $CO_2$ with biogenic $CO_2$ produced during bioethanol production.

successively decommissioned or replaced due to legal regulations. Of particular importance are the negative balances for carbon monoxide and volatile organic compounds as well as dust emissions of all particle sizes. In the case of biofuels, increased nitrous oxide and methane emissions occur due to the cultivation of energy crops.

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

Figures 28 and 29 show the savings of fossil energy sources through the use of renewable energy for electricity, heat and transport in 2020 and from 2010 to 2020. Total savings have risen continuously in recent years.

### Figure 28: Savings in primary energy through the use of renewable energy sources in 2020

| | Lignite | Hard coal | Natural gas | Divided into mineral oil: | | | Total |
|---|---|---|---|---|---|---|---|
| | | | | Fuel oil | Diesel fuel | Gasolines | |
| | Primary energy (TWh) | | | | | | |
| Electricity | 116.3 | 346.9 | 104.1 | | | | **567.3** |
| Heat | 13.8 | 14.4 | 75.2 | 66.1 | 2.3 | | **171.7** |
| Transport | | | 0.9 | | 22.6 | 8.7 | **32.5** |
| **Total** | **130.0** | **361.3** | **180.1** | **66.1** | **24.9** | **8.7** | **771.5** |
| | Primary energy (PJ) | | | | | | |
| **Total** | **468.1** | **1,300.8** | **648.3** | **237.9** | **87.5** | **32.6** | **2,777.6** |
| which corresponds to[1]: | 50.1 | 47.5 | 18,427 | 6,656 | 2,495 | 1,005 | |
| | million t[2] | million t[3] | million m³ | million litres | million litres | million litres | |

The savings in fossil fuels are calculated using the same methodology as is used to calculate emission balances, see UBA [32].

1 Savings in primary energy were calculated using the net calorific values determined by AGEB [14]

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

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

Source: German Environment Agency (UBA) [32] based on the sources quoted therein

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

| | Electricity | Heat | Transport | Total |
|---|---|---|---|---|
| | Primary energy (TWh) | | | |
| **2010** | 230.2 | 128.2 | 17.8 | **376.2** |
| **2011** | 252.7 | 123.6 | 18.6 | **414.6** |
| **2012** | 302.0 | 133.3 | 22.0 | **457.3** |
| **2013** | 320.0 | 137.5 | 20.9 | **478.4** |
| **2014** | 351.5 | 126.8 | 21.4 | **499.7** |
| **2015** | 425.7 | 159.5 | 20.0 | **605.3** |
| **2016** | 423.7 | 159.4 | 24.5 | **607.6** |
| **2017** | 473.5 | 164.7 | 27.0 | **665.2** |
| **2018** | 489.2 | 167.7 | 27.8 | **684.7** |
| **2019** | 548.2 | 171.4 | 26.4 | **746.0** |
| **2020** | 567.3 | 171.7 | 32.5 | **771.5** |

Source: German Environment Agency (UBA) [32] based on the sources quoted therein

Since fossil energy sources in Germany, i.e., mineral oil, natural gas and hard coal, are largely imported, these savings also lead to a reduction in German energy imports.

## The Renewable Energy Sources Act (RES Act)

Electricity from renewable energy sources makes a significant contribution to achieving the climate goals of Germany and the European Union. On the path to greenhouse gas neutrality, renewable energy must therefore be consistently expanded further before the year 2045. In Germany, the Renewable Energy Sources Act (RES) has been the basis for the expansion of renewable energy in the electricity sector for more than 20 years.

Since its introduction in 2000, the law has been continuously developed, comprehensively so with RES amendments in 2014 and 2017. Most recently, the RES was amended in December 2020 and entered into force as the RES 2021 on 01 January 2021. Subsequently, against the backdrop of the stricter EU climate target for 2030, extensive special tenders for wind and photovoltaics in 2022 were provided for as emergency measures in the RES 2021 in accordance with the coalition agreement of April 2021. These will bridge the period until there is clarity on the expansion targets for renewable energy sources at EU level until 2030. The tender volumes in 2022 will be increased by 1.1 GW to 4 GW for onshore wind and by 4.1 GW to 6 GW for photovoltaics.

In 202 0, electricity from renewable energy sources covered more than 45%, almost half of Germany's total electricity consumption. To expand the contribution of renewable energy to achieving climate targets and transforming the energy system, the framework conditions were improved in the RES 2021. In essence, the amended RES contains the following regulations:

- Greenhouse gas neutrality before 2050 for electricity generated and consumed in Germany was enshrined in law as a new long-term goal.
- Ambitious expansion paths for renewable energy sources until 2030 were enshrined in law to achieve a share of renewables amounting to 65% of gross electricity consumption by 2030. In order to adapt the RES 2021 to the Federal Climate Change Act, which will be tightened, and to developments at EU level (measures still to be adopted to implement the Green Deal, Fit for 55 package), the expansion target and paths must be increased accordingly. Acceptance for further renewable energy expansion will be improved: in future, municipalities can participate financially in the expansion of wind energy. Incentives for landlord-to-tenant electricity supply and the framework conditions for own electricity generation have also been improved.
- Cost efficiency and innovation will be increased: The subsidy costs for renewable energy will be reduced through various individual measures (including adjustment of the maximum values in tenders, expansion of the area for ground-mounted PV systems). A new tender segment for large rooftop PV systems has been created, and strong impulses for innovation are being provided by extending and increasing the number of innovation tenders.
- The competitiveness of electricity-cost-intensive industry is secured: Adjustments to the special equalisation scheme will give electricity-cost-intensive industry more planning security for future RES relief.
- Renewables are further integrated into the electricity system: Improved incentives for new plant technology and better controllability of plants (smart meter gateway) have been put in place. A "southern quota" for onshore wind and biomass should lead to better coordination between the expansion of renewables and grid expansion.
- Sector coupling is being driven forward: The law provides that the production of green hydrogen can be fully exempted from the EEG surcharge (this still requires an ordinance) or hydrogen producers can make use of the special equalisation scheme. This implements a central element of the national hydrogen strategy.

- For seagoing vessels, the possibility will be created to obtain shore power at low cost in seaports instead of using diesel generators.

- The path to the "post-subsidy era" has been prepared: Supported installations with a capacity of less than 100 kW (except wind-powered installations) are given the transitional option of continuing to market the electricity via the grid operator and receiving the market value minus the marketing costs. The marketing costs are reduced if the plants are equipped with intelligent metering technology.

- For onshore wind-powered installations that have been subsidised, the Act provides for tenders for further subsidies until 31 December 2022 for installations for which repowering is not possible due to the location, in view of the lower electricity prices in the wake of the Covid 19 pandemic. Until the tenders are held, or for onshore plants that are not awarded a contract, the market value pass-through will continue to be granted with slight surcharges until 31 December 2021.

The paradigm shift in renewable energy support from legally fixed tariffs to competitively determined support rates, which has already been implemented with the RES 2017, is an important step towards advancing the market integration of renewable energy sources. Since then, onshore wind energy, offshore wind energy, very large PV plants, and especially ground-mounted PV and biomass have had to compete in tenders. This is because only the most cost-effective bids are awarded a contract.

In 2017, the Offshore Wind Energy Act introduced a central system of state designation, preliminary investigation and tendering of areas in tandem with the required offshore grid connections. With the amendment of the Offshore Wind Energy Act in 2020, the expansion target for 2030 was increased from 15 to 20 gigawatts, a long-term target of 40 gigawatts by 2040 was adopted and adjustments were made, such as those for the maximum value and realisation deadlines.

Since the introduction of mandatory direct marketing with support via the market premium and other direct marketing, renewable energy sources have been increasingly integrated into the market. The parallel accompanying technical connection of the plants leads to improved system integration. In addition, the operators assume full balancing group responsibility for these plants. In relation to the total generation capacities, the share of generation capacities for grid operators with the market premium has increased from 43% in 2013 to around 66% in 2020.

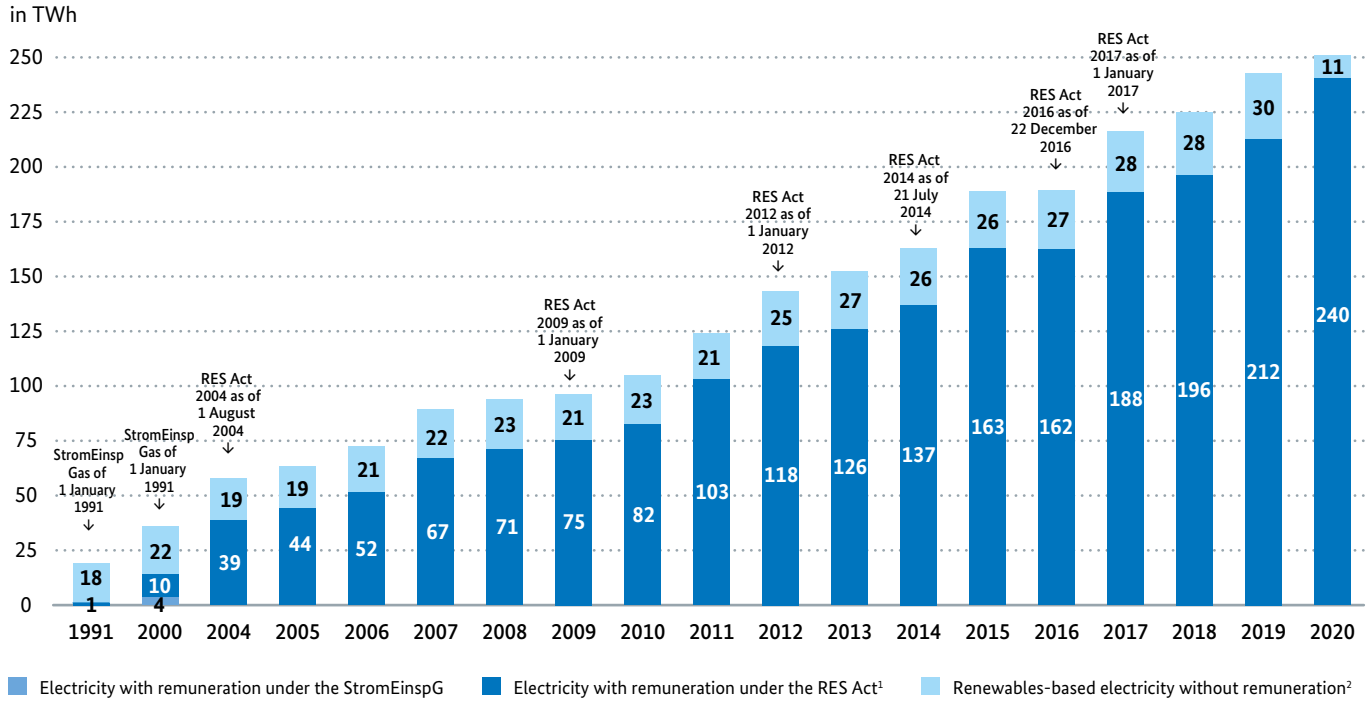
## Volumes of electricity quantities pursuant to the Renewable Energy Sources Act

Since the introduction of the RES in 2000, electricity generation from renewable energy has risen steadily: from 36 to 251 terawatt-hours in 2020. In 2020, this positive development was driven in roughly equal parts by wind energy and photovoltaics (PV). These two energy sources also contributed the largest shares of renewable electricity generation in 2020, at 52% (wind) and 20% (PV). Wind energy was also able to expand its position as the most important energy source in the German electricity mix.

However, not all electricity from renewable energy sources is subsidised under the RES. For example, large hydropower plants and conventional power plants that co-fire biomass are not eligible for remuneration. The electricity volumes remunerated via the RES are therefore only a part of the total electricity generated from renewable sources, as Figure 30 shows. RES-remunerated electricity generation has increased since 2000 from about 10 to 240.4 terawatt-hours in 2020.

Further information can be found on the websites of the information platform of the German transmission system operators at www.netztransparenz.de (in German only) and on the "Renewable Energies Information Platform" of the Federal Ministry for Economic Affairs and Energy www.erneuerbare-energien.de (in German only).

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




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

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

## Landlord-to-tenant electricity

If a solar power system on an apartment building does not feed the electricity generated into the public grid but passes it on directly to the tenants in the same building or neighborhood, this solar power is also called “landlord-to-tenant electricity supply”.

If the solar system on the roof produces more electricity than the tenants need, this electricity is fed into the public grid. If the rooftop system delivers too little or no solar power because the sun is not shining, the tenants are supplied from the public grid. The solar power and the grid power are bundled in a tenant power tariff. However, it is always up to the tenants to decide whether to use the tenant electricity tariff offered or to opt for a different electricity provider.

Unlike electricity purchased from the public grid, landlord-to-tenant electricity supply does not incur costs such as grid fees, surcharges or electricity tax. However, the additional meters, acquisition and billing, for example, result in higher costs for the landlord-to-tenant electricity supply provider. The EEG surcharge must also be paid for landlord-to-tenant electricity supply. To compensate for the higher costs, there is therefore a subsidy for each kilowatt-hour of landlord-to-tenant electricity supply, the so-called tenant electricity surcharge. This surcharge was introduced with the RES 2017 and is intended to make landlord-to-tenant electricity supply more economically attractive for landlords and tenants.

So far, the expansion of tenant electricity systems has fallen short of expectations, as the Government’s tenant electricity report [33] makes clear. With the RES 2021, the subsidy conditions were improved. The tenant electricity surcharge was increased and the regulation on plant aggregation was relaxed. As a result, the economic efficiency can be further improved, especially for larger ten-

ant electricity systems. In addition, so-called neighborhood solutions are now possible. This means that, under certain conditions, buildings in the surrounding area can also be supplied with landlord-to-tenant electricity supply. The introduction of the so-called "supply chain model" now makes it easier to claim the tenant electricity surcharge even if the tenant electricity is supplied by third parties.

The amount of the tenant electricity surcharge is based on the date of commissioning of the plant and then applies for a period of 20 years. As with the feed-in tariff, the amount of the tenant electricity surcharge is subject to degression according to the so-called breathing cap, i.e., it changes depending on the expansion. In January 2021, the tenant electricity surcharge for new installations ranged from 2.37 cents/kWh (100 kW) to 3.79 cents/kWh (10 kW). The electricity not consumed by tenants is fed into the general supply grid and remunerated according to the feed-in tariff applicable at the time of commissioning. The changes for tenant electricity systems in the RES 2021 apply to new systems that go into operation on or after 01 January 2021.

The potential for solar power generation on rental buildings is far from exhausted. A 2017 study commissioned by the BMWi on the topic of tenant electricity concludes that up to 3.8 million apartments could in principle be supplied with landlord-to-tenant electricity supply. This corresponds to around 18% of rented apartments. According to evaluations by the Federal Network Agency, more than 23 megawatts of photovoltaic tenant electricity systems have been installed in Germany since the introduction of tenant electricity subsidies in July 2017 until the end of April 2021 [33].

Further up-to-date information on the topic of landlord-to-tenant electricity supply can be found at www.bmwi-energiewende.de and on the website of www.bundesnetzagentur.de (both websites in German only).

## The renewable energy surcharge (EEG surcharge)

Electricity generation from renewable energy sources is funded under the Renewable Energy Sources Act (RES). The difference between the remuneration rates of installation operators for electricity generation regulated under the RES, and the sales value of the generated electricity on the electricity exchange is passed on to the consumers via the EEG surcharge (EEG is the German abbreviation for RES). It is a state-imposed component of the electricity price.

The remuneration for electricity from wind, solar and biomass plants depends on the size of the plant

- either via statutory remuneration rates (in this case, the renewable electricity is sold by the transmission system operators on the electricity exchange),
- or via a competitively determined market premium, which in the case of large plants is also determined via tenders. This compensates for the difference between the remuneration rate and the average electricity exchange price if the operator sells the electricity directly on the market.

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

Since the RES guarantees compensation over 20 years, the EEG surcharge finances a "cost backpack" in the form of compensation payments to existing installations. In this context, the existing plants of earlier years were installed with significantly higher compensation rates than newer plants and thus account for a large part of this "backpack". Since the beginning of EEG funding, but especially

since the introduction of market premiums in the RES 2014, the costs of renewable energy have fallen noticeably in many cases, so that new PV plants, for example, require significantly lower compensation. The further expansion of renewable energy is therefore taking place at increasingly lower cost.

This development is supported by the auction procedure introduced in the RES 2017 by determining remuneration rates for new RES plants on a competitive basis. Since 2017, the auctions for photovoltaic installations, for onshore wind-powered installations, and for biomass installations have resulted in remuneration rates that have fallen, in some cases significantly. In addition, the actions enabled quantity control, which ensures effective compliance with expansion targets. This makes the further expansion of renewable energy sources more plannable, reliable and, above all, more cost-effective.

Further information can be found at www.bundesnetzagentur.de (in German only).

The Federal Government's 2030 Climate Action Program envisages that the financing requirements resulting from the RES will increasingly be covered by federal budget funds from 01 January 2021 and in subsequent years. In this way, the federal government has initiated a system change on the financing side to ease the burden on electricity prices, which will benefit all electricity consumers.

The EEG surcharge is published annually on October 15 by the transmission system operators for the following calendar year.

As an example, the transmission system operators determined the EEG surcharge for the current calendar year 2021 as of 15 October 2020, based on the following measures: The EEG surcharge in this calendar year is derived from a forecast of revenues and expenses in 2021, taking into consideration the account balance on 30 September 2020. For the first time, revenues from a federal subsidy are also taken into account. The federal subsidy of €10.8 billion for 2021 is made up of funds from the economic stimulus package and revenue from the new national $CO_2$ price.

To calculate the EEG surcharge, it is therefore first necessary to determine the aggregate EEG surcharge. This is made up of four 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 (account balancing). Less the federal subsidy, this results in the RES levy amount. Further information on how the forecast is calculated of can be found on the grid operators' EEG information platform www.netztransparenz.de (in German only).

In 2021, the forecast funding requirement is €26.4 billion. In consideration of the account balance on 30 September 2020, as well as the liquidity reserve and the federal subsidy, this results in a forecast surcharge amount of €22.3 billion.

Together with the (forecast) surcharge-relevant final consumption of around 343 billion kilowatt hours, this results in the 2021 EEG surcharge of 6.5 cents per kilowatt hour (EEG surcharge without federal subsidy: 9.651 cents per kilowatt hour). Compared with the previous year, it fell by 0.265 cents/kWh. Thus, since 2014, the surcharge has ranged between 6.24 cents/kWh (2014) and to 6.88 cents/kWh (2018). However, this stable level for 2021 could only be guaranteed by the federal subsidy. Without this subsidy, the surcharge would have increased significantly because, due to the Corona pandemic in 2020, both electricity demand and prices on the electricity exchange collapsed

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

with serious consequences for the financing of the RES. First, RES costs were significantly higher in 2020 than expected for reasons discussed earlier. The resulting deficit on the RES account was offset when the surcharge was set in 2021. Secondly, the sales value of the funded electricity in 2021 was estimated to be lower at the time the surcharge was set.

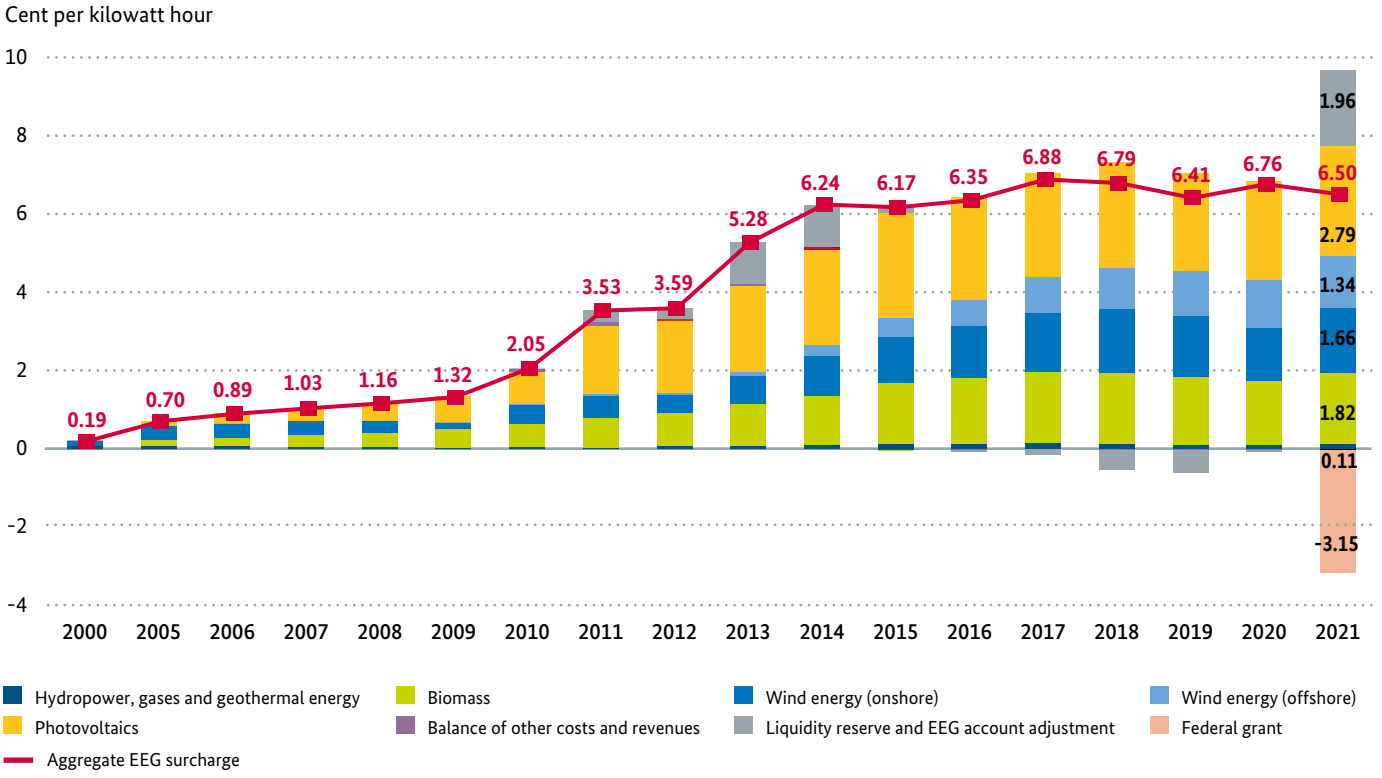
$$\text{EEG-surcharge} = \frac{\text{aggregate EEG surcharge}}{\text{final consumption subject to the EEG surcharge}}$$

More detailed information on the calculation of the forecast can be found on the grid operators' EEG information platform www.netztransparenz.de (in German only).

Based on the forecast aggregate EEG surcharge of 9.651 cents/kWh (excluding federal subsidy) in 2021, the shares of remuneration per energy source were distributed as follows: 29% photovoltaic installations, 19% biomass installations, 17% onshore wind-powered installations, and 14% offshore wind-powered installations. The surcharge shares of the liquidity reserve and the account balance account for about 21% of the remuneration costs [34].

As described above, the RES thus basically obliges electricity supply companies and auto producers to pay the EEG surcharge. The electricity supply companies then pass on the costs incurred by them to the electricity consumers. However, there are good reasons for partially exempting internationally competing electricity-cost-intensive companies and the railroads from paying the EEG surcharge. In order to limit the impact of the EEG surcharge on the international competitiveness of electricity-cost-intensive companies and on the intermodal competitiveness of railroads (i.e., competitiveness vis-à-vis other mobility options), the "special equalisation scheme" was introduced in 2004.

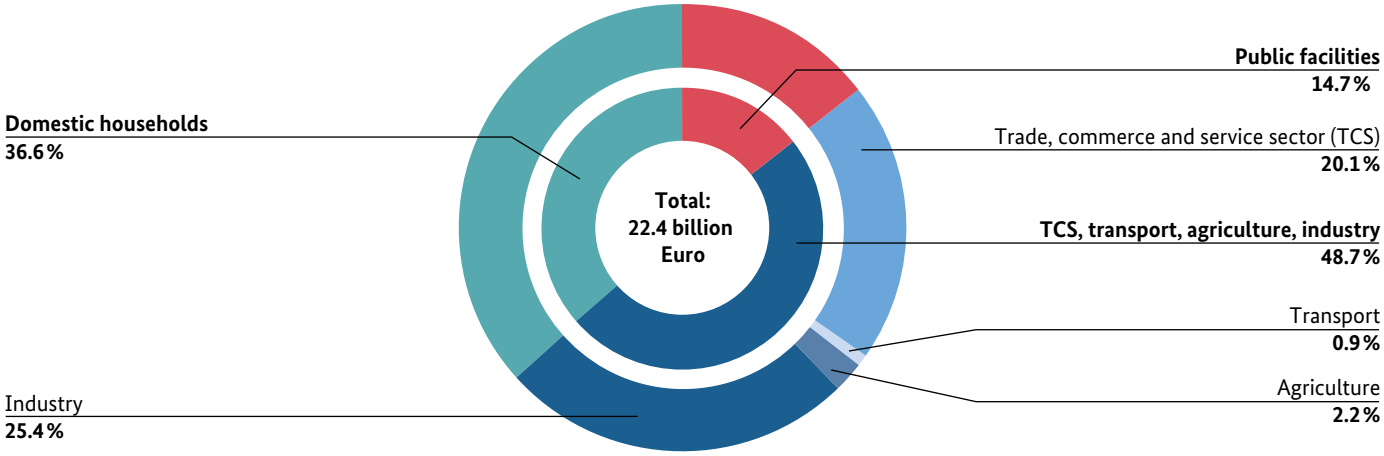
## Figure 31: Development of the renewable energy surcharge (EEG surcharge)




For the years 2001 to 2009, calculated EEG differential costs of all electricity suppliers based on the annual settlements of the transmission system operators (TSOs) with assumptions on the average value of EEG electricity. From 2010 TSO forecast of the EEG surcharge according to the Renewable Energy Ordinance, published on www.netztransparenz.de

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

Figure 32: Financing contribution of the EEG surcharge 2021 based on the October 2020 forecast




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

In 2020, 2,051 companies (1,903 manufacturing / 148 railroads) benefited from the special equalisation scheme [35]. These companies applied for partial exemption for a total electricity consumption of around 115.2 terawatt-hours. This amount corresponds to around 24% of total final consumption in Germany (= net electricity consumption minus self-generated and self-consumed electricity). Privileged companies also pay a proportional EEG surcharge, the amount of which depends on the company's specific situation. In any case, companies benefiting from the special equalisation scheme always participate in the financing of renewable energy.

Overall, the German economy (industry, commerce, trade and services, transport and agriculture) finances just under half of the EEG surcharge, private households around one third and public institutions the remaining share [8]. Irrespective of this, the relief measures result in the EEG surcharge being higher for all non-privileged final consumers.

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

### Renewable energy as an economic factor

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

The development of the investment as a stimulus to the economy reflects both the scale of new capacity construction and the cost development of the individual technologies. The record figure for investment in renewable energy installations was recorded in 2010 at just under €28 billion. Following this, investment dropped to just under €13.9 billion in 2015, and rose again to €15.8 billion in 2017, only to fall back to €10.5 billion in 2019. In 2020, investments rose again slightly to €11.0 billion. Germany continues to benefit strongly from these investments as a business location, since a large part of the value added in the manufacture and installation of these plants is generated in this country [36].

The significant decline in total investments after 2010 was primarily based on the development in the photovoltaics sector. In 2011 and 2012, installa-

tion prices fell, while new installations were added unabated. From 2013 onward, however, PV additions declined significantly while prices remained largely stable. While investments in PV systems still accounted for between 39 and 70% of total investments in the years 2007 to 2012, this share fell to between 9 and 11% in the years 2014 to 2017 after which the PV share grew again to 38.3% or €4.2 billion in 2020.

While investments in photovoltaic installations increased significantly in recent years, those in onshore wind power plants showed an opposite trend from 2017 to 2019. In 2020, there were again more investments in onshore wind turbines. However, investments in offshore wind-powered installations decreased significantly. After completion of the last installations designed and built before the introduction of auctions, a gap exists until the implementation of the surcharged installations awarded in the 2017 and 2018 auctions. Their commissioning is scheduled to take place from 2022 to 2025.

The increase in heat pumps, wood heating and solar thermal systems – supported by the "Heating with renewable energy sources" subsidy program – developed very positively in 2020. In addition to offshore wind energy, investments in hydropower and biomass installations also declined compared with the previous year. Together, investments in the aforementioned areas amounted to €4.8 billion in 2020, or just under 44% of total investments.

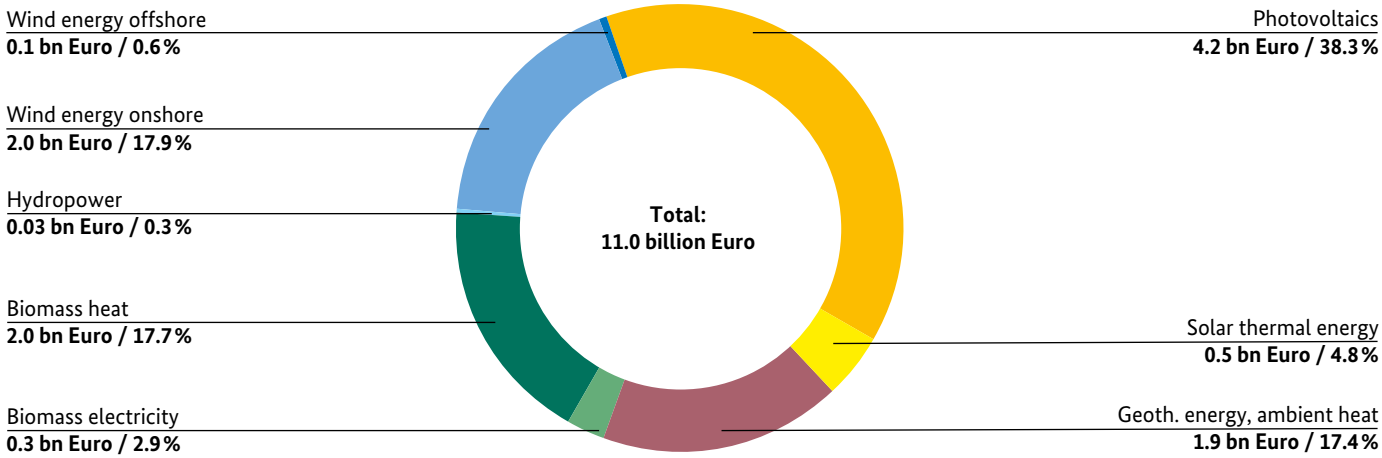
At 60%, electricity generating installations funded under the RES still account for the lion's share of the investments shown. Compared with the previous year, this share decreased by a good 10 percentage points.

## Figure 33: Investment in the building of renewable energy installations

| | Hydropower | Wind energy onshore | Wind energy offshore | Photo-voltaics | Solar thermal energy | Geoth. energy, ambient heat | Biomass electricity | Biomass heat | Total |
|---|---|---|---|---|---|---|---|---|---|
| | (billion €) | | | | | | | | |
| **2000** | 0.5 | 1.9 | 0 | 0.3 | 0.4 | 0.1 | 0.5 | 0.9 | **4.7** |
| **2005** | 0.2 | 2.5 | 0 | 4.8 | 0.6 | 0.4 | 1.9 | 1.5 | **12.0** |
| **2006** | 0.2 | 3.2 | 0 | 4.0 | 1.0 | 0.9 | 2.3 | 2.3 | **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 | 1.2 | 2.0 | 1.8 | **17.7** |
| **2009** | 0.5 | 2.8 | 0.5 | 13.6 | 1.5 | 1.1 | 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** | 0.09 | 7.1 | 3.9 | 1.5 | 0.8 | 1.1 | 0.7 | 1.4 | **16.4** |
| **2015** | 0.08 | 5.4 | 3.7 | 1.5 | 0.8 | 1.0 | 0.2 | 1.3 | **13.9** |
| **2016** | 0.06 | 6.9 | 3.4 | 1.6 | 0.7 | 1.2 | 0.3 | 1.2 | **15.3** |
| **2017** | 0.05 | 7.3 | 3.4 | 1.7 | 0.5 | 1.3 | 0.3 | 1.2 | **15.8** |
| **2018** | 0.06 | 3.3 | 4.1 | 2.6 | 0.5 | 1.5 | 0.4 | 1.2 | **13.7** |
| **2019** | 0.05 | 1.5 | 2.1 | 3.4 | 0.4 | 1.4 | 0.4 | 1.2 | **10.5** |
| **2020** | 0.03 | 2.0 | 0.1 | 4.2 | 0.5 | 1.9 | 0.3 | 2.0 | **11.0** |

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

## Figure 34: Investment in the building of renewable energy installations, 2020




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

### Permanent impulses from plant operations

In addition to investment, plant operation and maintenance also has considerable economic importance. Due to the attendant need for personnel, electricity (ancillary energy), replacement parts and fuel, operating and maintaining installations sends economic impulses to other sectors as well. The operating costs incurred by the operator lead to corresponding amounts of revenue, not least for suppliers. The economic stimulus from operation has risen steadily in past years in tandem with the increasing number of installations. For example, since 2000, revenues have risen steadily, climbing from just under €2 billion to over €18 billion in 2020. This means that the economic stimulus from installation operation has exceeded investment in installations since 2015 – and significantly so in recent years.

In contrast to other renewable energy installations, biomass installations require fuel to generate electricity and heat. The costs of this mean that the largest proportion of the total economic stimulus derives from the operation of biomass installations. It is followed by stimulus from the sale of biofuels for transport. Further stimuli derive from the operation of wind energy installations, geothermal and environmental heat recovery installations, PV, solar thermal, and hydropower installations. These economic stimuli (operating costs or revenues from the sale of biofuels) provide a long-term boost to the economy, as the costs are incurred over the entire life of the installations (in the case of electricity funded under the RES Act, mostly 20 years) and increase as more plants are installed.

In 2020, just over half of the economic stimulus deriving from plant operations was triggered by electricity generation installations, 30% from heat generation installations, and 19% from revenues from biofuel sales for transport. The development of these shares mainly reflects the increasing stock of power generation installations. In 2000, heat generation installations accounted for two-thirds of the total, while electricity and fuels accounted for 22 and 11% respectively. Since then, the share of electricity generation installations has grown to about 50% while that of heat generating plants has fallen to about 30%. The share of fuels rose briefly in the interim to as much as 43% in 2006 due to sales, and then leveled off at 16 to 19%.

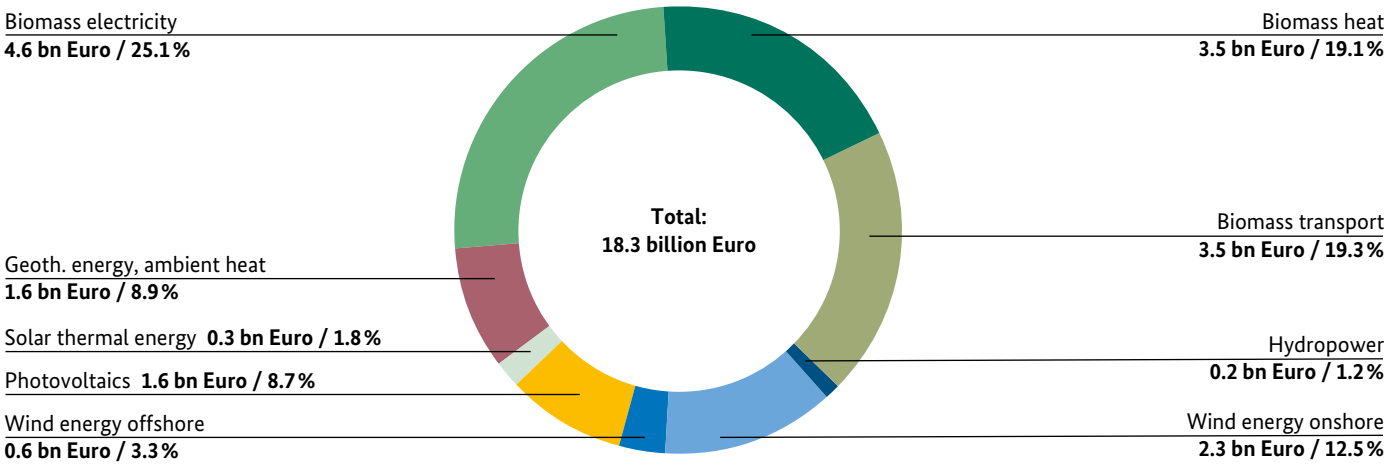
For information on the methodology used, see the “Information on methodology” section.

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

| | Hydro-power | Wind energy onshore | Wind energy offshore | Photo-voltaics | Solar thermal energy | Geoth. energy, ambient heat | Biomass electricity | Biomass heat | Biomass fuels | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | (billion €) | | | | | | | | | |
| **2000** | 0.1 | 0.2 | 0 | 0.01 | 0.00 | 0.2 | 0.2 | 1.1 | 0.2 | **1.9** |
| **2005** | 0.1 | 0.6 | 0 | 0.1 | 0.05 | 0.2 | 0.7 | 1.5 | 1.8 | **5.1** |
| **2006** | 0.1 | 0.6 | 0 | 0.2 | 0.07 | 0.3 | 1.1 | 1.7 | 3.2 | **7.3** |
| **2007** | 0.1 | 0.7 | 0 | 0.3 | 0.1 | 0.4 | 1.6 | 2.0 | 3.8 | **8.9** |
| **2008** | 0.2 | 0.8 | 0 | 0.4 | 0.1 | 0.4 | 1.9 | 2.2 | 3.5 | **9.5** |
| **2009** | 0.2 | 0.9 | 0.01 | 0.5 | 0.1 | 0.5 | 2.3 | 2.5 | 2.4 | **9.4** |
| **2010** | 0.2 | 1.0 | 0.02 | 0.8 | 0.2 | 0.6 | 2.8 | 2.9 | 2.9 | **11.3** |
| **2011** | 0.2 | 1.1 | 0.03 | 1.0 | 0.2 | 0.7 | 3.2 | 2.9 | 3.7 | **13.0** |
| **2012** | 0.2 | 1.2 | 0.06 | 1.3 | 0.2 | 0.8 | 3.9 | 3.1 | 3.7 | **14.4** |
| **2013** | 0.2 | 1.4 | 0.1 | 1.4 | 0.2 | 0.9 | 4.0 | 3.3 | 3.1 | **14.6** |
| **2014** | 0.2 | 1.6 | 0.2 | 1.4 | 0.2 | 1.0 | 4.3 | 3.0 | 2.6 | **14.6** |
| **2015** | 0.2 | 1.7 | 0.3 | 1.4 | 0.3 | 1.1 | 4.4 | 3.2 | 2.4 | **15.0** |
| **2016** | 0.2 | 1.9 | 0.4 | 1.4 | 0.3 | 1.2 | 4.4 | 3.4 | 2.6 | **15.7** |
| **2017** | 0.2 | 2.1 | 0.4 | 1.5 | 0.3 | 1.3 | 4.5 | 3.4 | 2.7 | **16.3** |
| **2018** | 0.2 | 2.2 | 0.5 | 1.5 | 0.3 | 1.4 | 4.5 | 3.4 | 2.7 | **16.7** |
| **2019** | 0.2 | 2.3 | 0.6 | 1.5 | 0.3 | 1.5 | 4.6 | 3.5 | 2.8 | **17.3** |
| **2020** | 0.2 | 2.3 | 0.6 | 1.6 | 0.3 | 1.6 | 4.6 | 3.5 | 3.5 | **18.3** |

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

## Figure 36: Economic impetus from the operation of renewable energy installations, 2020




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 2019: approximately 299,700 people were employed in the renewable energy sector that year. This was around 11,500 people fewer than in the previous year (311,200 people).

If the development in employment is broken down by technology, differing developments between the years 2000 and 2019 emerge. These are mainly related to the way the roll-out of the various technologies has taken place. For example, employment in onshore wind energy rose to around 134,700 people by 2016, and then – despite an increasing proportion of exports – fell by around 38% within three years to approximately 83,200 people as fewer turbines have been installed in Germany. The same trend is evident in offshore wind energy. For example, the number of employees rose to 28,700 in 2016 and then fell by around 22% to approximately 22,500 people in 2019 due to the halt in the expansion of offshore wind energy.

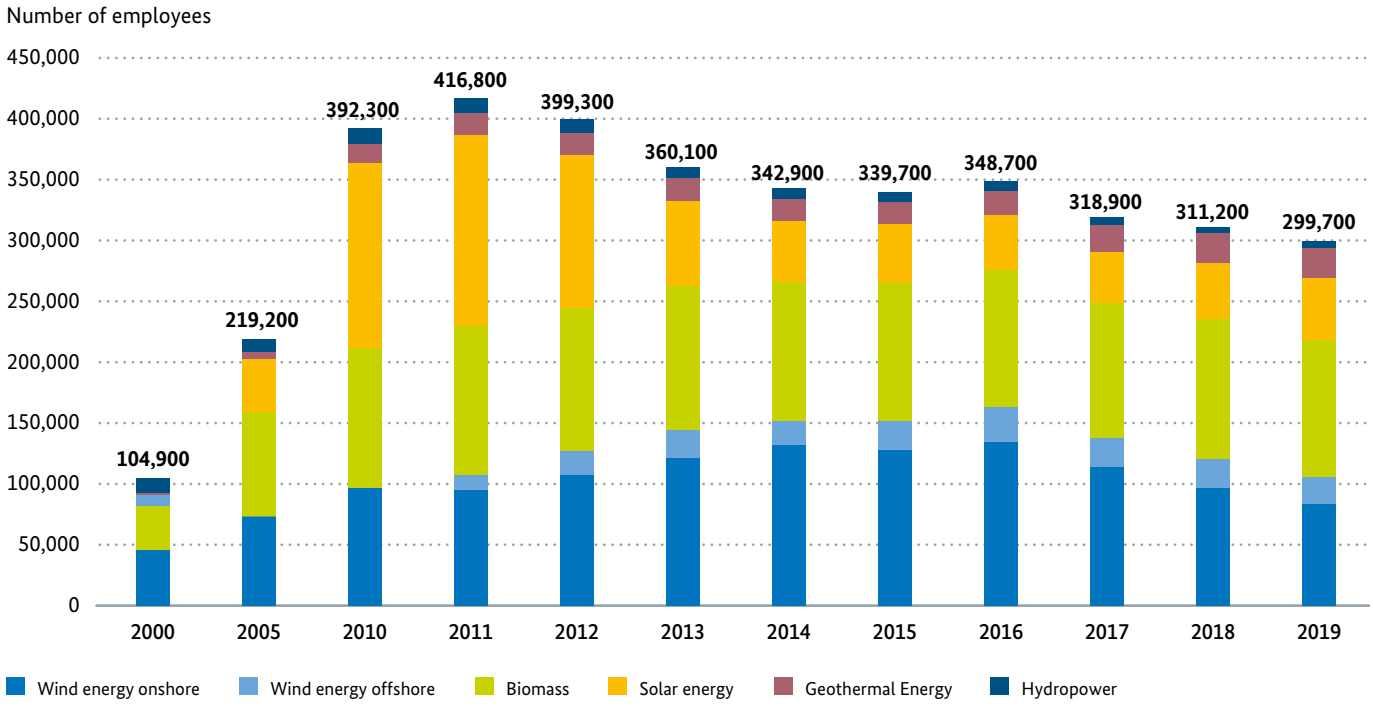
The use of biomass use involves a wide range of technologies, some of which developed very differently during the reference period. Following an initial increase, employment remained at a relatively steady level in these fields, contributing about 37% (about 112,100 people) of total employment in the field of renewable energy in 2019.

The greatest fluctuations between 2000 and 2019 were seen in employment in solar energy. Following a very sharp rise in employment until 2011, when solar energy accounted for the largest share of renewable energy employment at 38% (156,700 people), the numbers fell by over 70% in the period up to 2017. It was not until 2018 that this trend was halted, when rising amounts of installations of photovoltaics resulted in a renewed increase in the number of people working in the sector. Some 51,700 people were working in the solar energy sector in 2019.

In 2019, geothermal accounted for about 8% of employment, with a relatively steady rate of employment attained since 2000 after an initial rise.

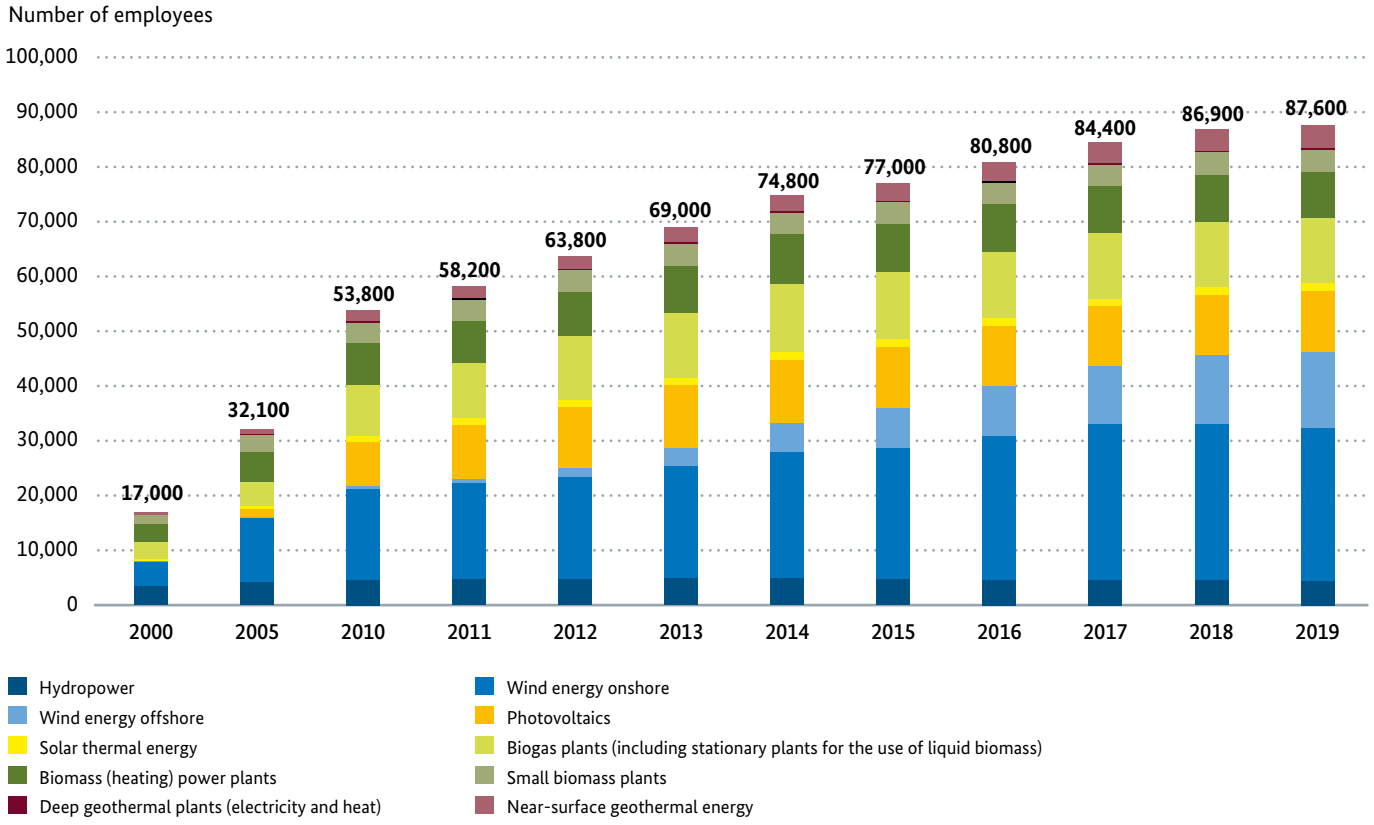
In the field of hydropower, in contrast, the technology and the related industry were already very mature in 2000, so that the employment trend has

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




Sources: DIW, DLR, GWS [37]

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




Sources: DIW, DLR, GWS [37]

tended to decline. In 2019, hydropower contributed only about 2% of total employment in renewable energy sources, with 5,700 people. Some of the decline in total employment in plant construction was offset by rising employment in the operation and maintenance of renewable energy installations.

Overall, as recently as 2000, only about 17,000 people were employed in the operation and maintenance of renewable energy installations, with employment relatively evenly distributed among onshore wind energy (27%), hydropower (20%), biomass (combined heat and) power plants (19%), and biogas installations (18%). In 2019, employment from operation and maintenance of renewable energy installations was already five times higher, totaling 87,600 people, and was dominated by onshore wind energy (32%), offshore wind energy (16%), biogas plants (14%), and photovoltaics (13%). Biomass (combined heat and) power plants still contributed 10% to employment. Small-scale biomass plants, hydropower, and likewise near-surface geothermal and ambient heat each still accounted for just under 5%, and solar thermal about 2%. Deep geothermal plants are still at a low level of expansion to date, so the resulting employment contributes less than 1% to the total [37].

# Legislation and promotion of renewable energy in the heating sector

## Buildings Energy Act

The Buildings Energy Act (GEG), which entered into force on 01 November 2020, merged the former Energy Conservation Act (EnEG), the former Energy Conservation Ordinance (EnEV) and the former Renewable Energies Heat Act (EEWärmeG) into one law. The aim, through a coordinated set of regulations, is to facilitate application and enforcement of energy requirements for new buildings, for existing buildings and for the use of renewable energy to supply heating and cooling to buildings.

Within the framework of the GEG, the EU requirements for the energy performance of buildings are implemented and the regulations for ultra-low energy buildings are integrated into the unified energy conservation law. The law retains the current energy standards for new construction and refurbishment.

As with the Renewable Energies Heat Act, the new GEG also requires that the heating requirements for new buildings be covered proportionately by renewable energy. A new feature is the recognition of electricity from renewable energy as an option for meeting the requirements. Electricity from renewable energy sources can thus contribute to meeting the heating and cooling requirements of buildings in the same way as solar thermal energy, for example. The new GEG will continue to offer the possibility to use substitute measures instead of renewable energy sources as well as to combine different measures.

General information and practical examples can be found on the homepage of the German Energy Agency (dena) under the topic portal "Zukunft Haus" www.zukunft-haus.info (in German only).

Further information on the topic of energy conservation in the building sector is available from the Federal Institute for Research on Building, Urban Affairs and Spatial Development www.bbsr.bund.de and on the BBSR topic portal www.bbsr-energieeinsparung.de (in German only).

### Previous promotion measures: The Market Incentive Programme

The Market Incentive Programme (MAP) is a funding program of the German Federal Ministry for Economic Affairs and Energy to promote measures for the use of renewable energy sources in the heating market. Private individuals, companies, municipalities and non-profit organizations are eligible to apply. The MAP comprised two funding components, depending on the type and size of the investment measure, administered by the following responsible agencies: The Federal Office for Economic Affairs and Export Control (BAFA) made investment grants for the promotion of predominately small installations with an output of up to 100 kW in the areas of solar thermal energy, biomass and heat pumps. The "Renewable Energies Premium" program of the Kreditanstalt für Wiederaufbau (KfW) provides funding for large solar thermal installations, biomass heating plants, certain efficient heat pumps, biogas pipelines, deep geothermal systems, local heating networks for heat from renewable energy sources (subordinate to Combined Heat and Power Act funding), and large thermal storage systems for heat from renewable energy via low-interest loans in conjunction with attractive repayment grants. MAP was partially integrated into the "Federal Support for Efficient Buildings" (BEG) at the beginning of 2021 (former BAFA part of MAP). For more information on funding in the BEG, please visit the BMWi website www.deutschland-machts-effizient.de (in German only).

The "Guidelines on the funding of measures to use renewable energy in the heating market" on which the MAP is based had been comprehensively amended as of 1 January 2020 before being largely transferred to the BEG at the beginning of 2021. From 01 January to 31 December 2020, the BAFA portion of the MAP applied percentage-based incentive rates of 20% for gas condensing boilers to be retrofitted to incorporate renewable energy within two years ("Renewable Ready"), 30% for gas hybrid systems, and 35% for systems based entirely on renewable energy. At the same time, the so-called "oil exchange premium" adopted in the 2030 climate protection program was integrated into the MAP. The funding rates were increased by up to 10 percentage points for the replacement of an old oil heating system and the installation of an efficient new heating system based on renewable energy.

Since 2000, approximately 2.4 million installations have received nearly €7.8 billion under the MAP (BAFA and KfW funding programs). By adjusting the support measures, around €3.2 billion were approved in 2020 alone. To date, the MAP was one of the most important instruments for the expansion of renewable energy in the heating market.

In the investment grants section (BAFA), around 1.2 million solar thermal installations were funded between 2000 and 2020 with investment grants

totalling around €1.5 billion, and around 472,000 smaller biomass heating systems, e.g., pellet boilers, were funded in the amount of €979 million. The resulting induced investments came to about €10.7 billion in the solar thermal funding segment and around €6.9 billion in the biomass segment.

By the year 2020, efficient heat pump heating systems, which have been eligible for funding since 2008, saw investment grants totalling around €602 million paid out in around 182,000 funding cases. The induced investment volume amounted to around €3.1 billion.

An overview of the applications approved for funding measures for the use of renewable energy sources in the heating market in 2020 is shown in Figure 39.

In the other funding component of the MAP, the KfW "Renewable Energy Sources – Premium" programme, low-interest loans with repayment funding were approved for around 28,200 larger projects in the years 2000 to 2020. The total volume of loans granted was around €3.7 billion and the volume of repayment funding around €980 million.

An overview of the purposes for which the repayment grant (TGZ) were committed in 2020 is shown in Figure 40.

### New support measures: Federal support for efficient buildings (BEG)

The "Federal Support for Efficient Buildings" (BEG), which came into force successively in 2021, completely restructures and further develops energy-related building support in implementation of the

Figure 39: Market incentive program, share from Federal Office for Economic Affairs and Export Control (BAFA)-Program „Heizen mit erneuerbaren Energien", Investment grants 2020

| | Number of approvals | Approved funds [€] |
|---|---|---|
| Pure renewable energy systems | 166,410 | 2,739,765,264 |
| Gas hybrid | 29,967 | 481,630,652 |
| Renewable Ready | 281 | 1,224,424 |
| **Total** | **196,658** | **3,222,620,340** |
| Of which is oil exchange in existing buildings | 88,300 | 1,830,053,301 |

Source: Federal Ministry for Economic Affairs and Energy

Figure 40: Market incentive Program, KfW-Program part „Erneuerbare Energien – Premium" 2020

| | Number of approvals, KfW part | Partial loan commitment | committed TGZ volume |
|---|---|---|---|
| Solar collector systems | 17 | 7,290 | 4,195 |
| Solid biomass combustion plant | 51 | 4,574 | 1,081 |
| Biomass heating systems | 44 | 2,902 | 553 |
| CHP biomass plant | 1 | 255 | 6 |
| Heating networks | 1,352 | 60,734 | 34,651 |
| Biogas pipeline for raw biogas | 11 | 4,588 | 1,382 |
| Large heat storage | 79 | 12,261 | 4,248 |
| EE-renewable heat storage | 150 | 6,292 | 3,400 |
| Geothermal energy | 1 | 82 | 18 |
| Others | 2 | 20,000 | 7,705 |
| **Total** | **1,708** | **118,978** | **57,239** |

Source: Federal Ministry for Economic Affairs and Energy

Climate Protection Programme 2030. The BEG combines the previous building funding programmes into a single funding program and develops them further in line with the target group:

1. the $CO_2$ building renovation program, implemented through the KfW "Energy-efficient construction and renovation" (EBS) programmes,

2. the MAP program implemented by BAFA as the "Heating with Renewable Energy" incentive program,

3. the Energy Efficiency Incentive Programme (APEE), and

4. the Heating Optimization Programme (HZO).

5. das Heizungsoptimierungsprogramm (HZO).

The BEG will reduce the complexity of the funding landscape and thus the bureaucratic burden with the aim of achieving even stronger incentives for investments in energy efficiency and renewable energy in the future, thus making a decisive contribution to achieving the 2030 energy and climate targets in the building sector.

In addition, the BEG brings together the promotion of energy efficiency and renewable energy under one roof for the first time. For new buildings and complete renovations, the use of renewable energy sources will be rewarded even more. In addition, there are new funding offers for particularly ambitious refurbishments and new buildings. Furthermore, sustainability certificates recognized by the German Federal Ministry of the Interior, for Construction and Home Affairs (BMI) will also be taken into account in the investment funding. At the same time, funding for digitization measures to optimize energy operation and consumption will be expanded ("Efficiency Smart Home").

In addition, the BEG also offers more flexibility: To best meet the respective individual needs of funding recipients, funding is offered in the form of both grants and loans.

An overview of funding programs can be found on the BMWi website "Deutschland-macht's-effizient" www.deutschland-machts-effizient.de; (in German only) and on the websites of BAFA www.bafa.de; (in German only) and KfW (www.kfw.de) (in German only).

## Promotion of renewable energy in transport

### Biofuels for transport

Biofuels were initially subsidised exclusively via tax concessions in Germany.

The first biofuel report of the Federal Ministry of Finance [25] found that considerable overfunding had occurred in 2006, as the tax refund was much higher than the difference in production costs. For this reason, biofuel funding was shifted to a purely regulatory basis [39], [40]. The new biofuel quota introduced in this context required the oil industry to market a minimum proportion of biofuels – in terms of a company's total annual sales of gasoline, diesel and biofuel – on the market. From 2010 to 2014, the overall quota stood at 6.25% (in terms of energy content), the sub-quotas for biofuel substituting diesel fuel were 4.4% (energy content) and for biofuel substituting gasoline 2.8% (energy content). From 2011, it was possible to give certain biofuels (particularly biofuels produced from wastes and residues) a double weighting when calculating the biofuel quota.

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

As of 01 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% in 2015 and 2016, 4.0% in 2017-2019, and 6.0% from 2020 [44]. This is also intended to ensure that the target for the use of biofuels and electro 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 methodological notes in the Annex).

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

## Electric mobility

E-mobility is a key technology for creating a clean and efficient transportation system. To achieve the climate targets, at least seven to ten million electric vehicles should be on Germany's roads by 2030. In addition, one million charging points are to be available in the same period. To support this, the Government has adopted various funding measures, including the 2030 Climate Action Program. Since 2009, funding of around €5 billion has already been made available and framework conditions have been set to make electric mobility more attractive.

To accelerate demand in the electric mobility market, the Government adopted a package of measures in 2016 with an investment volume of just under €1 billion. The increase in the Government's premium by €2 billion to just under €3 billion approved by the coalition committee on 03 June 2020, will enable around 300,000 more electric vehicles to be funded by 31 December 2021. With the introduction of the innovation premium, the Government has doubled its share of the purchase premium for a limited period until the end of 2021 and made it possible to fund newer used cars. An extension of the innovation premium beyond 2021 is planned.

Three financially effective measures are at the forefront of the funding of electric mobility: time-limited purchase incentives (environmental bonus or innovation premium), the expansion of the charging infrastructure, and the public procurement of electric vehicles.

In the case of the purchase premium for e-cars, the environmental bonus, buyers of vehicles with a net list price of less than €40,000 will now receive a total of €9,000 for pure electric cars with the innovation premium including the manufacturer's share of €3,000, and a total of €6,750 for plug-in hybrids including the dealer's share of €2,250. For vehicles with a net list price of over €40,000, the premium amounts to a total of €7,500 for pure electric cars and €5,625 for plug-in hybrids. The innovation premium applies to vehicles registered on or after June 4, 2020 and is currently limited until December 31, 2021 (www.bmwi.de). Car buyers can submit their applications to the Federal Office for Economic Affairs and Export Control (BAFA) (www.bafa.de; in German only). This has given additional momentum to electromobility. As a result, 846,735 applications have been submitted to the Federal Office for Economic Affairs and Export Control (BAFA) so far as of October 2021. The frontrunners were pure battery electric vehicles with 468.186 applications, followed by plug-in hybrid vehicles with 378.336 applications and fuel cell vehicles with 213 applications [40].

As a result, registrations of e-cars are also on the rise. E-mobility has become more prevalent than ever in Germany in 2020, despite a roughly 20% drop in registrations in the year of the COVID 19 pandemic. According to the Federal Motor Transport Authority (KBA), the number of newly registered electric passenger vehicles (BEVs) almost tripled in 2020 (+206.8). Their share rose by 4.9 percentage points to 6.7%. Higher increases were seen only in plug-in hybrid passenger cars (+342.1), whose share rose to around 6.9%. A total of 394,940 new cars with electric drive systems were registered in 2020 [41].

Another key element for strengthening demand for electric mobility is the expansion of the charging infrastructure. The Government is providing €300 million for this purpose: €200 million for fast-charging infrastructure and €100 million for normal-charging infrastructure.

The publicly accessible charging stations in Germany reported under the Charging Station Ordinance (LSV) are published by the Federal Network Agency at www.bundesnetzagentur.de (in German only). As of August 2021, 41,239 normal charging points and 6,845 fast charging points had been registered with the Federal Network Agency. 18,963 charging points had at least two publicly accessible charging points, and 534 charging points had 4 charging points [42].

In addition, further tax incentives for electric vehicles have been in place since the beginning of 2020, such as special depreciation allowances for e-utility vehicles and cargo bikes, as well as a reduced tax base for the taxation of electric company cars. In addition, if employees charge their electric vehicle at their employer's premises, this no longer constitutes a non-cash benefit.

Extensive information on energy-efficient mobility and funding measures can also be found at www.deutschland-machts-effizient.de (in German only).

In addition to promoting electric vehicles, the BMWi is supporting the development of battery cell production and associated value chains in Germany and Europe together with other EU countries. To this end, the BMWi is providing almost €3 billion in funding. Most of these funds will be used to support large-scale research and investment projects in two "important projects of common European interest" (IPCEI), which have already received state aid approval by the EU Commission. In these alliances, 14 EU member states are participating in the development of new environmentally friendly value creation in the EU. Among other things, the funding is intended to help increase the use of renewable energy in battery production and thus reduce the $CO_2$ lifecycle emissions of electric vehicles.

To provide in-depth support for the sustainability of battery production, in addition to the other topics of digitalization of battery production, testing & certification, and the application of new battery cell technologies, the BMWi published the funding call "Research in Priority Funding for Battery Cell Production" in March 2021 as part of the Government's 7th Energy Research Program. This new measure will promote the innovation base along the battery value chain to support the industrial production of sustainable battery cells of the highest quality in Germany.

Another funding measure flanking the IPCEIs, which serves to secure skilled labor in the growing battery industry, was launched in July 2021. It is intended to facilitate the transition of skilled workers to the battery industry through accompanying vocational qualification measures. This is to be achieved by setting up industry-specific and regionally oriented competence networks, so-called "battery competence trios", consisting of scientific institutions, educational institutions and an industry-specific innovation cluster.

Further information on the Government's support for electromobility can be found at www.bmwi.de.

## Promotion of renewable energy research and development

Energy research in Germany is intended to prepare a climate neutral energy system of the future and to ensure a reliable, affordable and environmentally sound energy supply in the future. It is a strategic element of the Government's energy policy, serves to implement energy industry and climate policy goals during the energy transition, and is thus the elementary instrument for defining the basic lines and priorities of funding policy.

The Government has been promoting the development of new technologies and applications for a modern energy supply since the 1970s with its ongoing energy research programs. This funding included renewable energy technologies early on and laid the foundation for their success. Since 2018, the current and now 7th energy research program has been running, comprehensively focused on promoting technical and non-technical innovations for the energy transition.

In 2020, the federal government invested €1.216 billion in energy research. This is an increase of around 6% compared to the previous year. Project funding accounted for €750.6 million of this. In total, the federal ministries supported 5,980 ongoing projects from taxpayers' money in 2020 and approved 1,590 new ones. In the area of non-nuclear energy research, companies contributed a total of €303.6 million to the financing of these research projects. A further €415.8 million were spent on the HGF's energy research within the framework of institutional funding from the Helmholtz Association (HGF) [43]. Ongoing and completed research projects related to the topic of "energy research" are published daily by the BMWi on the EnArgus Internet portal (www.enargus.de).

In the 7th Energy Research Program, the BMWi established "living laboratories of the energy transition" as a new funding format. To develop new energy technologies and business models – such as low-$CO_2$ hydrogen, energy-optimized neighborhoods or large-scale electricity storage – and bring them to market maturity, they must be tested in practice. This is to be done in "living laboratories of the energy transition". These are systemically designed cross-sectional projects in which different energy technologies and their interaction are tested on an industrial scale and in a real environment. The focus is on accelerating the transfer of innovations from the laboratories, test rooms and minds of scientists to energy industry practice and social life. The first energy transition living labs started in 2020, and until now, nine projects are already underway.

One example is the H2-Wyhlen living lab which started on 01 January 2021, in Grenzach-Wyhlen in Baden-Württemberg. There, electricity from a run-of-river power plant splits water into hydrogen and oxygen in an electrolysis plant. The hydrogen produced is available for various uses. With H2-Wyhlen, an existing power-to-hydrogen infrastructure is to be expanded into a test area with the adjacent neighborhood and industrial site: The priority here is to develop business models for the demand-based generation, local distribution and use of hydrogen in the various sectors and, if viable, to ultimately test them.

Since April 2021, the transfer research project Trans4ReaL has also been providing scientific support for the living laboratories of the energy transition with a focus on sector coupling and hydrogen technologies. The findings obtained in the project will subsequently be incorporated as options for action in a hydrogen roadmap of the Government.

More information on the topic of energy transition living labs can be found on the BMWi website www.energieforschung.de (in German only).

In addition to living labs which focus on the cross-sector networking of technologies, the BMWi also supports application-oriented research and development in the field of renewable power generation technologies which play a key role in the transformation of the energy supply. Universities, research institutions and companies are continuously working to further reduce the cost of generating electricity and other energy sources from renewable energy and to further develop or create secondary energy sources that are particularly reliable, efficient and durable.

In 2020, for example, the BMWi funded a total of 488 ongoing projects in the field of wind energy with around €76 million. In addition, 99 research projects were newly approved in this area with funding of around €65 million. One of these projects is "X-Wakes". In this research project, scientists are investigating which wake currents occur in the German Bight when offshore wind farms are expanded over large areas, and how these should be taken into account in the future design of offshore wind farms. This is because, given the limited usable area, offshore wind farms are built in groups (called clusters). As a result, the wind farms and the individual turbines influence each other. In the wind shadow behind the turbines, so-called wake currents with lower wind speeds and stronger turbulence occur.

The portal www.strom-forschung.de provides further information on the funding areas of non-nuclear energy provision via wind energy, photovoltaics, bioenergy, geothermal energy and hydropower/sea energy as well as thermal power plants. In addition, a separate website provides information on the promotion of biomass energy use www.energetische-biomassenutzung.de.

The following figure 41 shows the number of new research projects approved by the BMWi and the funds spent on them in the period from 2017 to 2020.

More information on the topic of energy research can be found on the BMWi website www.energie-forschung.de (in German only) and the Internet portal of the Energy Research Networks www.forschungsnetzwerke-energie.de.

Furthermore, information on funding topics and how to apply for research funding programs in the field of renewable energy can be found on the website of Projektträger Jülich, which is commissioned by the BMWi (www.ptj.de).

## Figure 41: Newly approved projects for renewable energy technologies

| | 2017 | | | 2018 | | | 2019 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | 1,000 Euro | Share in % | Number | 1,000 Euro | Share in % | Number | 1,000 Euro | Share in % | Number | 1,000 Euro | Share in % |
| Wind energy | 86 | 96,668 | 32.2 | 121 | 89,776 | 29.9 | 112 | 78,994 | 22.7 | 99 | 65,323 | 23.1 |
| Photovoltaics | 101 | 89,946 | 30.0 | 96 | 83,207 | 27.7 | 135 | 100,175 | 28.8 | 116 | 65,702 | 23.3 |
| Solar thermal power plants | 21 | 5,617 | 1.9 | 29 | 12,962 | 4.3 | 28 | 11,679 | 3.4 | 28 | 10,527 | 3.7 |
| Geothermal energy | 17 | 7,654 | 2.6 | 21 | 10,471 | 3.5 | 25 | 24,097 | 6.9 | 41 | 40,951 | 14.5 |
| Hydropower | 2 | 1,208 | 0.4 | 0 | 0 | 0.0 | 7 | 3,541 | 1.0 | 0 | 0 | 0.0 |
| Biomass | 42 | 5,987 | 2.0 | 47 | 9,097 | 3.0 | 69 | 16,959 | 4.9 | 38 | 7,726 | 2.7 |
| Electricity grids and grid integration renewable energy[1] | 85 | 53,214 | 17.8 | 135 | 67,247 | 22.4 | 136 | 59,182 | 17.0 | 123 | 51,677 | 18.3 |
| Energy storage | 61 | 22,264 | 7.4 | 24 | 10,969 | 3.7 | 57 | 28,170 | 8.1 | 50 | 25,551 | 9.0 |
| Energy system analysis and overarching questions of the energy transition | 39 | 17,188 | 5.7 | 64 | 16,646 | 5.5 | 60 | 24,751 | 7.1 | 34 | 15,132 | 5.4 |
| **Total** | **454** | **299,746** | **100** | **537** | **300,375** | **100** | **629** | **347,548** | **100** | **529** | **282,589** | **100** |

1 Integration of renewable energy and renewable energy supply systems

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

Source: Federal Ministry for Economic Affairs and Energy

# Data platforms of the Federal Network Agency

## Core market data register – data for the energy transition

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

The central objective of the core market data register (MaStR) is to simplify energy industry processes, while at the same time significantly increasing data quality. This will reduce the bureaucratic burden on citizens and companies. The design of the new overall register has been regulated by the Core Energy Market Data Register Ordinance (MaStRV) since 2017.

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

Installation operators need to register themselves and their installations in the register and are responsible for entering and curating their data. This also applies to all other market players. In this way, all electricity and gas system operators can be found in the register. The list of those obliged to register themselves includes electricity and gas suppliers, direct marketers and energy industry authorities, associations and institutions in the energy sector. A detailed description of who is obliged to register can be found in the help section of the online platform of the Core market data register.

The core energy market data register only contains core data: names, addresses, locations, categorisations, technologies, performance values, etc. It does not include the so-called “transaction data” associated with the energy activity of a market player or the processes within installations (e.g., production quantities, load flow data, or storage levels). A detailed description of which data is recorded can also be found in the help section of the register.

The core market data register of the German Federal Network Agency can be found with all background information at www.marktstammdaten-register.de/MaStR (in German only).

## SMARD Electricity Market Data

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

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

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

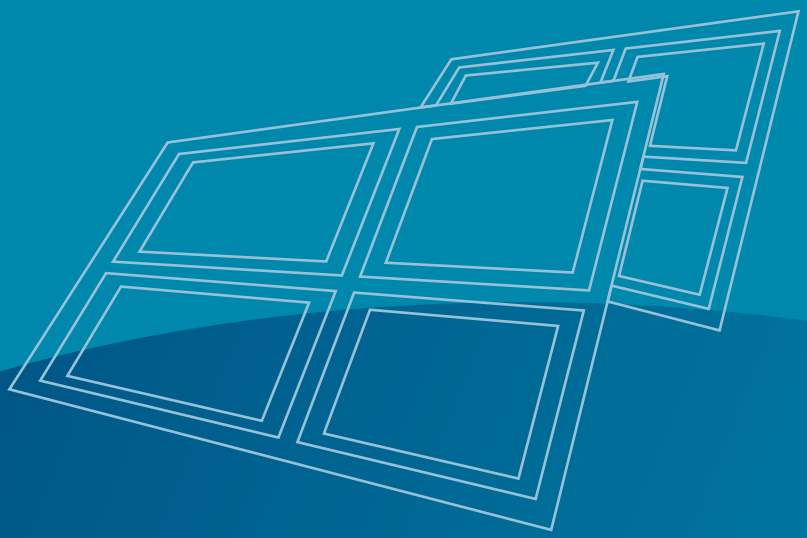
The market data visuals uses a map to show the geographical electricity generation situation in Germany. Further to this, other key variables like electricity consumption and international wholesale prices are mapped.

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

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

# Part II: Renewable energy in the European Union

*In June 2009, with Directive 2009/28/EC, a binding EU-wide framework for the expansion of renewable energy came into force for the first time: by 2020, renewable energy sources should cover 20% of gross final energy consumption in the EU. Directive (EU) 2018/2001 updated this target at the end of 2018: By 2030, the share of renewable energy in the EU's final energy consumption should now increase to at least 32%. Due to the increase in the EU climate target for 2030, which came into force in 2021 with a greenhouse gas reduction of 55% in 2030 compared to 1990 (formerly 40%), the EU target for the expansion of renewable energy for 2030 will have to be increased again. As part of its so-called "Fit for 55" package, the European Commission proposed an amendment to the Directive in July 2021 with a new overarching target of 40% for the share of renewable energy in gross final energy consumption. The proposal also increases existing sub-targets in the transport and heating sectors and introduces new indicative sub-targets for the use of renewable energy sources in the buildings and industry sectors.*



To underpin the expansion target, Directive 2009/28/EC also set binding national targets for the individual Member States based on the 2005 baseline figures. For Germany, this meant a national target of an 18% share of renewable energy sources in gross final energy consumption by 2020, whereby the calculation of the share follows certain rules. In particular, weather-related fluctuations in electricity generation from hydropower and wind energy are normalised, i.e., converted to average precipitation and wind conditions. The calculation of the achievement of the sub-target of 10% renewable energy sources in transport is also based on special rules (e.g., 2.5-fold crediting of the use of electricity from renewable energy sources in road transport).

Based on Directive 2009/28/EC and the assigned targets, Member States have submitted National Renewable Energy Action Plans ("NREAPs") to implement their targets and are required to report progress to the Commission every two years according to Article 22 of the Directive. The progress reports of the Member States are published on the website of the European Commission at https://ec.europa.eu The European Commission also prepares a progress report every two years in accordance with Article 23 of the Directive, documenting national progress towards the target achievement path set by the EU Directive. The most recent progress report, which refers to data from 2018, was published by the European Commission in October 2020 [44]. In it, the Commission noted that in 2018, 12 Member States already had RES shares above the 2020 target and a further 11 had already met or exceeded their indicative target path for 2017/18. The Commission concluded already in this report that the vast majority of Member States would meet their 2020 targets. Accordingly, the achievement of the overall target was considered realistic.

With Directive (EU) 2018/2001, a new version of the Renewable Energy Directive entered into force on 24 December 2018. Basically, it sets the goal of increasing the share of renewable energy sources in the EU's final energy consumption to at least 32% by 2030. In addition to common support regulations in the electricity sector, the directive also provides for measures in the heating and transport sectors. For example, the member states are to increase the share of renewable energy in the heating and cooling sector by 1.3 percentage points annually from 2021. In the transport sector, fuel distributors are obliged to increase the share of renewable fuels to 14% by 2030. This is to be ensured primarily through new technologies and fuels. The Commission's draft amendment to the directive, now proposed as part of the so-called "Fit for 55" package, provides for an increase in these targets and sub-targets, the introduction of new sub-targets in the buildings and industry sectors, and numerous other measures.

A framework for the new directive is provided by the European Regulation on the Governance of the Energy Union and Climate Action (Governance Regulation), which entered into force at the end of 2018. This introduced a new planning and monitoring tool for the implementation of the Energy Union objectives, in particular the EU 2030 energy and climate targets. Each EU Member State should submit an integrated National Energy and Climate Plan (NECP) for the next decade (2021-2030). In the NECPs, Member States must describe their national energy and climate policy goals, strategies and measures and formulate national target contributions to the EU 2030 targets. The Government submitted the German NECP to the Commission in summer 2020. It builds on the targets and measures of the 2010 Energy Concept, the 2030 Climate Action Plan and the 2050 Energy Efficiency Strategy. It contains the goals of the Federal Government to cut primary energy consumption by 30% by 2030 (from 2008) by boosting energy efficiency and increasing the proportion of renewable energy in gross final energy consumption to 30% by 2030. As of 2023, Member States are expected to submit NECP progress reports to the EU Commission every two years.

### The European "Green Deal"

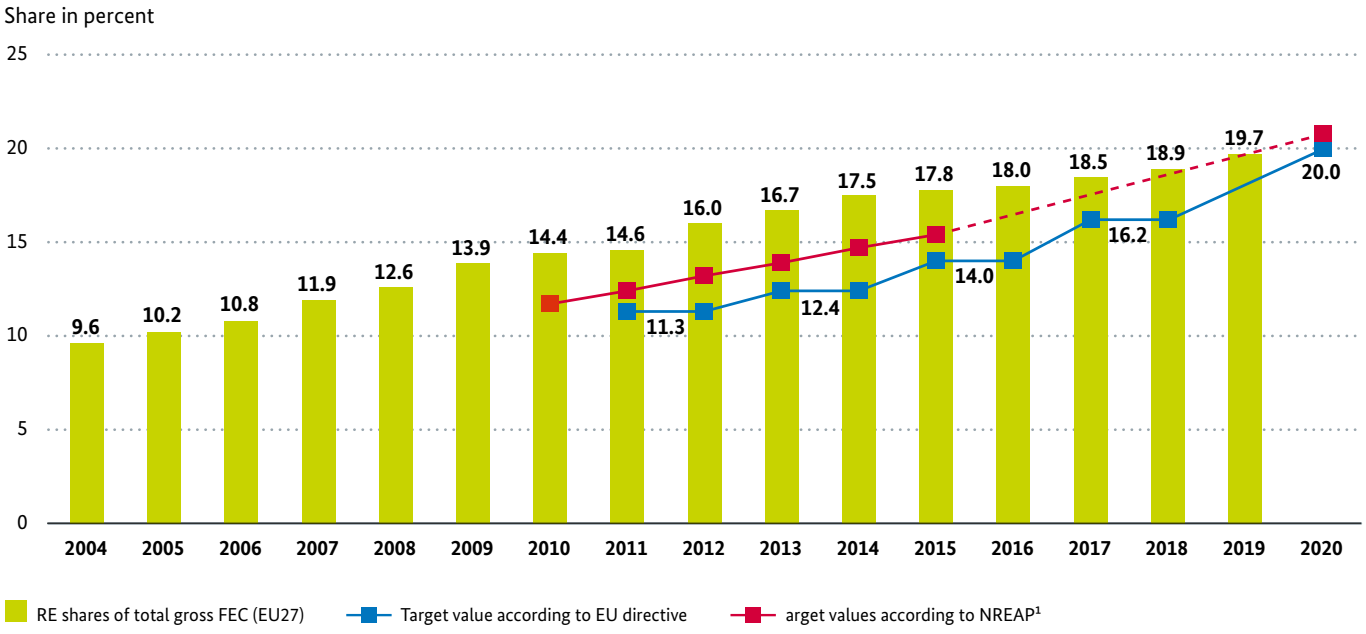
On 11 December 2019, the Commission presented its Communication on the European Green Deal. The Green Deal is the new growth strategy for the EU and aims to put the EU on a path to a climate neutral, fair and prosperous society with a modern, resource efficient and competitive economy. At the December 2019 European Council, EU Member State leaders took note of the Commission's Com-

munication on the Green Deal. By endorsing the EU's 2050 climate neutrality target in their conclusions, they reaffirmed the EU's determination to take a leading role in the global fight against climate change.

In December 2020, the European Council reaffirmed its commitment to the EU's green transition by adopting the new binding EU target to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. This was a significant increase on the original target agreed in 2014 to reduce emissions by at least 40% by 2030. With the new European Climate Law, the Commission has put forward a proposal to enshrine in law the 55% target, as well as the wider goal of climate neutrality by 2050 and to establish a framework necessary to achieve it. This is to ensure that all sectors of the economy and society contribute to reducing net emissions to zero by 2050. In April 2021, the Council and the European Parliament reached a preliminary agreement on the climate bill. This was adopted by the Parliament and the Council in June and entered into force on 29 July 2021.

With the "Fit for 55" package, the EU Commission presented a set of proposals on 14 July 2021 to revise and update climate and energy-related legislation. Against this backdrop, the Renewable Energy Directive (EU) 2018/2001 is also due to be revised again, as it must be adapted to the new overarching climate protection targets. Discussions on this at the European level will begin in September.

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




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

Sources: Eurostat (SHARES) [45]; Energy research Centre of the Netherlands (ECN), European Agency (EEA) [46]

**Notes:**

Some of the data on the generation and use of renewable energy sources in Germany provided in European and international statistics differ from the data provided by German sources. In addition to the different origin of the data, different accounting methods also play a role.

In the "Europe" section, the data for Germany are taken from the international statistics for reasons of con-

sistency. However, the more detailed data from the national sources on the preceding pages are generally more reliable.

The United Kingdom's withdrawal from the EU on 1 January 2021 is also associated with changes to the statistics on the use of renewable energy sources in the EU. Starting with the present edition of "Renewable energy sources in figures", the presentation is therefore for the EU-27 without the United Kingdom. Comparability with the data in the previous brochures is therefore only possible to a limited extent for the EU part.

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

| | RE shares of gross final energy consumption [%] | | | | | | RE shares of gross final energy consumption[1] [%] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2010 | 2017 | 2018 | 2019 | Target (2020) | 2005 | 2010 | 2017 | 2018 | 2019 |
| Austria | 24.4 | 31.2 | 33.1 | 33.8 | 33.6 | **13** | 62.9 | 66.4 | 71.6 | 74.2 | 75.1 |
| Belgium | 2.3 | 6.0 | 9.1 | 9.5 | 9.9 | **16** | 2.4 | 7.2 | 17.3 | 18.9 | 20.8 |
| Bulgaria | 9.2 | 13.9 | 18.7 | 20.6 | 21.6 | **30** | 8.7 | 12.4 | 19.0 | 22.4 | 23.5 |
| Croatia | 23.7 | 25.1 | 27.3 | 28.0 | 28.5 | **18** | 35.2 | 37.5 | 46.4 | 48.1 | 49.8 |
| Cyprus | 3.1 | 6.2 | 10.5 | 13.9 | 13.8 | **25** | 0.0 | 1.4 | 8.9 | 9.4 | 9.8 |
| Czech Republic | 7.1 | 10.5 | 14.8 | 15.1 | 16.2 | **38** | 3.8 | 7.5 | 13.7 | 13.7 | 14.0 |
| Denmark | 16.0 | 21.9 | 34.7 | 35.4 | 37.2 | **23** | 24.6 | 32.7 | 59.9 | 62.4 | 65.4 |
| Estonia | 17.4 | 24.6 | 29.2 | 30.0 | 31.9 | **18** | 1.1 | 10.3 | 17.0 | 19.7 | 22.0 |
| Finland | 28.8 | 32.3 | 40.9 | 41.2 | 43.1 | **16** | 26.9 | 27.7 | 35.2 | 36.8 | 38.1 |
| France | 9.6 | 12.7 | 15.9 | 16.4 | 17.2 | **17** | 13.7 | 14.8 | 19.9 | 21.1 | 22.4 |
| Germany | 7.2 | 11.7 | 15.5 | 16.7 | 17.4 | **20** | 10.6 | 18.2 | 34.6 | 37.8 | 40.8 |
| Greece | 7.3 | 10.1 | 17.3 | 18.1 | 19.7 | **40** | 8.2 | 12.3 | 24.5 | 26.0 | 31.3 |
| Hungary | 6.9 | 12.7 | 13.5 | 12.5 | 12.6 | **23** | 4.4 | 7.1 | 7.5 | 8.3 | 10.0 |
| Ireland | 2.8 | 5.8 | 10.5 | 10.9 | 12.0 | **11** | 7.2 | 15.6 | 30.1 | 33.3 | 36.5 |
| Italy | 7.5 | 13.0 | 18.3 | 17.8 | 18.2 | **10** | 16.3 | 20.1 | 34.1 | 33.9 | 35.0 |
| Latvia | 32.3 | 30.4 | 39.0 | 40.0 | 41.0 | **14** | 43.0 | 42.1 | 54.4 | 53.5 | 53.4 |
| Lithuania | 16.8 | 19.6 | 26.0 | 24.7 | 25.5 | **34** | 3.8 | 7.4 | 18.3 | 18.4 | 18.8 |
| Luxembourg | 1.4 | 2.9 | 6.2 | 9.0 | 7.0 | **15** | 3.2 | 3.8 | 8.1 | 9.1 | 10.9 |
| Malta | 0.1 | 1.0 | 7.2 | 8.0 | 8.5 | **31** | 0.0 | 0.0 | 6.8 | 7.7 | 8.0 |
| Netherlands | 2.5 | 3.9 | 6.5 | 7.3 | 8.8 | **24** | 6.3 | 9.6 | 13.8 | 15.2 | 18.2 |
| Poland | 6.9 | 9.3 | 11.1 | 11.5 | 12.2 | **49** | 2.7 | 6.6 | 13.1 | 13.0 | 14.4 |
| Portugal | 19.5 | 24.2 | 30.6 | 30.2 | 30.6 | **14** | 27.7 | 40.6 | 54.2 | 52.2 | 53.8 |
| Romania | 17.6 | 22.8 | 24.5 | 23.9 | 24.3 | **25** | 28.8 | 30.4 | 42.0 | 41.8 | 41.7 |
| Slovakia | 6.4 | 9.1 | 11.5 | 11.9 | 16.9 | **20** | 15.7 | 17.8 | 21.3 | 21.5 | 21.9 |
| Slovenia | 19.8 | 21.1 | 21.7 | 21.4 | 22.0 | **13** | 28.7 | 32.2 | 32.4 | 32.3 | 32.6 |
| Spain | 8.4 | 13.8 | 17.6 | 17.5 | 18.4 | **13** | 19.1 | 29.8 | 36.3 | 35.1 | 36.9 |
| Sweden | 40.3 | 46.6 | 54.2 | 54.7 | 56.4 | **13** | 50.9 | 55.8 | 65.9 | 66.2 | 71.2 |
| **Region EU-27** | **10.2** | **14.4** | **18.5** | **18.9** | **19.7** | **20** | **16.4** | **21.3** | **31.1** | **32.2** | **34.1** |

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

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

Source: Eurostat (SHARES) [45]

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

| | Renewable energy shares of gross final energy consumption in the heating/cooling sector [%] | | | | | RE shares of gross FEC for transport [%] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2010 | 2017 | 2018 | 2019 | 2005 | 2010 | 2017 | 2018 | 2019 | Target |
| Austria | 17.9 | 27.2 | 26.6 | 25.4 | 25.7 | 5.1 | 10.7 | 9.7 | 9.9 | 9.8 | All countries 10 % |
| Belgium | 3.4 | 6.7 | 8.1 | 8.3 | 8.3 | 0.7 | 4.8 | 6.6 | 6.7 | 6.8 | |
| Bulgaria | 14.3 | 24.3 | 29.9 | 33.3 | 35.5 | 0.9 | 1.5 | 7.3 | 8.1 | 7.9 | |
| Croatia | 30.0 | 32.9 | 36.6 | 36.7 | 36.8 | 1.0 | 1.1 | 1.2 | 2.6 | 5.9 | |
| Cyprus | 29.3 | 32.5 | 46.5 | 46.0 | 47.4 | 0.0 | 2.0 | 2.6 | 2.7 | 3.3 | |
| Czech Republic | 22.8 | 30.4 | 44.6 | 45.5 | 48.0 | 1.1 | 5.2 | 6.6 | 6.6 | 7.8 | |
| Denmark | 7.7 | 12.1 | 13.4 | 14.1 | 14.6 | 0.4 | 1.1 | 6.9 | 6.9 | 7.2 | |
| Estonia | 39.1 | 44.0 | 54.6 | 54.6 | 57.5 | 0.2 | 0.4 | 0.4 | 3.3 | 5.1 | |
| Finland | 9.9 | 18.1 | 19.9 | 18.2 | 18.1 | 0.9 | 4.4 | 18.8 | 17.7 | 21.3 | |
| France | 8.2 | 15.6 | 20.1 | 19.3 | 19.7 | 2.1 | 6.6 | 8.8 | 9.0 | 9.2 | |
| Germany | 32.2 | 43.2 | 51.7 | 53.7 | 52.3 | 4.0 | 6.4 | 7.0 | 7.9 | 7.7 | |
| Greece | 13.4 | 18.7 | 28.2 | 30.3 | 30.2 | 0.1 | 1.9 | 4.0 | 4.1 | 4.0 | |
| Hungary | 22.8 | 31.0 | 33.7 | 34.2 | 33.8 | 1.0 | 6.2 | 7.7 | 7.7 | 8.0 | |
| Ireland | 12.4 | 16.2 | 20.7 | 21.4 | 22.5 | 0.1 | 2.5 | 7.4 | 7.2 | 8.9 | |
| Italy | 42.7 | 40.7 | 54.6 | 55.4 | 57.8 | 1.0 | 4.9 | 6.5 | 7.7 | 9.0 | |
| Latvia | 3.6 | 4.7 | 7.5 | 8.5 | 8.7 | 2.4 | 4.0 | 2.3 | 4.7 | 5.1 | |
| Lithuania | 1.0 | 7.3 | 19.3 | 23.3 | 25.7 | 0.7 | 3.8 | 4.3 | 4.3 | 4.0 | |
| Luxembourg | 2.4 | 3.1 | 5.7 | 6.1 | 7.1 | 0.2 | 2.1 | 6.5 | 6.6 | 7.7 | |
| Malta | 10.2 | 11.8 | 14.9 | 15.1 | 16.0 | 0.0 | 0.0 | 6.8 | 8.0 | 8.7 | |
| Netherlands | 32.1 | 33.8 | 41.0 | 40.9 | 41.6 | 0.5 | 3.4 | 6.0 | 9.6 | 12.5 | |
| Poland | 49.8 | 58.5 | 65.8 | 65.3 | 66.1 | 1.7 | 6.6 | 4.2 | 5.7 | 6.1 | |
| Portugal | 5.0 | 7.9 | 9.8 | 10.6 | 19.7 | 0.5 | 5.5 | 7.9 | 9.0 | 9.1 | |
| Romania | 26.4 | 29.5 | 34.6 | 32.3 | 32.2 | 1.9 | 1.4 | 6.6 | 6.3 | 7.8 | |
| Slovakia | 10.8 | 14.1 | 19.7 | 20.6 | 22.6 | 1.7 | 5.3 | 6.9 | 7.0 | 8.3 | |
| Slovenia | 9.4 | 12.6 | 17.7 | 17.6 | 18.9 | 0.8 | 3.1 | 2.6 | 5.5 | 8.0 | |
| Spain | 3.4 | 4.3 | 6.6 | 6.3 | 6.3 | 1.3 | 5.0 | 5.8 | 6.9 | 7.6 | |
| Sweden | 10.0 | 18.8 | 26.5 | 37.2 | 35.1 | 6.6 | 9.6 | 26.8 | 29.7 | 30.3 | |
| **Region EU-27** | **12.4** | **17.0** | **20.9** | **21.2** | **22.1** | **2.0** | **5.5** | **7.5** | **8.3** | **8.9** | |

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

Source: Eurostat (SHARES) [45]

## Estimate of the shares of renewable energy in Germany in 2020 according to Directive 2009/28/EC

Initial estimates and calculations indicate that in Germany renewable energy made up 19.2% of gross final energy consumption in 2020, based on the calculation method set out in EU Directive 2009/28/EC. Compared to the previous year, this represents an increase of almost two percentage points (2019: 17.4%). Germany thus clearly exceeded its target of 18% set under the directive.

## Renewables-based electricity generation in the EU

In 2005, the share of renewable energy sources in the total gross electricity consumption of the EU-27 was only 16.3% [45]. The National Action Plans, which the Member States were required to submit within the framework of Directive 2009/28/EC, were however already clearly oriented towards an expansion of renewable energy in the electricity sector. In total, they envisaged a doubling of the share of gross electricity consumption covered by renewable energy in the EU by 2020 (from 2005).

## Figure 45: 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

| | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | | | | | | | |
| RES share in GFEC electricity | 10.6 | 18.2 | 20.9 | 23.6 | 25.3 | 28.2 | 30.9 | 32.3 | 34.6 | 37.8 | 40.8 | |
| RES share in GFEC heating/cooling | 7.7 | 12.1 | 12.6 | 13.4 | 13.4 | 13.4 | 13.4 | 13.0 | 13.4 | 14.1 | 14.6 | |
| RES share in GFEC transport | 4.0 | 6.4 | 6.5 | 7.3 | 7.3 | 6.9 | 6.6 | 7.0 | 7.0 | 7.9 | 7.7 | |
| **RES share in total GFEC** | **7.2** | **11.7** | **12.5** | **13.5** | **13.8** | **14.4** | **14.9** | **14.9** | **15.5** | **16.7** | **17.4** | **19.2** |

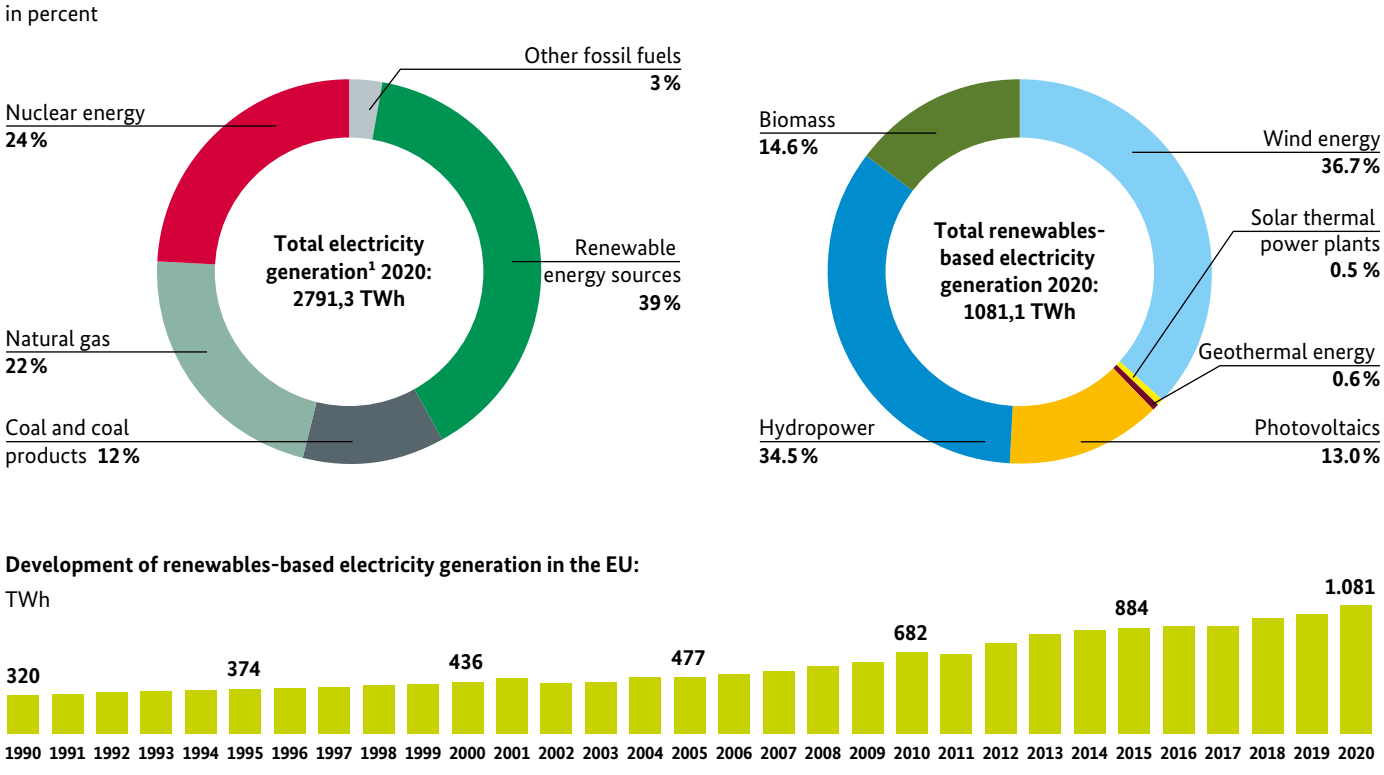
1 This overview is based on currently available statistics. At the time of the editorial deadline, the figure for the RES share of total gross final energy consumption was provisional for 2019.

Source: Eurostat (SHARES) [45]

This target was clearly exceeded in 2020, as the expansion of renewable energy sources in the electricity sector progressed much more quickly than in the heating and transport sectors. Thus, in the EU-27, 1,081 terawatt-hours of electricity were generated from combined renewable sources in 2020 (2005: 477 terawatt-hours), which makes for 38.5% of total gross electricity generation.

While in 2005 hydropower still dominated electricity generation from renewable energy sources with a share of more than 70%, in 2020 wind energy (36.7%) was ahead of hydropower (34.5%) for the first time. This was followed by biomass (14.6%) and photovoltaics (13%).

## Figure 46: Electricity generation in the EU-27, 2020




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

Sources: Eurostat (Production of electricity and derived heat by type of fuel) [47], figure for 2020 provisional based on the "Early Estimates" (Eurostat) [48]

## Figure 47: Electricity generation from renewable energy sources in the EU-27

| | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019[4] | 2020[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (TWh) | | | | | | | | | | | |
| Biomass[1] | 70.1 | 111.6 | 119.0 | 132.9 | 139.2 | 144.3 | 149.4 | 151.2 | 153.7 | 155.7 | 159.9 | 158.3 |
| Hydropower[2] | 348.4 | 401.3 | 332.8 | 359.6 | 396.7 | 398.6 | 363.2 | 372.7 | 322.5 | 370.3 | 345.3 | 373.3 |
| Wind energy | 71.0 | 139.8 | 165.3 | 187.5 | 209.5 | 222.4 | 263.2 | 266.8 | 312.3 | 320.5 | 367.1 | 397.1 |
| Geoth. energy | 5.4 | 5.6 | 5.9 | 5.8 | 6.0 | 6.3 | 6.6 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 |
| Photovoltaics | 1.5 | 22.5 | 45.3 | 66.4 | 79.3 | 88.7 | 95.3 | 95.5 | 102.0 | 110.5 | 120.0 | 140.2 |
| Solar thermal | 0.0 | 0.8 | 2.0 | 3.8 | 4.8 | 5.5 | 5.6 | 5.6 | 5.9 | 4.9 | 5.7 | 5.0 |
| Ocean energy | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| RE total | 496.9 | 682.0 | 670.9 | 756.4 | 835.8 | 866.2 | 883.8 | 899.0 | 903.6 | 968.9 | 1.005.3 | 1.081.1 |
| **RE share of gross electricity consumption[3]** | **14.9 %** | **22.8 %** | **22.8 %** | **25.7%** | **28.6 %** | **30.3 %** | **30.5 %** | **30.7 %** | **30.6 %** | **32.8 %** | **34.5 %** | **38.5 %** |
| | (TWh) | | | | | | | | | | | |
| EU-gross final electricity generation | 3,316.0 | 2,985.4 | 2,941.8 | 2,939.1 | 2,921.1 | 2,861.5 | 2,906.8 | 2,928.3 | 2,961.0 | 2,945.3 | 2,908.9 | 2,791.3 |
| Import | 335.1 | 291.5 | 321.1 | 349.5 | 332.1 | 363.7 | 387.6 | 362.5 | 366.6 | 372.3 | 369.4 | 381.1 |
| Export | 319.4 | 286.6 | 320.1 | 342.7 | 333.9 | 368.7 | 394.3 | 361.9 | 371.1 | 363.5 | 366.5 | 367.9 |

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

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

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

4 This overview reflects the current status of available statistics (until 2019 EUROSTAT, generation of electricity and derived heat by fuel), 2020 EUROSTAT (Early Estimates, provisional data).

Sources: Eurostat (Production of electricity and derived heat by type of fuel) [47]; Early Estimate (Eurostat) [48]

With 257.2 terawatt-hours (Calculated according to the EU Directive), Germany alone contributed almost 24% to the total electricity generation from renewable energy in the EU-27 in 2020. It was followed by France with 130.2 terawatt-hours and, close behind, Italy (117.9), Spain (116.4) and Sweden (109.1 terawatt-hours).

In the course of the current expansion of renewable energy, installed capacity is rising faster than electricity generation. This is due to the fact that wind and solar technologies have lower full-load hours than hydropower plants, which until a few years ago dominated the stock of renewable energy electricity generation capacity. Thus, the installed capacity of renewable energy sources in the EU-27 rose from 172 gigawatts in 2005 to 481 gigawatts at the end of 2020. While hydropower still dominated in 2005 with two-thirds of the installed capacity at that time, wind energy was already clearly in the lead at the end of 2020 with almost 37% of the installed capacity – followed by photovoltaics with almost 29% and hydropower with 27%.

## Figure 48: Electricity generation from renewable energy sources in the EU-27, 2020

| | Hydro-power[1] | Wind energy | Solid biomass[2] | Biogas[3] | Liquid biogenic fuels | Photo-voltaics | Solar thermal power plants | Geoth. energy | Ocean energy | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | (TWh) | | | | | | | | | |
| Austria | 45.3 | 6.8 | 4.0 | 0.6 | 0.0001 | 2.0 | - | 0.0001 | - | 58.8 |
| Belgium | 1.3 | 12.9 | 4.3 | 1.0 | 0.02 | 5.0 | - | - | - | 24.4 |
| Bulgaria | 3.3 | 1.5 | 1.5 | 0.2 | - | 1.5 | - | - | - | 8.0 |
| Croatia | 5.8 | 1.7 | 0.6 | 0.4 | - | 0.1 | - | 0.1 | - | 8.7 |
| Cyprus | - | 0.2 | - | 0.1 | - | 0.3 | - | - | - | 0.6 |
| Czech Republic | 3.4 | 0.7 | 2.6 | 2.6 | - | 2.2 | - | - | - | 11.6 |
| Denmark | 0.02 | 16.4 | 5.2 | 0.7 | - | 1.2 | - | - | - | 23.5 |
| Estonia | 0.03 | 0.8 | 1.5 | 0.03 | - | 0.1 | - | - | - | 2.5 |
| Finland | 15.9 | 7.9 | 11.1 | 0.3 | 0.001 | 0.3 | - | - | - | 35.5 |
| France | 66.7 | 40.7 | 5.8 | 2.8 | 0.0001 | 13.6 | - | 0.1 | 0.5 | 130.2 |
| Germany | 24.9 | 131.0 | 17.1 | 33.0 | 0.4 | 50.6 | - | 0.2 | - | 257.2 |
| Greece | 3.4 | 9.3 | 0.02 | 0.3 | - | 4.4 | - | - | - | 17.5 |
| Hungary | 0.2 | 0.7 | 1.8 | 0.3 | - | 2.5 | - | 0.02 | - | 5.5 |
| Ireland | 1.2 | 11.5 | 0.7 | 0.2 | - | 0.06 | - | - | - | 13.7 |
| Italy | 48.6 | 18.7 | 6.8 | 8.2 | 4.7 | 24.9 | - | 6.0 | - | 117.9 |
| Latvia | 2.6 | 0.2 | 0.5 | 0.3 | - | 0.005 | - | - | - | 3.6 |
| Lithuania | 1.1 | 1.6 | 0.4 | 0.1 | - | 0.1 | - | - | - | 3.4 |
| Luxembourg | 1.1 | 0.3 | 0.3 | 0.1 | - | 0.2 | - | - | - | 2.0 |
| Malta | - | 0.0001 | - | 0.01 | - | 0.2 | - | - | - | 0.2 |
| Netherlands | 0.05 | 15.3 | 7.9 | 0.9 | - | 8.0 | - | - | - | 32.2 |
| Poland | 2.9 | 15.8 | 7.0 | 1.2 | 0.002 | 2.0 | - | - | - | 28.9 |
| Portugal | 14.0 | 12.3 | 3.5 | 0.3 | - | 1.7 | - | 0.2 | - | 31.9 |
| Romania | 15.7 | 6.9 | 0.4 | - | - | 1.7 | - | - | - | 24.8 |
| Slovakia | 4.7 | 0.004 | 1.0 | 0.5 | - | 0.7 | - | - | - | 6.9 |
| Slovenia | 5.2 | 0.01 | 0.2 | 0.1 | 0.01 | 0.4 | - | - | - | 5.9 |
| Spain | 33.9 | 56.3 | 4.8 | 0.8 | 0.01 | 15.6 | 5.0 | - | 0.03 | 116.4 |
| Sweden | 71.8 | 27.5 | 8.8 | 0.01 | 0.01 | 1.0 | - | - | - | 109.1 |
| **EU 27** | **373.3** | **397.1** | **98.1** | **55.1** | **5.1** | **140.2** | **5.0** | **6.7** | **0.5** | **1081.1** |

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.

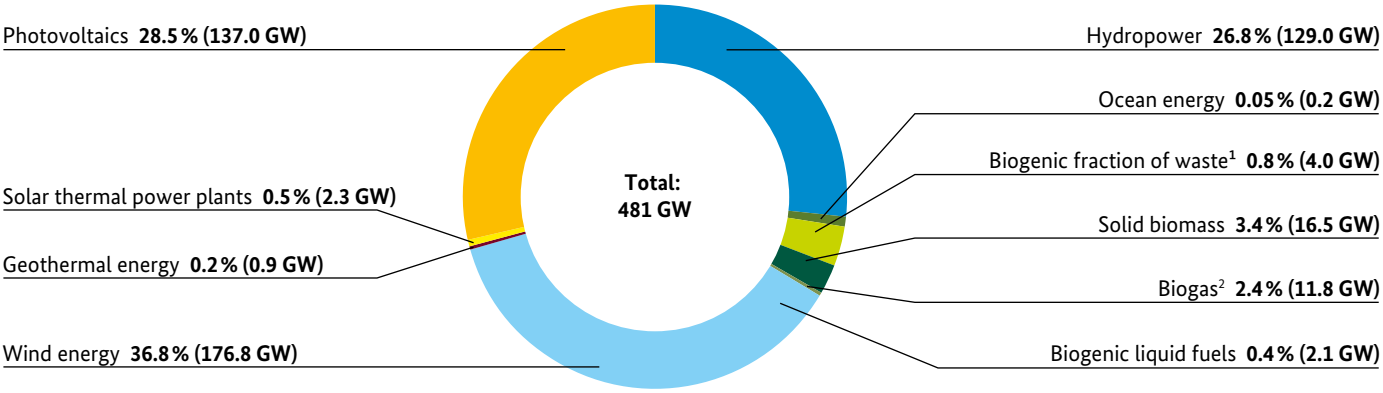
1 In the case of pumped storage power plants, power generation from natural inflow only

2 Including the biogenic share of municipal waste

3 Including sewage and landfill gas

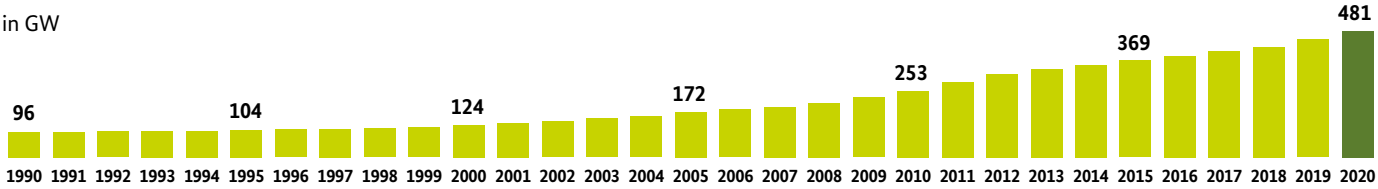
Source: Eurostat (Production of electricity and derived heat by type of fuel) [47]

## Figure 49: Total installed renewables-based electricity generation capacity in the EU-27, 2020




**Development of installed capacity for renewables-based electricity generation in the EU:**

in GW




If the annual yield of a production plant is divided by its rated capacity, you get the number of hours that the same production plant would theoretically have to be operated at full output to achieve their annual energy yield on the balance sheet.

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

2 Including landfill gas and sewage gas

Source: Eurostat [49]

## Wind energy use

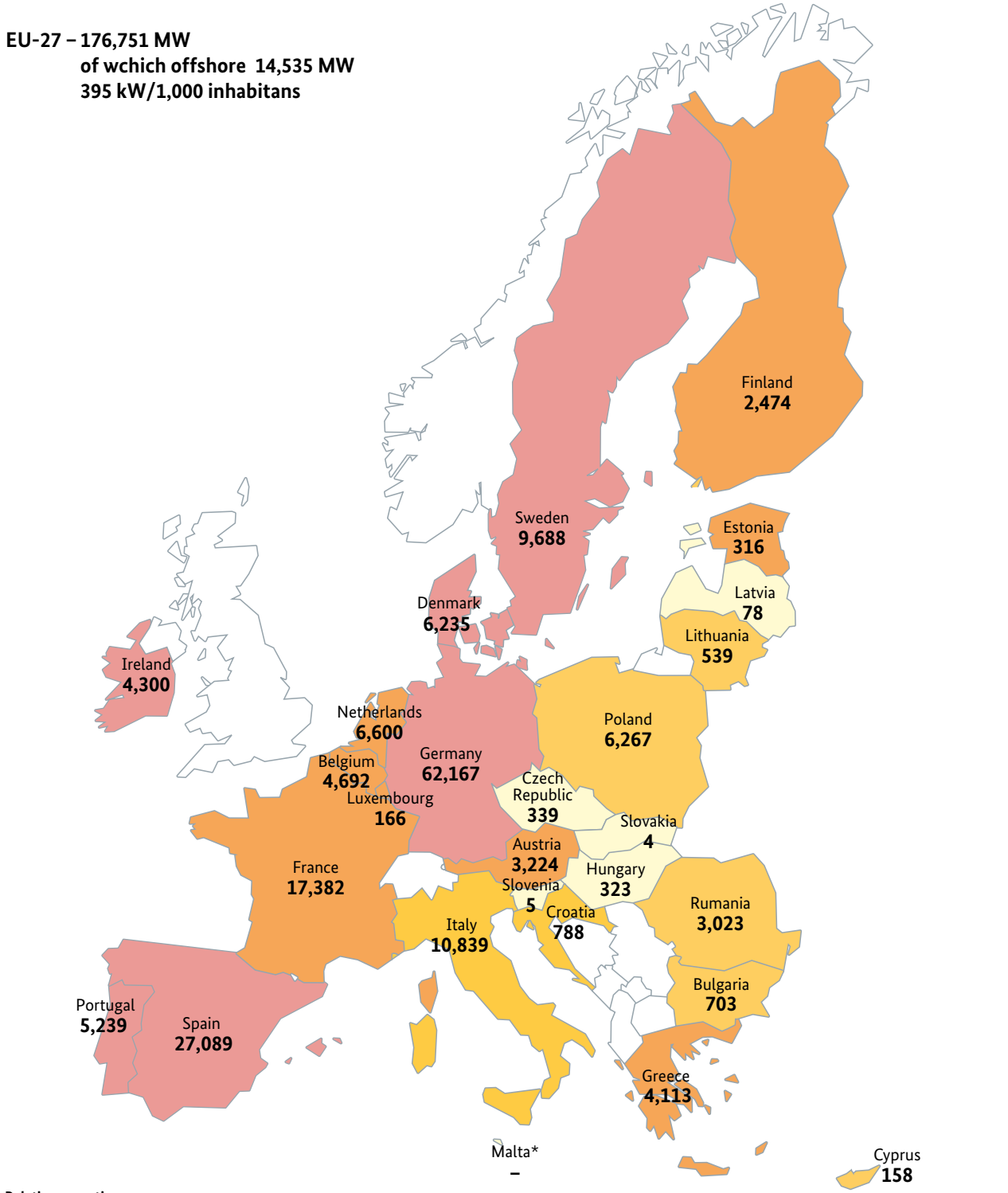
The expansion of wind energy use in the EU-27 weakened slightly in 2020. With a good 9.6 gigawatts, around 4% less new wind energy capacity was installed on land and offshore than in the previous year (2019: 10.0 gigawatts). With 2.1 gigawatts, the Netherlands took the top position ahead of Spain (1.5 gigawatts) and Germany (1.4 gigawatts). This was followed by Sweden and France (approx. 1 gigawatt each). Differentiating between newly installed capacity on land and offshore, there was a 16% decline on land, while offshore installations increased by two thirds. Looking only at new installations on land, Spain (1.5 gigawatts) led the EU, followed by Germany (1.2 gigawatts), Sweden and France with 1 gigawatt each. Offshore, on the other hand, the Netherlands (1.5 gigawatts) was clearly ahead of Belgium (0.7 gigawatts) and Germany (0.2 gigawatts).

In total, 176.8 gigawatts of wind energy capacity was installed in the EU-27 at the end of 2020 of which 162.2 gigawatts were onshore and 14.5 gigawatts offshore. Germany (35% or 62.2 gigawatts), remained in the top position in terms of cumulative capacity. It was followed by Spain (27.1 gigawatts), France (17.4 gigawatts) and Italy (10.8 gigawatts).

In relation to the number of inhabitants of the individual Member States, the installed wind energy capacity in the EU-27 presents a different picture: EU-wide, a capacity of 395 kilowatts per 1,000 inhabitants was installed at the end of 2020. As in previous years, Denmark (1,071 kilowatts per 1,000 inhabitants) was in first place, followed by Sweden (938 kilowatts) and Ireland (866 kilowatts). Germany (747 kilowatts per 1,000 inhabitants) ranked fourth.

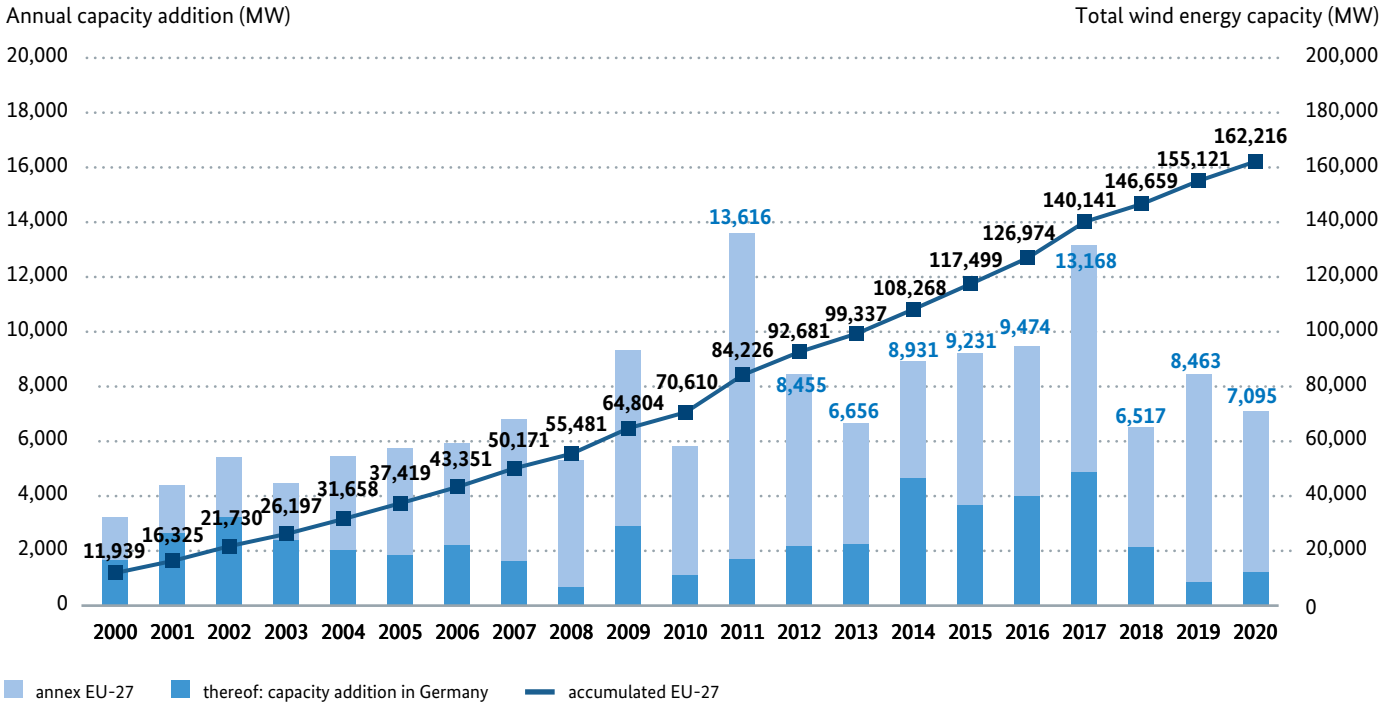
All wind-powered installations in the EU-27 together produced 397 terawatt-hours of electricity in 2020, accounting for 14.2% of total gross electricity generation [49]. Denmark had the highest share of wind power in electricity generation with almost 59%, ahead of Ireland (38%). It was followed closely by Portugal (24%), Germany (23%) and Spain (22%) [50].

## Figure 50: Total installed wind energy capacity in the EU-27 at the end of 2020




Source: EWEA [51]

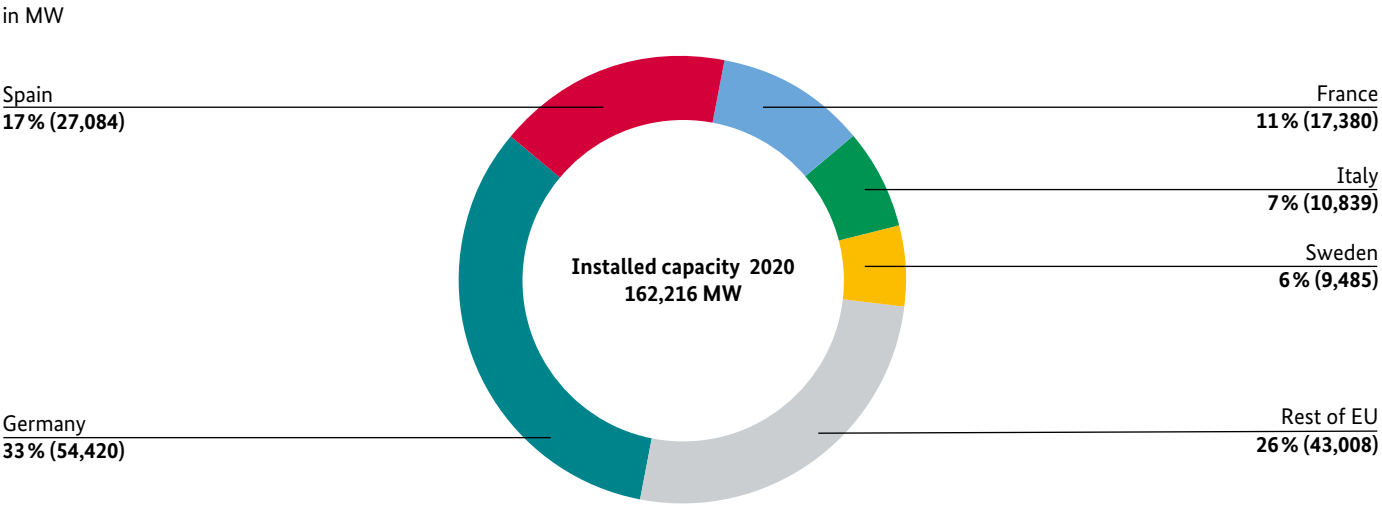
## Figure 51: Development of total wind energy output (onshore) in the EU-27




The 2020 wind capacity corresponds to the IRENA estimate ("Renewable Capacity Statistics 2021")

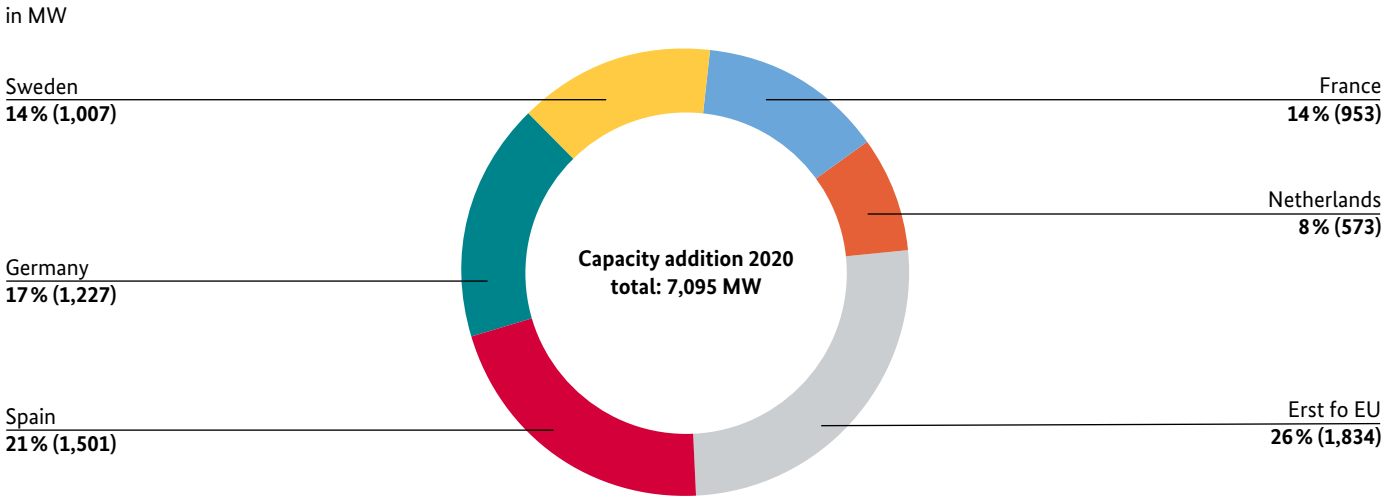
Source: Eurostat [49]; IRENA ("Renewable Capacity Statistics 2021") [52]

## Figure 52: Share of individual countries in the cumulative wind energy capacity (onshore), 2020



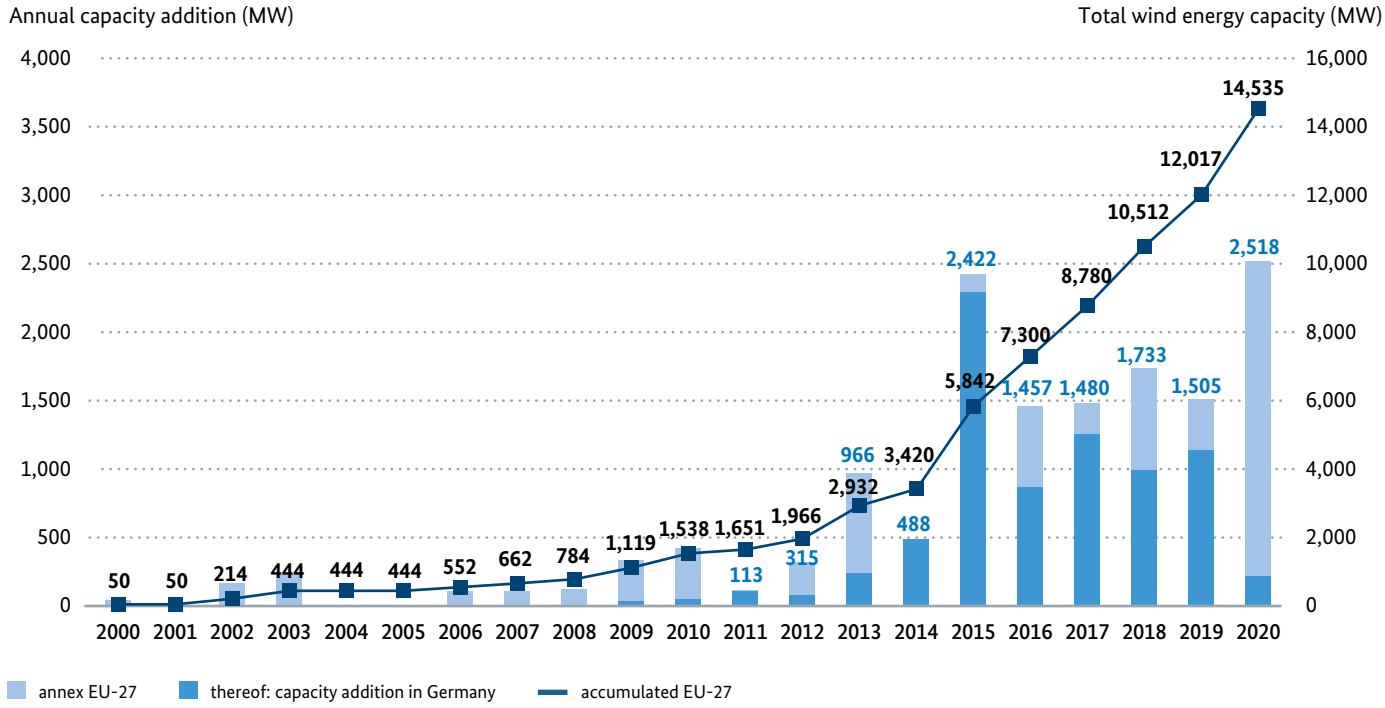

Source: IRENA ("Renewable Capacity Statistics 2021") [52]

## Figure 53: Share of individual countries in the expansion of wind energy capacity (onshore), 2020




Source: IRENA ("Renewable Capacity Statistics 2021") [52]

## Figure 54: Development of the cumulative wind energy offshore capacity in the EU-27

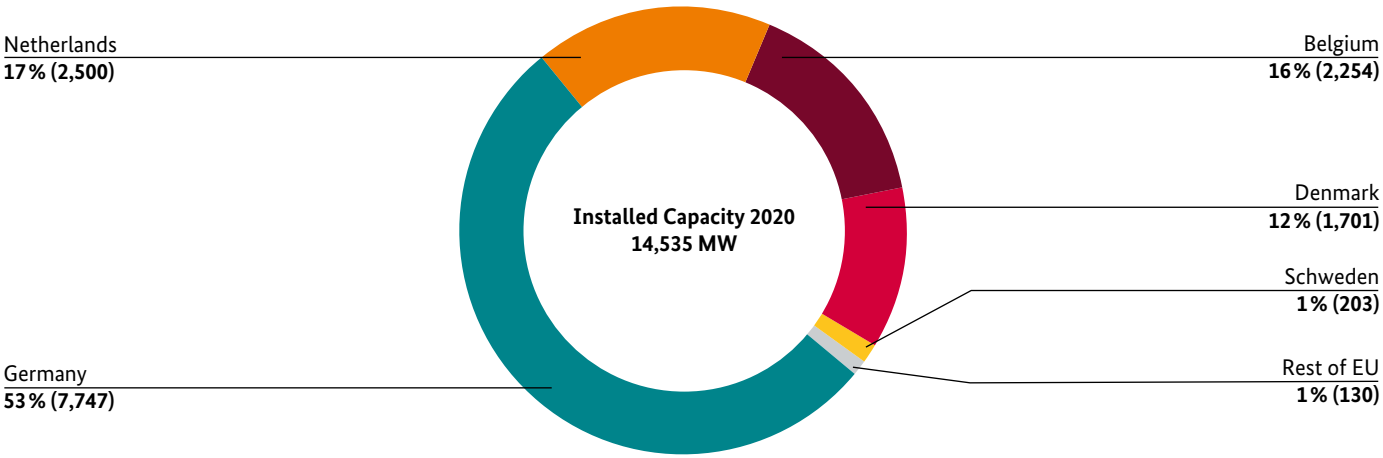



The wind power 2020 corresponds to the estimate by IRENA ("Renewable Capacity Statistics 2021")

Source: EUROSTAT (Stromerzeugungskapazität von erneuerbaren Energien und Abfällen [nrg_inf_epcrw]); IRENA ("Renewable Capacity Statsitics 2021")

## Figure 55: Share of individual countries in the cumulative wind energy capacity (offshore), 2020

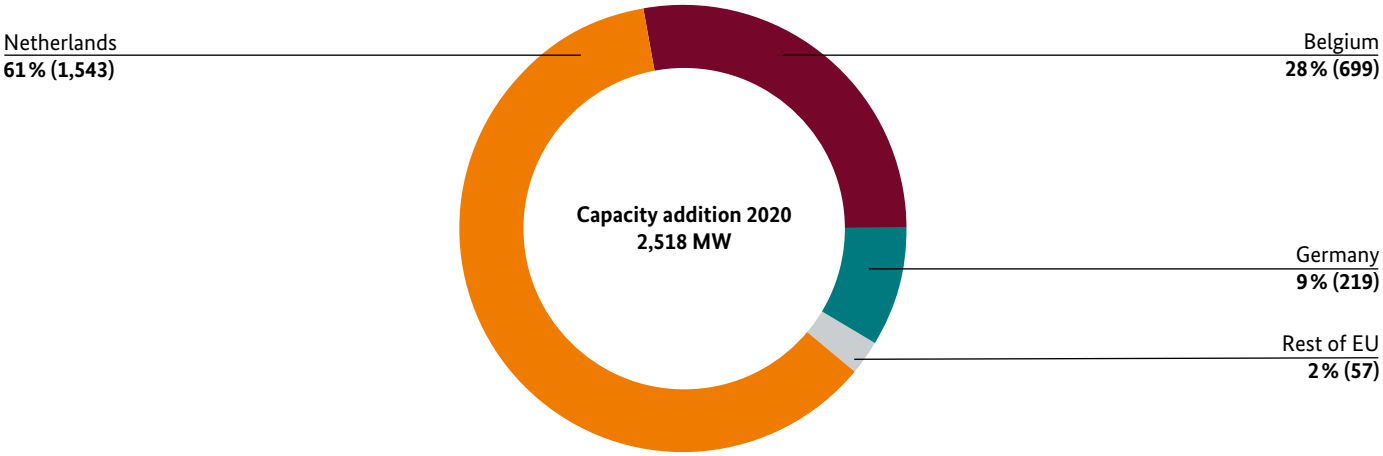
in MW




Source: IRENA ("Renewable Capacity Statistics 2021") [53]

## Figure 56: Share of individual countries in the expansion of wind energy capacity (offshore), 2020

in MW




Source: IRENA („Renewable Capacity Statistics 2021") [52]

## Solar energy use – electricity generation

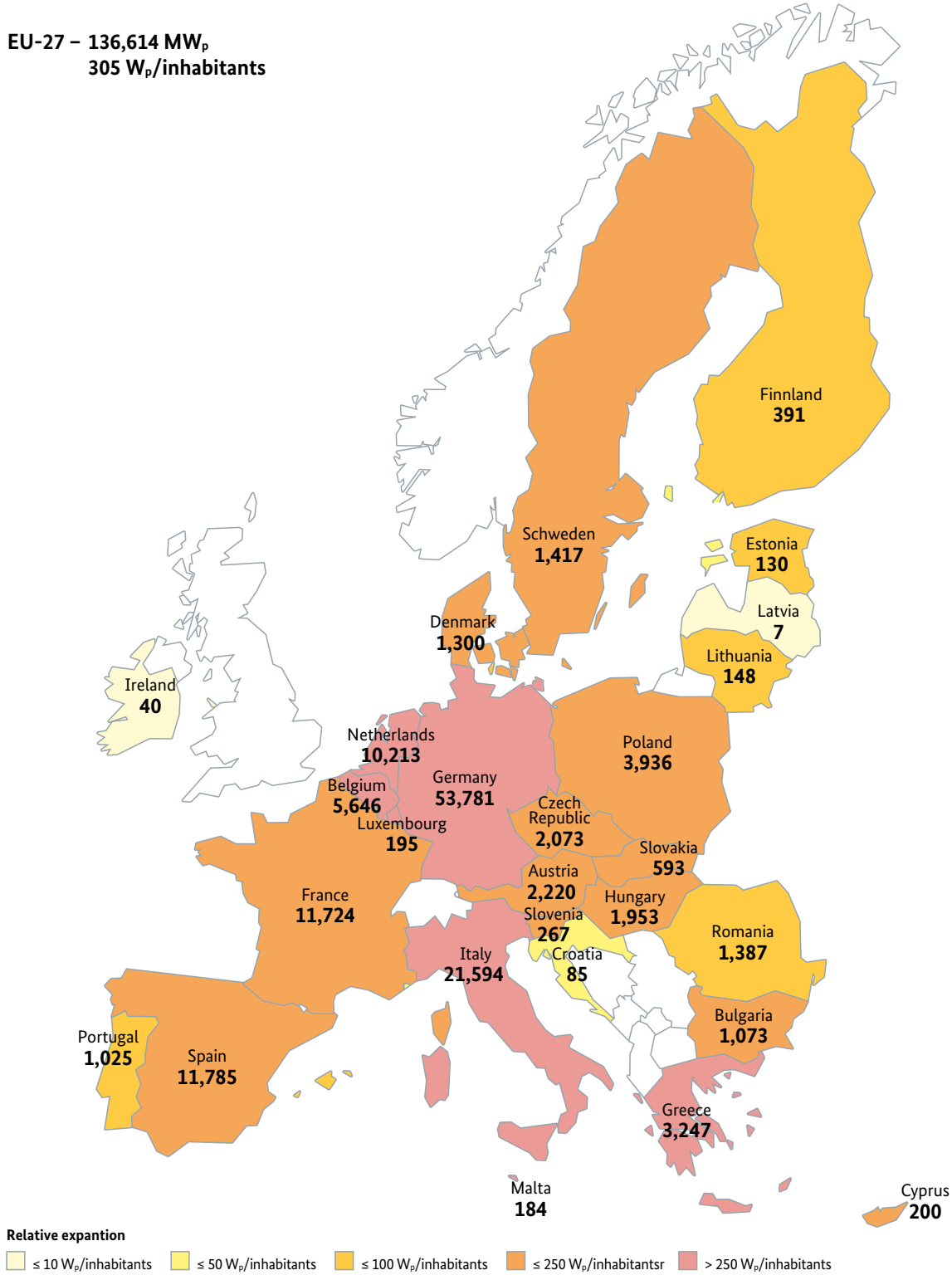
The European photovoltaic market, already very strong in the previous year, continued to grow at a high level in 2020. At almost 18.6 gigawatts, around 14% more photovoltaic capacity was newly installed than in the previous year (2019: 16.3 gigawatts) [49]. The upward trend was driven by further increasing markets in Germany and the Netherlands, as well as the Polish market, which played a significant role for the first time as a result of a new funding programme. With 4.7 gigawatts, most PV systems were built in Germany, followed by the Netherlands (3.0 gigawatts). Last year's leader Spain (2.8 gigawatts) took third place, followed by Poland (2.4 gigawatts).

At the end of 2020, a total of just under 136.6 gigawatts of photovoltaic capacity was installed in the EU-27. Germany still had by far the largest share of this, with 53.8 gigawatts or 39%. It was followed by Italy (21.6 gigawatts) and, close behind, Spain (11.8

gigawatts) and France (11.7 gigawatts). The installed photovoltaic capacity per 1,000 inhabitants was now 305 kilowatts across the EU. Here, too, Germany currently occupies the top position with 647 kilowatts, closely followed by the Netherlands (587 kilowatts). Belgium (490 kilowatts per 1,000 inhabitants) was in third place.

Electricity generation from photovoltaic systems in the EU-27 also increased significantly compared to

## Figure 57: Total installed photovoltaics capacity in the EU-27, 2020




Source: IRENA ("Renewable Capacity Statistics 2021") [52]

the previous year – by almost 17% to 140.2 terawatt-hours (2019: 120.0 terawatt-hours).

In addition to photovoltaic installations, solar thermal power plants are also used in the EU to generate electricity from solar energy. However, their use makes more sense in southern European regions with high numbers of sunshine hours. The subsidy conditions in Spain were at times particularly attractive for such power plants. As a result, the country had become a pioneer in solar thermal power generation both in the EU and globally. Accordingly, almost the entire installed capacity of solar thermal power plants in the EU, a good 2,300 megawatts, is in Spain. With around 5 billion kilowatt hours of electricity, these plants cover about 2% of annual Spanish electricity consumption [49]. Since 2013, however, there has been no more expansion due to a lack of funding.

## Solar energy use – heat supply

According to the Solar Thermal Barometer by EurObserv'ER [53], the EU-wide market for solar thermal systems, which was finally able to grow again in 2018 and 2019 following a prolonged period of weakness, suffered a significant setback in 2020. In the EU-27, a total of 1.94 million square metres of solar collector area was newly installed. This corresponds to a thermal capacity of around 1.36 gigawatts and thus a good 15% less than in the previous year (2019: 2.29 million square metres or 1.60 gigawatts). At the end of 2020, a collector area of just under 53.9 million square metres was installed in the EU-27, corresponding to a thermal capacity of 37.7 gigawatts.

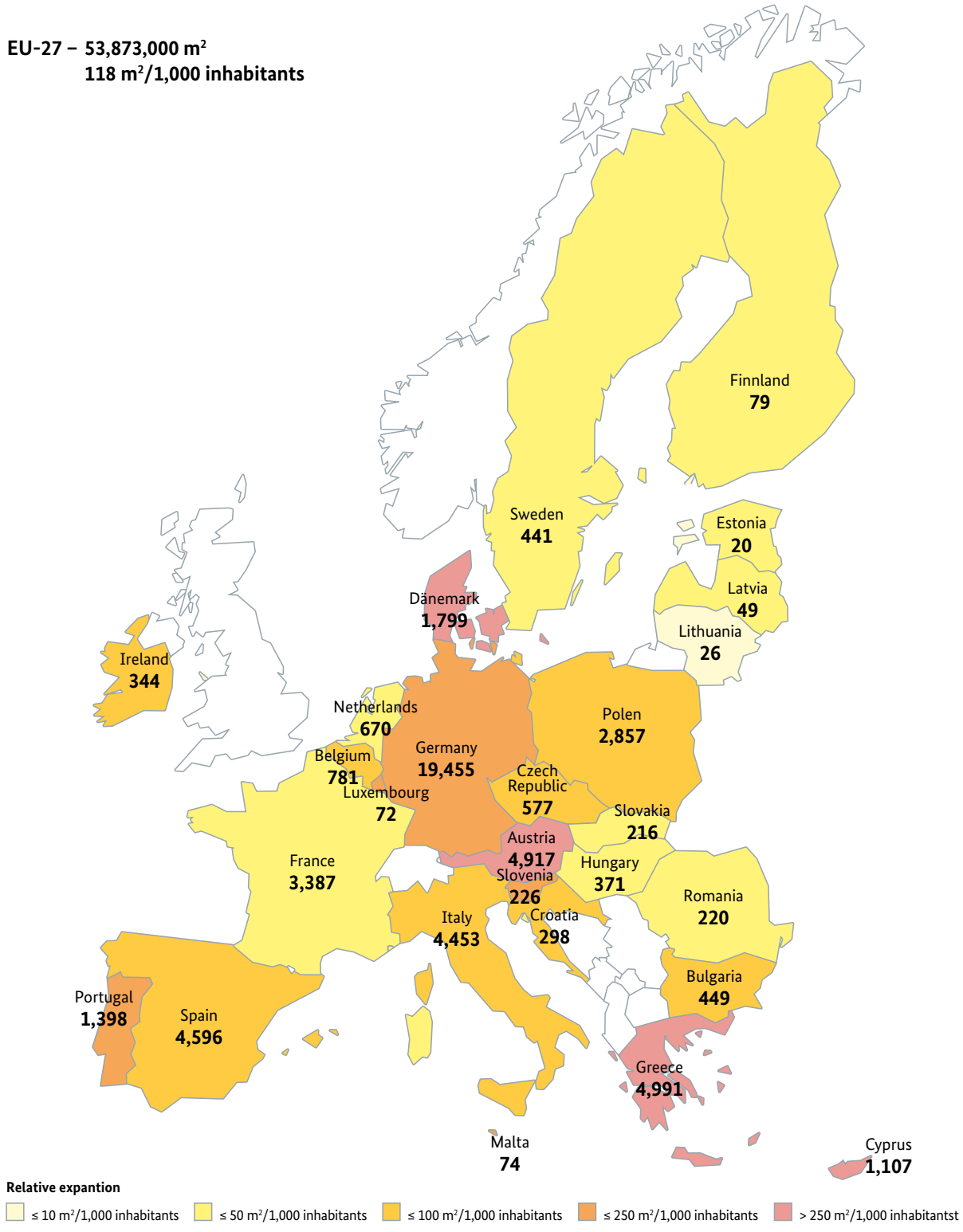
The German solar thermal market, which regained strength for the first time in 2020, prevented the EU-wide decline in installation figures from being even more pronounced. With an increase of 26% and a newly installed collector area of 643,000 square metres, the German market now accounted for one third of the total EU market (2019: 22%). In all other important national markets, however, there were more or less significant declines. For example, new installations in Greece fell by 16% to 304,500 square metres, in Spain by 7% to 190,650 square metres and in Poland by as much as 44% to 161,200 square metres. Thus Greece remained in second place behind Germany, while Spain passed Poland again to take third place. In the previous year, fifth-placed Denmark was still decisive for the revived solar thermal market in the EU, but contributed significantly to the decline in 2020. Here, large collector fields for heating grids play a role above all. After 15 such fields were built or expanded in 2019, resulting in a new collector area of more than 194,000 square metres, in 2020 there were only 4 fields with just under 15,000 square metres.

In terms of the total collector area installed in the EU at the end of 2020, Germany was also far and away in first place with just under 19.5 million square metres. It was followed closely by Greece with 5.0 million, Austria with 4.9 million, Spain with 4.6 million and Italy with just under 4.5 million square metres. In terms of installed solar thermal capacity per inhabitant (see also Figure 58), as in previous years Cyprus led with 0.87 kilowatts, ahead of Austria with 0.39 kilowatts and Greece with 0.33 kilowatts per inhabitant. Germany was in 5th place behind Denmark with 0.16 kilowatts. Further information on the topic of solar energy use in Europe can also be found on the EurObserv'ER [53] website https://www.eurobserv-er.org.

## Renewable energy sources in the transport sector

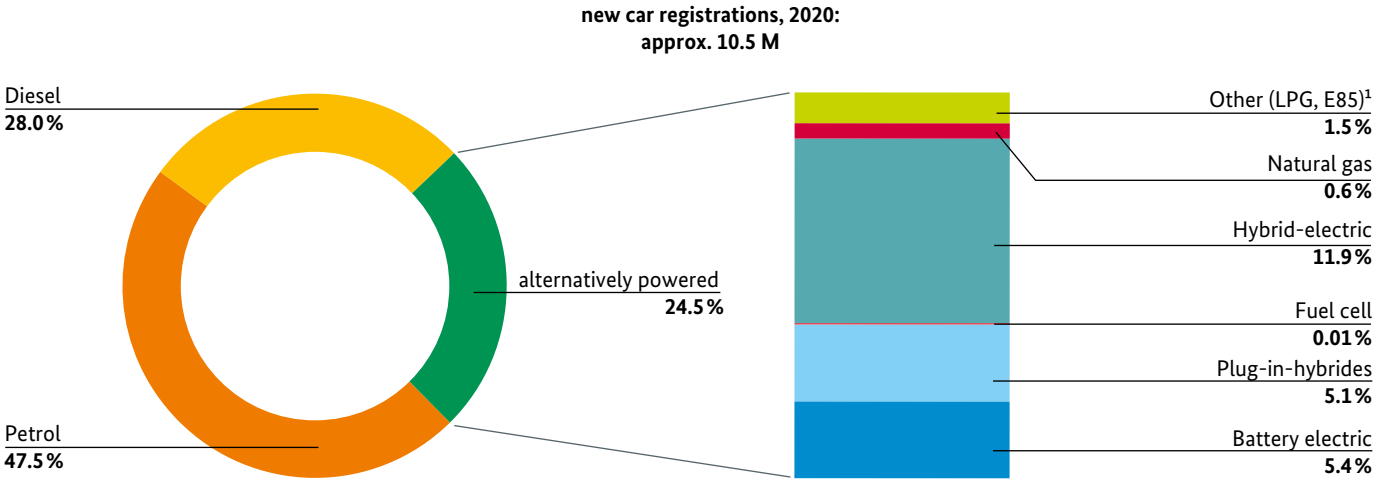
The EU Directive 2009/28/EC sets a binding target for the transport sector that by 2020 the share of final energy consumption from renewable sources in the individual EU Member States should be at least 10%, taking multiple-counting options into consideration. Further to this, Directive 2018/2001 states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

## Figure 58: Total installed solar thermal capacity in the EU-27, 2020




Source: EUROSTAT [55]

## Figure 59: New car registrations in the EU-27, by fuel type, 2020




1 Biofuels and hydrogen

Source: ACEA [55]

Following a period of decline in the use of biofuels, related particularly to questions about sustainability aspects, their sales have been rising again in the EU since 2017. to 2019. They remained at about the same level in 2020 as in the previous year. At just under 20.5 million tonnes, slightly fewer biofuels were sold than in the previous year (2019: 20.6 million tonnes). The small increase in sales of biodiesel and a minor decrease in bioethanol more or less balanced each other out (see also Figure 59).

The minor decline in sales of biofuels should viewed in light of the Corona pandemic and the simultaneous significant drop in transport activity throughout Europe, which led to a significantly lower use of fossil fuels. According to current information, a significantly increased share of biogenic fuels can be assumed for 2020.

Regional sales of electric vehicles (incl. plug-in hybrids) increased significantly in the EU Member States in 2020. They increased by 170% from around 388,000 vehicles in 2019 to around 1.05 million vehicles. The largest number of new registrations of electric vehicles was in Germany with nearly 395,000 vehicles, followed by France (ca. 186,00) and Norway (ca. 106,000). In fourth place was Sweden (ca. 94,000), closely followed by the Netherlands with approximately 89,000 vehicles. Of the nearly 10.5 million total passenger car registrations in 2020, battery electric and plug-in hybrid vehicles made up 10.5% (3% in 2019) and almost 12% were hybrid vehicles (5.7% in 2019) [55].

Figure 60 shows the consumption of biofuels in the EU in 2019 and 2020 (provisional values according to Eurostat).

Further information on the topic of biofuels in Europe can also be found on the EurObserv'ER website [56] at www.eurobserv-er.org.

## Figure 60: Consumption of biofuels in the EU Member States in 2019 and 2020

| | 2019 | | | | 2020[1] | | | |
|---|---|---|---|---|---|---|---|---|
| | Bioethanol | Biodiesel | Other biofuels | Total | Bioethanol | Biodiesel | Other biofuels | Total |
| | kilotons (kt) | | | | kilotons (kt) | | | |
| Austria | 104 | 274 | 0 | 377 | 90 | 301 | 0 | 392 |
| Belgium | 183 | 400 | 23 | 605 | 177 | 607 | 7 | 792 |
| Bulgaria | 49 | 168 | 0 | 218 | 41 | 140 | 0 | 181 |
| Croatia | 1 | 35 | 0 | 35 | 0 | 26 | 0 | 26 |
| Czech Republic | 141 | 239 | 0 | 380 | 126 | 354 | 0 | 479 |
| Denmark | 67 | 208 | 4 | 279 | 122 | 207 | 0 | 329 |
| Estonia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Finland | 141 | 331 | 41 | 513 | 146 | 297 | 44 | 487 |
| France | 973 | 3,088 | 26 | 4,087 | 839 | 2,619 | 26 | 3,485 |
| Germany | 1,158 | 2,437 | 232 | 3,827 | 1,117 | 2,997 | 230 | 4,344 |
| Greece | 41 | 201 | 0 | 242 | 123 | 177 | 0 | 300 |
| Hungary | 75 | 131 | 0 | 206 | 92 | 131 | 0 | 223 |
| Ireland | 26 | 87 | 0 | 114 | 21 | 116 | 0 | 136 |
| Italy | 35 | 1,413 | 1,039 | 2,487 | 23 | 1,410 | 1,043 | 2,475 |
| Latvia | 11 | 35 | 0 | 47 | 20 | 40 | 0 | 60 |
| Lithuania | 24 | 89 | 0 | 113 | 35 | 105 | 0 | 139 |
| Luxembourg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Malta | 0 | 11 | 0 | 11 | 0 | 14 | 0 | 14 |
| Netherlands | 320 | 665 | 56 | 1,041 | 478 | 780 | 32 | 1,290 |
| Poland | 265 | 895 | 2 | 1,163 | 267 | 924 | 2 | 1,193 |
| Portugal | 6 | 303 | 0 | 309 | 5 | 263 | 0 | 268 |
| Romania | 153 | 364 | 0 | 517 | 153 | 364 | 0 | 517 |
| Slovakia | 56 | 152 | 0 | 208 | 65 | 155 | 0 | 220 |
| Slovenia | 0 | 103 | 0 | 103 | 0 | 122 | 0 | 122 |
| Spain | 203 | 1,696 | 3 | 1,903 | 139 | 1,434 | 3 | 1,576 |
| Sweden | 333 | 1,379 | 80 | 1,792 | 239 | 1,158 | 38 | 1,435 |
| Zypern | 0 | 4 | 0 | 4 | 1 | 12 | 0 | 13 |
| **Region EU-27** | **4,365** | **14,708** | **1,507** | **20,580** | **4,318** | **14,753** | **1,426** | **20,497** |

1 figures are provisional

Source: Eurostat, Energy Balances "Early estimates 2020" [48]

# Part III: Global use of renewable energy sources

*The absolute contribution of renewable energy sources to global energy supply is growing steadily, but their share of global energy consumption has been stagnating for years. This makes it clear that if the foreseeable further increase in energy demand is to be met sustainably and the goals agreed in the Paris Climate Agreement are to be reached, the pace of the global expansion of the use of renewable energy must be significantly increased.*

In its latest World Energy Transitions Outlook [57] from June 2021, the International Renewable Energy Agency (IRENA) states that global energy-related $CO_2$ emissions continued to increase by 1.3% annually for the period 2014-2019. This is all the more remarkable given that for seven years now, more capacities for electricity generation from renewable energy sources have been connected to the grid each year than fossil and nuclear combined – in 2020 already more than four times as much. In order to reach the 1.5-degree target, $CO_2$ emissions must be reduced by 45% by 2030 compared to 2010 and be reduced to zero by 2050. Since the key to this is the electrification of the energy supply based on renewable energy, according to IRENA, electricity must reach a share of more than 50% of final energy consumption by 2050 – starting from 21% in 2018. This requires electricity generation capacities from renewable energy of almost 10,800 gigawatts by 2030 alone. This means an increase of around 800 gigawatts per year over the next 10 years – more than three times as much as in the previous record year of 2020.

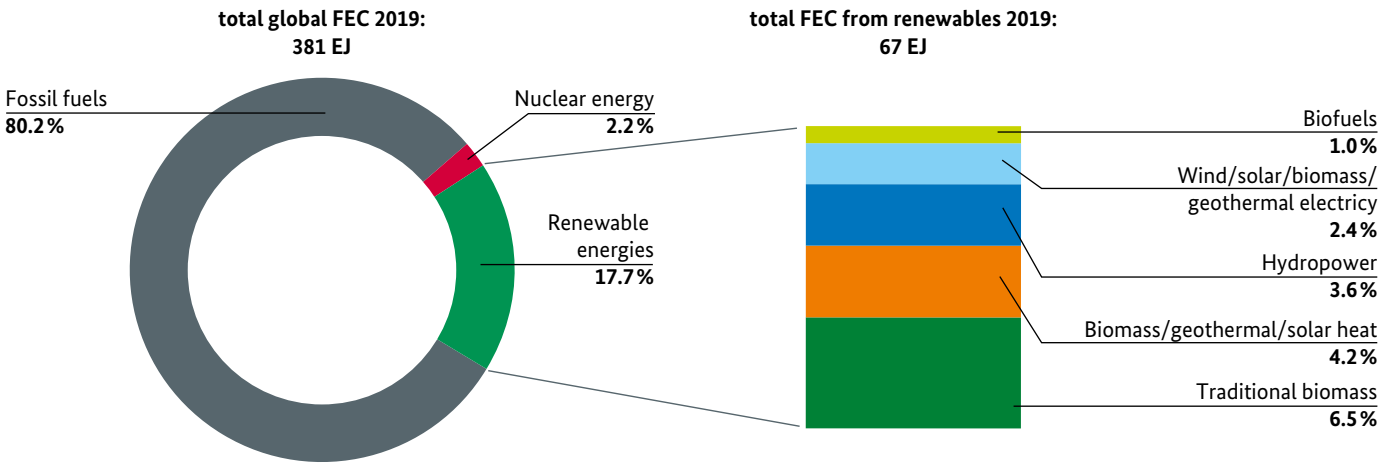
In developing countries, almost one billion people are still without access to electricity. Due to their decentralised nature, renewable energy sources can often secure a basic supply, e.g., via off-grid photovoltaic systems for domestic needs or for village power supply. In this way, they can contribute to improved living conditions. According to IEA estimates, around 2.7 billion people still rely on traditional biomass use for cooking, i.e., mostly over open fires. However, this is often associated with irreversible deforestation and significant health risks for the users themselves [58].

The status of the global use of renewable energy presented below was done according to the data available at the time of writing. It largely but not yet completely refers to the year 2020.

According to estimates by REN21 [50], renewable energy sources accounted for 17.7% of global final energy consumption in 2019, a slight decrease for the second year in a row (2018: 17.9%). This makes it clear that the current pace of expansion of renewable energy sources is not yet sufficient to offset the rising global energy demand. Rather, a significant global acceleration of the pace of expansion is required in order to attain the urgently needed increases in the share of global energy consumption covered by renewables.

Fossil fuels accounted for 80.2% of global final energy consumption in 2019, nuclear energy 2.2%. Modern forms of renewable energy sources have been showing encouraging growth rates for years and are eclipsing traditional forms of biomass use, which cannot be deemed sustainable. Nevertheless, the latter still accounted for 6.5 percentage points of the 17.7% share of renewable energy consumed in 2019 (2018: 6.9%). Of the 11.2% final energy that

## Figure 61: Distribution of global final energy consumption (FEC), 2019




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

Source: REN21: Renewables 2021 Global Status Report [50]

came from modern renewable energy technologies, 4.2% came from heat from biomass, geothermal and solar heat, 3.6% from hydropower and 1% from biofuels in transport. The only sector to record a significant increase over the previous year was electricity from wind, solar, biomass and geothermal, which now accounts for 2.4% (2018: 2.1%).

## Electricity generation from renewable energy sources

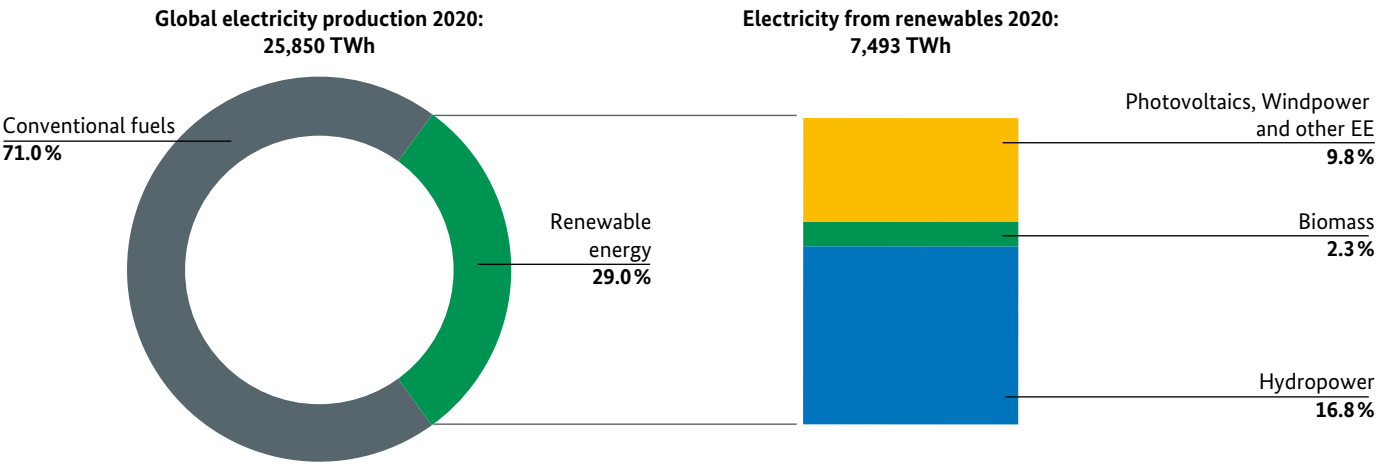
As has already become clear from the development of final energy consumption, the most significant growth in renewable energy sources is taking place in the electricity sector, not only in Germany and the EU, but also globally. According to REN21 [50], 7,493 terawatt-hours of electricity were generated worldwide from solar, wind, water, biomass and geothermal energy in 2020. While this was only slightly less than 2% more than the previous year, the pandemic-related decline in electricity consumption increased the share of renewable energy sources in total global electricity generation from 27.3% in 2019 to 29.0%.

Globally, the growth in electricity generation from renewable energy sources is also mainly due to wind energy and photovoltaics. Their combined share of global electricity generation was more than 9% in 2020 (2019: 7.9%). In some countries, this value was even many times higher – for example in Denmark with 63%, in Uruguay with 43% and in Ireland with 38%. Germany was in fourth place with 33%, ahead of Greece with 32%.

Considering the newly installed capacity in the electricity sector worldwide, the trend towards renewable energy is also more than clear: 83% of the new electricity generation capacity installed in 2020 was accounted for by renewables. With a total of 256 gigawatts – around a quarter more than in the previous year – a new all-time high was also reached in the expansion of renewable electricity generation capacity. With 139 gigawatts, 54% of this was accounted for by photovoltaics and 93 gigawatts or 36% by wind energy. Eight percent or 20 gigawatts was accounted for by hydropower, the rest mainly by biomass. At 116 gigawatts, more than half of the newly installed capacity was in China, where new installations almost doubled compared to the previous year. The USA followed far behind with 36 gigawatts and Vietnam with 11 gigawatts.

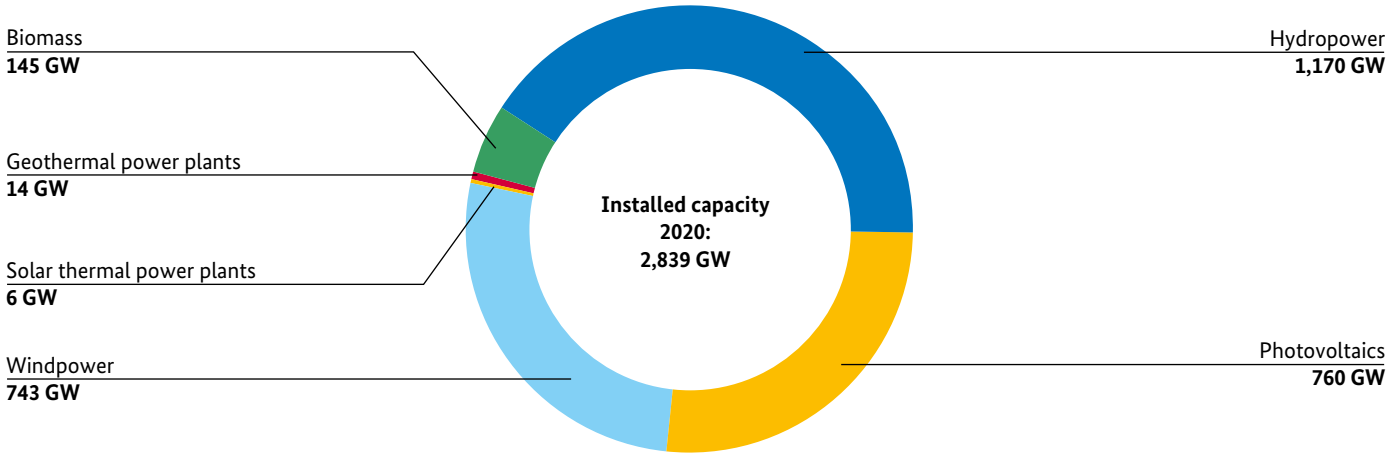
Including hydropower, global electricity generation capacity from renewable energy sources amounted to 2,839 gigawatts at the end of 2020 of which hydropower accounted for 1,170 gigawatts or around 41%. With 760 gigawatts, photovoltaics was ahead of wind energy (743 gigawatts) for the first time. Biomass accounted for another 145 gigawatts, geothermal (14 gigawatts) and solar thermal (6 gigawatts). According to REN21, China, with 908

Figure 62: Distribution of global electricity generation, 2020




Source: REN21: Renewables 2021 Global Status Report [50]

Figure 63: Total installed power generation capacity based on renewables at the end of 2020




Source: REN21: Renewables 2021 Global Status Report [50]

gigawatts of cumulative capacity, was also in the lead here by a wide margin. It was followed by the USA (313 gigawatts), Brazil (150 gigawatts), India (142 gigawatts) and, still in fifth place, Germany (132 gigawatts) [50].

With around 93 gigawatts, 86.9 gigawatts of which were onshore and 6.1 gigawatts offshore, a new all-time high was reached in the worldwide expansion of wind energy use. The figure was 53% higher than in the previous year and 45% higher than in the previous record year 2015. At 52 gigawatts, more than half of the new wind energy capacity was installed in China, almost twice as much as in the previous year. In the USA, too, installation figures rose by 85% to 16.9 gigawatts compared to the previous year. Brazil followed far behind, but with 2.3 gigawatts, three times as much as in the previous year was newly installed. At the end of 2020, 743 gigawatts of wind energy capacity were installed worldwide, 707 gigawatts of which onshore and 36 gigawatts offshore. Of this, 288 gigawatts were connected to the grid in China alone, followed in second place by the USA with 122.5 gigawatts.

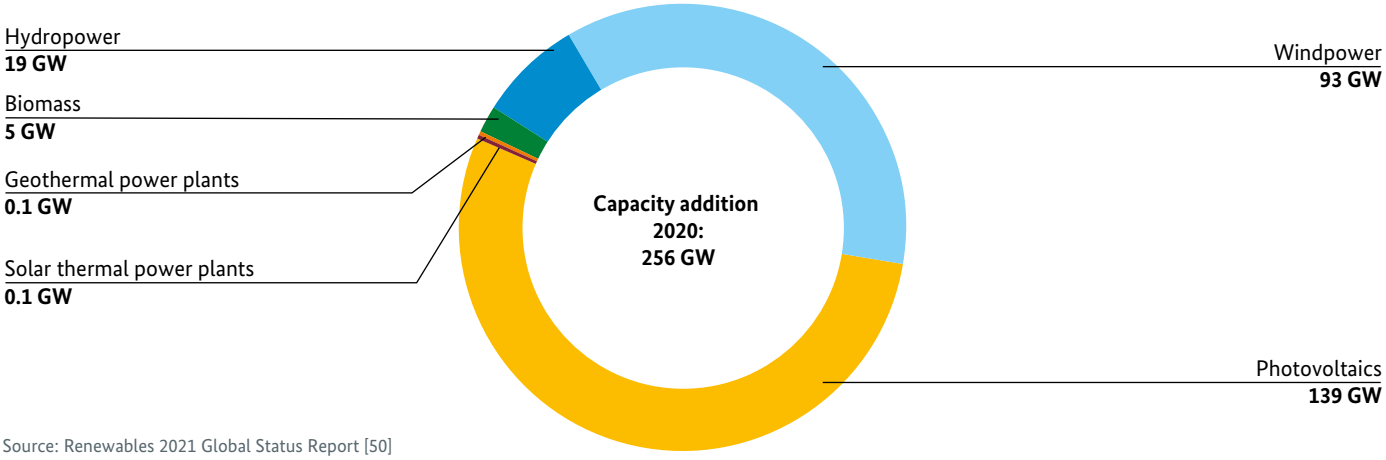
Globally, new photovoltaic capacity rose by 26% over the previous year to 139 gigawatts in 2020. Here, too, the largest share, 48.2 gigawatts, was newly installed in China. This was followed by the USA (19.2 gigawatts), Vietnam (11.1 gigawatts) and Japan (8.2 gigawatts). By the end of 2020, 760 gigawatts of photovoltaic capacity had been installed worldwide. With more than 253 gigawatts, one third of the capacity was in China. The USA (96 gigawatts) was in second place, followed by Japan (71.4 gigawatts), Germany (53.8 gigawatts) and India (47.4 gigawatts).

As in the previous year, the global installed capacity for electricity generation from biomass increased by around 8 gigawatts in 2020 to 145 gigawatts. Here, too, the highest total capacity was installed in China, followed by the USA and Brazil. Electricity generation capacity from geothermal energy rose only slightly by 0.1 gigawatts to 14.1 gigawatts. The USA continues to lead the way here, followed by Indonesia and the Philippines. Last year, new capacity was added almost exclusively in Turkey.

## Renewable energy sources in the other sectors

As in Germany and Europe, the share of renewable energy in the heating and cooling sector, which is responsible for a good half of global final energy consumption, is growing much more slowly than in the electricity sector. For example, the share of renewable energy in worldwide building heating rose only from 7.8 to 10.4% between 2009 and 2019. This illustrates that efficiency measures are of central importance in achieving higher shares. In the industrial sector, which has roughly the same sig-

## Figure 64: Expansion of power generation capacity based on renewables, 2020

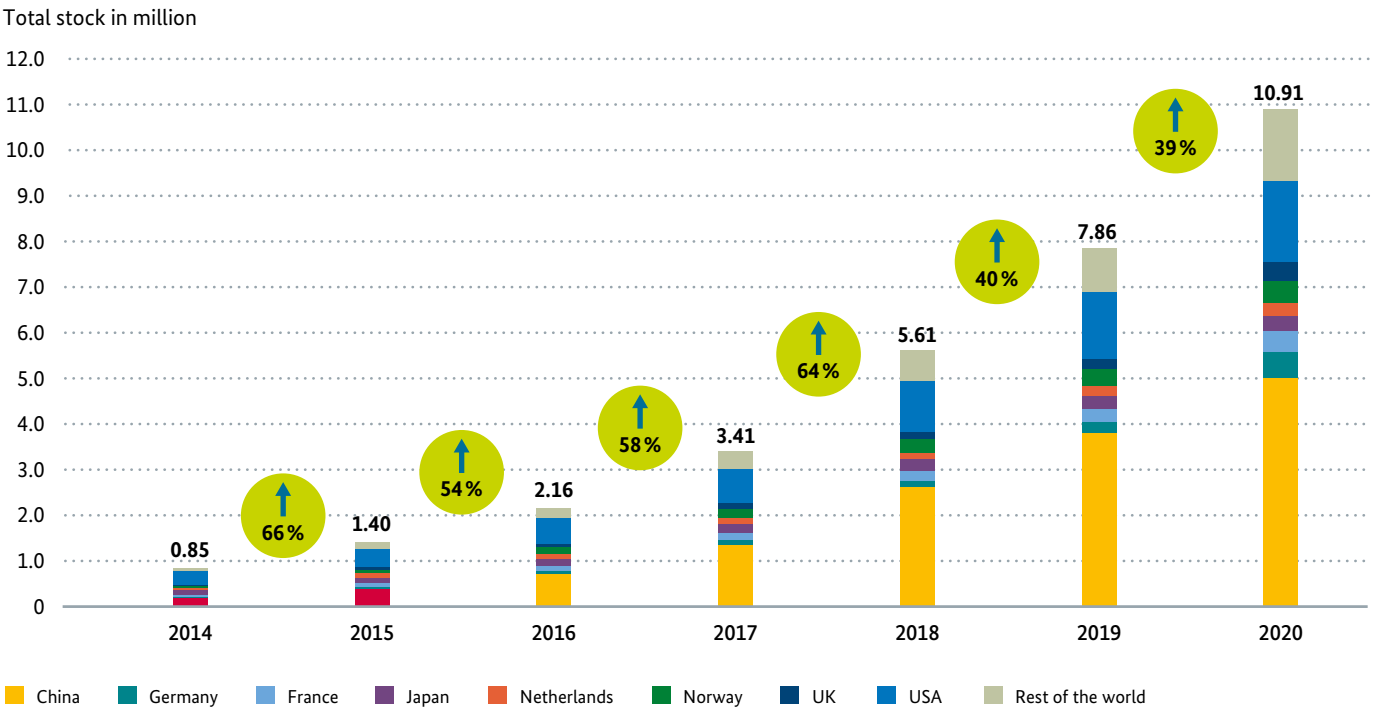



Source: Renewables 2021 Global Status Report [50]

nificance for energy consumption as the buildings sector, renewable energy had a share of 14.8% of final energy consumption in 2020 [50].

In the transport sector, the share of renewable energy in 2020 was even lower: 3.1% of final energy consumption is covered by biofuels, 0.3% by electricity from renewable energy sources in the context of electromobility. [59]. The latter, however, recently presented itself as a clear growth market: the global stock of electric cars rose by 39% to 10.91 million in 2020. With 1.2 million new vehicles, or a share of around 46%, China was the clear driver, followed by Germany with just under 331,000 and the USA with around 323,000 vehicles. In terms of stock, China (with around 5 million vehicles) was well ahead of the USA (1.8 million) [60].

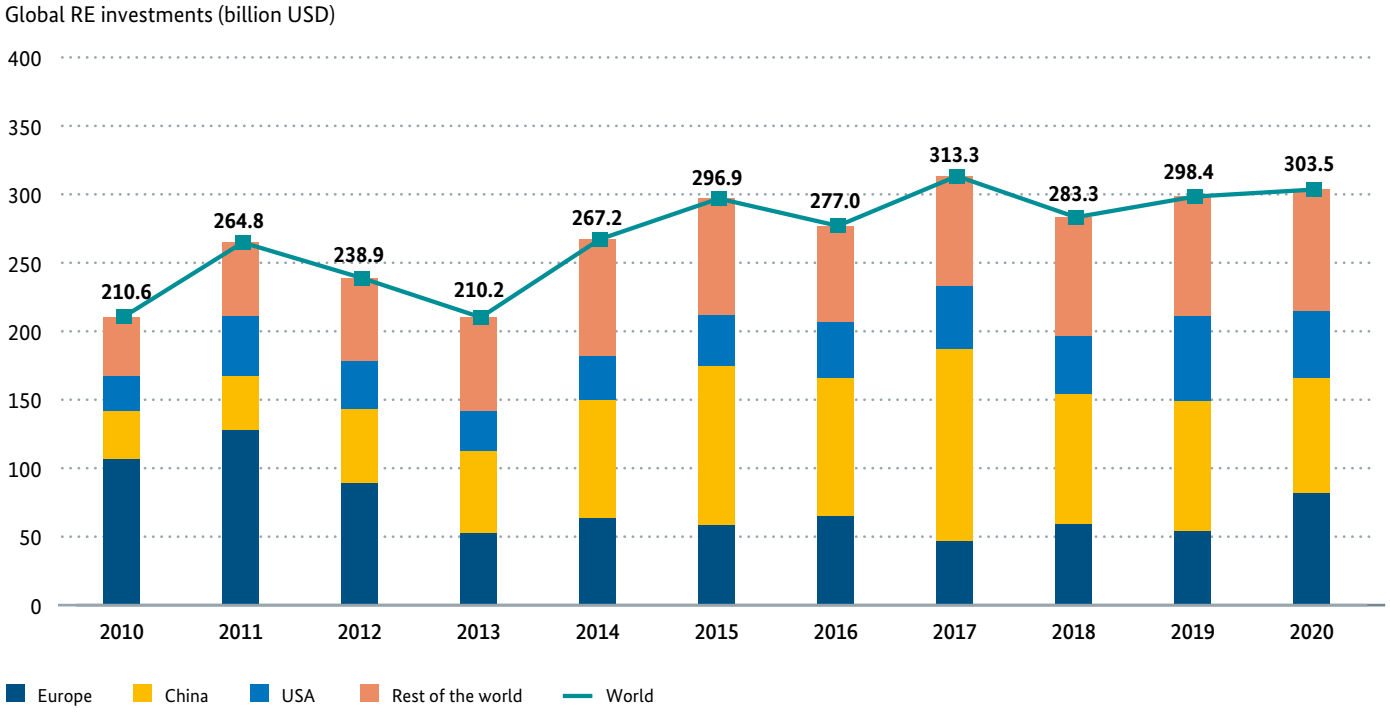
## Figure 65: Global fleet of electric vehicles




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

Source: ZSW [60]

Figure 66: Investment in renewable energy sources by region




Source: REN21: Renewables 2021 Global Status Report [50]

## Investments and jobs

For years, investments in renewable energy sources have also been a significant economic factor worldwide. However, the amount of global annual investment has fluctuated in recent years and has only seen a slight upward trend. In 2020, a small increase of just under 2% to USD 303.5 billion was recorded compared to the previous year. These figures clearly show the decline in prices for renewable technologies. Most investments in renewable energy sources in 2020 were made in China with USD 83.6 billion, followed closely by Europe with USD 81.8 billion [59].

Differentiated by technologies, photovoltaics accounted for the most investments in 2020 with USD 148.6 billion and a plus of 12%, while wind energy was only in second place with a minus of 6% with USD 142.7 billion. Together, these two lead technologies accounted for 96% of total investment in renewable energy (excluding large hydropower), as all other technologies saw more or less sharp declines in 2020.

According to IRENA [61], the number of people employed in the renewable energy sector increased by almost half a million worldwide in 2020, so that over 12 million people had a job in this sector. At just under 4 million, a good third of these worked in photovoltaics, followed by the biofuel industry with just under 2.4 million jobs. In third and fourth places are hydropower with around 2.2 million jobs and wind energy with just under 1.3 million jobs.

## Figure 67: Worldwide investments in 2019 and 2020 disaggregated by renewable energy sector

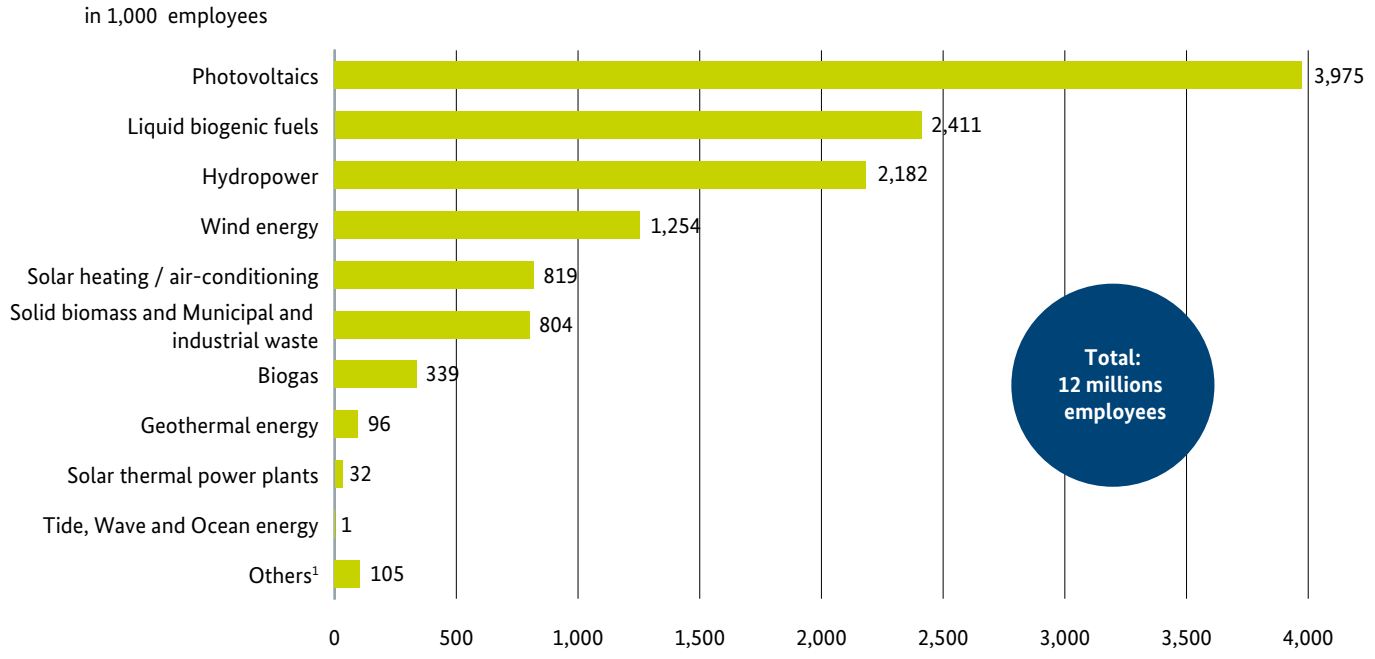
| Sektor | 2019 | 2020 | Groth rate 2019/2020 |
|---|---|---|---|
| | RE-investment (billion USD) | | (%) |
| Wind energy | 151.3 | 142.7 | -6 |
| Solar energy | 132.4 | 148.6 | 12 |
| Biofuels | 1.7 | 0.6 | -65 |
| Biomass[1] | 10.3 | 10.0 | -3 |
| Hydropower[2] | 1.7 | 0.9 | -48 |
| Geothermal power | 1.0 | 0.7 | -30 |
| Ocean energy | - | - | |
| **Total** | **298** | **304** | **2** |

1 Including waste

2 Only hydropower plants < 10 MW

Source: REN21: Renewables 2021 Global Status Report [50]

## Figure 68: Persons employed in the renewable energy sectors in 2020




1 Including tide, wave and ocean energy, and jobs not broken down by individual renewable energy technologies

Source: IRENA – Renewable Energy and Jobs – Annual Review 2021 [61]

# Annex

## International networks for renewable energy sources

### Internationale Agentur für Erneuerbare Energien – IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation dedicated to the worldwide promotion of the growth of renewable energy. IRENA now has 164 members, with 20 states currently in the accession process. IRENA is headquartered in Abu Dhabi, United Arab Emirates. The IRENA Innovation and Technology Centre (IITC), one of its three core divisions, is based in Bonn. Since April 2019, Francesco La Camera of Italy has been the Director-General in charge of the IRENA Secretariat. IRENA currently employs around 150 people.

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

#### Cooperation with other players

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

#### Work programme and budget

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

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

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

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

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

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

1. Centre of Excellence for Energy Transformation

2. Global Voice of Renewables

3. Network Hub

4. Source of Advice and Support

5. International Cooperation and Strategic Engagement

6. Efficient, Transparent and Innovative Management

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

IRENA has made a name for itself in recent years

with the analysis and development of measures to implement the goal of the UN initiative "Sustainable Energy for All". It aims to substantially increase the global share of renewable energy sources by 2030 and to double the rate of energy efficiency improvements. In addition, IRENA published a revised "Global Renewables Outlook: Energy transformation 2050" (GRO) in April 2020. This is an update of the report "Global Energy Transformation: A roadmap to 2050" first published in 2017. The report examines the building blocks of an energy system, as well as the investment strategies and policy frameworks required to successfully implement a global energy transition based primarily on the use of renewable energy. IRENA's key renewable energy map scenario shows how to reduce global $CO_2$ emissions by at least 70% by 2050. The current report also considers how a more far-reaching decarbonisation to net-zero or zero emissions can already be achieved by 2050 [62]. IRENA updates this study annually as input for the discussions at the Berlin Energy Transition Dialogue. In addition, IRENA plans to develop regional energy transition strategies (Regional Energy Transition Outlooks, RETOs). More information on IRENA's publications can be found on the organisation's website: www.irena.org.

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

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

### Main bodies and structure

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

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

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

Further information at: www.irena.org.

### The International Energy Agency (IEA)

The International Energy Agency (IEA) is one of the world's central energy organisations. An autonomous institution within the OECD, it acts as a voice for the energy-consuming industrialised countries, and currently consists of 31 OECD member countries. The accession of Chile and Lithuania to the IEA is being prepared. Given the strong growth in energy demand outside the OECD, the IEA is also expanding its cooperation with countries that are not members of the OECD and therefore cannot become members of the IEA according to the current rules. Since the end of 2015, the IEA has concluded association agreements in this regard with Brazil, China, India, Indonesia, Morocco, Singapore, South Africa and Thailand.

The IEA was founded in 1974 in response to the first oil crisis, with a view to ensuring that the supply of oil would not be subject to disruptions. To achieve this goal, its member countries agreed to hold at least 90 days' worth of emergency oil stocks.

In addition, the IEA has developed into a central platform for sharing experience and advising policymakers on virtually all aspects of energy policy. A key part of this is discussing how renewable energy can be developed and integrated into the various energy systems. The IEA toolkit includes regular country reviews setting out policy recommendations, as well as the annual World Energy Outlook

(WEO), a comprehensive international reference publication on energy policy with forecasts currently reaching up to 2050. These are the most influential publications released by the IEA and serve as key reference material in the designing of national energy policies right around the world.

In the field of renewable energy, the IEA publishes numerous papers, most recently the Renewable Energy Market Report with a forecast horizon up to 2025. Furthermore, in May 2021, the IEA published the report "Net-Zero by 2050: A roadmap for the global energy sector", which for the first time models a detailed transformation path for the energy sector to achieve global greenhouse gas neutrality by 2050. The results will also likely be included in the WEO (World Energy Outlook).

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

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

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

### Energy cooperation in the G20

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

In the following years, the energy policy exchange was continued in separate working groups under the Argentinian, Japanese and Saudi Arabian G20 presidencies. Under the current presidency of Italy, energy and climate have again been merged into a joint working group and are addressing, among other things, sustainable economic recovery and the impact of the global Covid-19 pandemic on energy markets.

### Renewable Energy Policy Network for the 21st Century – REN21

The first International Renewable Energy Conference – renewables2004, which was initiated by the Federal Government and held in Bonn, put renewable energy on the global agenda. This conference provided crucial momentum: the more than 100 participating countries agreed that renewable energy would play a central role in an energy system of the future and committed to national or regional targets and actions. To maintain this momentum, the Renewable Energy Policy Network for the 21st Century (REN21) was then founded. REN21 publishes the Global Status Report each year, a publication, that informs policy debate on renewable energy [50].

The global policy network REN21 (Renewable Energy Policy Network for the 21st Century), which Germany played a major role in founding and promoting after the "renewables2004" conference, has since developed into the most important global multi-stakeholder network with the aim of supporting political measures to accelerate the expansion of renewable energy. It plays a central role in providing conceptual and organisational support to the host countries of the IRECs (International Renewable Energy Conferences). Representatives of governments, international organisations, civil society, science and the private sector from the energy, environment and development sectors are represented in REN21. The REN21 secretariat is located in Paris.

REN21 publishes the annual "Renewables Global Status Report" (GSR), which tracks the annual expansion of renewable energy worldwide and has become the network's flagship publication. The report presents the status and geographical distribution of renewable energy capacities installed worldwide, the expansion targets and policy instruments, as well as the investments made in renewable energy sources worldwide [50].

In addition to the Global Status Report, REN21 publishes reports with different focuses, such as the Global Futures Report (GFR) series or the Renewables in Cities Global Status Report (REC). The portfolio is supplemented by regional status reports, which examine the development of renewable energy sources in individual regions of the world in greater depth.

Further information at: www.ren21.net.

### International Renewable Energy Conferences (IRECs)

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

The topics and focal points of the past IRECs cover a broad spectrum. For example, at the MEXIREC in Mexico City, numerous ministers and high-ranking participants from energy policy organisations and business discussed the framework conditions and success factors for the expansion of renewable energy in Central and South America, or at the SAIREC in Cape Town, South Africa, the development of renewable energy sources in Africa, especially the sub-Saharan region.

In October 2010, the Delhi International Renewable Energy Conference (DIREC) took place. DIREC culminated in the signing of a joint political declaration that affirmed the commitment of all conference participants to accelerate the global expansion of renewable energy sources and to support the UN's Sustainable Energy for All initiative.

KIREC, hosted in Seoul in 2019, was the first IREC to be co-organised by a national and municipal government. This underlines the importance of cities for the use of renewable energy, as well as for the implementation of environmental policies at the local level. At the conference, the city of Seoul presented its ambitions and promotion approaches for renewable energy sources, as well as its efforts to create a more efficient, sustainable and safe urban environment.

Due to the uncertainties of the Covid 19 pandemic, no IREC will take place in 2021. However, discussions are currently underway to host the next IREC in spring or autumn 2022.

### Berlin Energy Transition Dialogue – BETD

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

In 2021, more than 13,000 domestic and foreign decision-makers from politics, business, academia and civil society, as well as world-leading energy experts from 134 countries – including 73 foreign and energy ministers, as well as high-level delegates ("VIPs") from around the world – followed the event, which was held in an online format due to the Corona pandemic. The aim of the conference was to further advance the international dialogue on a secure, environmentally sound and affordable global energy transition in view of the Paris climate agreements. Another focus was on transatlantic cooperation, which is experiencing a new dynamic since the return of the USA to the Paris Climate Agreement. Accompanying the conference, participants were offered an extensive online framework programme, e.g. virtual excursions to experience the German energy transition on site.

Further information at:
https://2021.energydialogue.berlin

### Clean Energy Ministerial – CEM

The Clean Energy Ministerial (CEM) is a global forum founded in 2010 to promote a sustainable global energy supply in which 28 industrialised and emerging countries, as well as the European Union, participate. Most recently, Poland and Portugal joined the 12th CEM Ministerial Meeting under the auspices of Chile in early June 2021.

The core of CEM is the cooperation of member states, mostly organised on a technology-specific basis in various initiatives as well as in short-term campaigns that also include actors from the private sector and civil society. This cooperation goes back to ten technology action plans on a range of low-carbon technologies that were jointly developed by a number of industrialised countries in 2009 in preparation for the COP 15 climate conference in Copenhagen.

The Government, represented by the Federal Ministry for Economic Affairs and Energy, is leading the multilateral initiative on long-term scenarios for the energy transition and the Investment and Finance Initiative, among others, together with Denmark. New priorities for the work of the initiatives are decided in annual conferences at the ministerial level.

Further information at: www.cleanenergyministerial.org and www.cem12mi6chile.com.

### Mission Innovation – MI

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

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

The MI Annual Conferences typically take place after the CEM meetings at the same venue. In 2021, Mission Innovation will enter a second phase (MI2.0). Within the framework of MI2.0, Germany focuses on the inherently global topic of hydrogen and participates accordingly in “Mission Hydrogen”.

### SEforALL – The Sustainable Energy for All initiative

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

In 2018, about 789 million people worldwide still live without electricity. In addition, about 2.8 billion people do not have access to renewable, zero-emission energy sources for daily cooking. It is unlikely that this number will decrease by 2030 without additional efforts. The impact of the pandemic is expected to reveal a downward trend in access to electricity and further exacerbate the issue of lack of energy access.

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

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

Further information at: www.se4all.org.

## Information on methodology

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

For more information on the German terminology used in energy statistics, please refer to the website of the Federal Ministry for Economic Affairs and Energy www.bmwi.de (in German only).

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

### Methodological changes

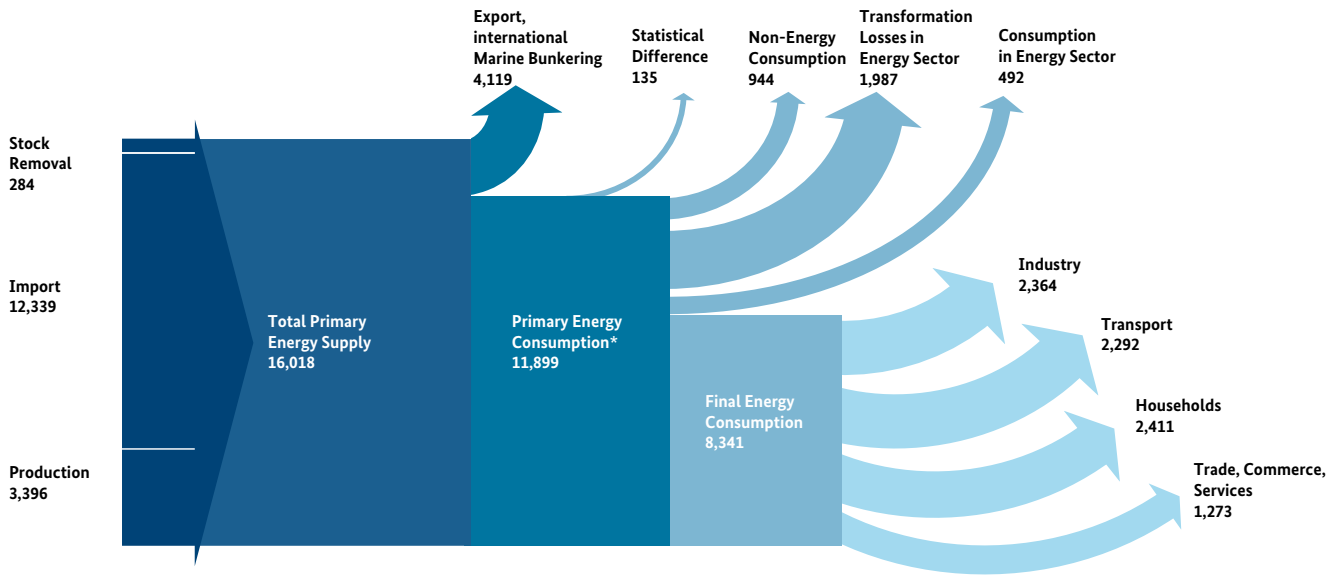
AGEE-Stat is continuously working on methodological improvements to the renewable energy sources statistics. In technical discussions and through the exchange of experts on individual renewable energy sources, new insights are continuously gained to improve the data basis of electricity generation and heat supply from renewable energy sources. The methodological changes derived from this aim to ensure the long-term updating of the renewable energy statistics and at the same time to create a uniform data basis for the fulfilment of national and international reporting obligations. An overview of the current methodological changes is provided below:

### Self-use and technical own consumption of photovoltaic systems

The time series of gross electricity generation from photovoltaic systems was reviewed for the present publication and fundamentally updated based on new findings within the framework of the scientific monitoring of the AGEE-Stat. In contrast to

### Figure 69: Energy Flow Chart for Germany, 2020

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 16.5%
* Data preliminary

Source: Working Group on Energy Balances (AG Energiebilanzen) 09/2021

other renewable energy sources, photovoltaic systems increasingly use self-generated electricity in addition to feeding it into the grid. The AGEE-Stat addressed the economically motivated self-consumption from photovoltaic systems at an early stage to close the energy statistics coverage gap created by the abolition of the self-consumption bonus from the RES 2012 despite the introduction of the apportionment obligation on self-consumption with the RES 2014 due to the de *minimis* regulations for small systems and thus to cover the entire gross electricity generation. However, new research results from Fraunhofer-ISE and the Leipzig Institute for Energy as part of the AGEE-Stat's accompanying scientific project show that the previous estimation model, which was agreed with industry representatives in an expert meeting in 2015, needs to be revised. The basis for the correction is a detailed evaluation of the RES movement data and the use of the technical plant characteristics stored in the Core market data register.

In addition to updating the model for economic self-consumption, an estimate of the technical self-consumption (including conversion and inverter losses) of PV systems was made and implemented for the first time. Based on characteristic values of modern inverters, and in accordance with the flat rate for own electricity consumption permitted under §12a of the Electricity Tax Act (StromStV), a technical self-consumption of 2% is applied.

### Installed capacity of hydropower plants

Since the amendment of the Energy Statistics Act in 2017, official data bases for the net output of run-of-river and storage hydropower plants in Germany have been almost completely available, apart from a few isolated plants not connected to the general electricity grid. Also, for reasons of consistency with internationally reported energy data, the time series of installed capacity was adjusted accordingly from 2018.

### Calculation of the share according to EU Directive 2009/28/EC:

For the calculation of target achievement, the EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources contains detailed specifications. In addition to the overall share of renewable energy sources in gross final energy consumption, specific shares are also determined in the sub-sectors of electricity, heat and transport. When calculating the contributions of wind and hydropower, the effects of climatic fluctuations on the electricity yield are taken into account. Through this "normalisation" to an average year, the value for wind and hydropower no longer corresponds to the actual yield of the corresponding year, but instead better reflects the capacity expansion. For liquid bioenergy sources and biofuels to be counted towards meeting the overall target as well as the target in the transport sector, they must fulfill certain sustainability criteria. In the transport sector, the contribution of electricity generated from renewable energy and consumed in electrified rail transport is counted with a factor of 2.5. A factor of 5 is counted for the contribution of electricity generated from renewable energy sources and consumed in electric road vehicles. Furthermore, biofuels produced from raw materials according to Annex IX of Directive 2009/28/EC (esp. used cooking oil) are double counted.

Gross final energy consumption is defined in Directive 2009/28/EC in Article 2 (f) as follows: *"Energy products supplied to industry, transport, households, the service sector, including the public services sector, and agriculture, forestry and fisheries for energy purposes, including electricity and heat consumed by the energy sector for the production of electricity and heat, and including electricity and heat losses occurring during distribution and transmission."*

A comparison of data determined according to the specifications of the EU Directive with statistics from other sources, such as the data on the RES or national statistics, is therefore only possible to a limited extent.

### Calculation of the share without applying the calculation method according to the EU Directive:

The Federal Government's Energy Concept of 2010 also sets a target of 18% for renewable energy sources in gross final energy consumption for the year 2020. To reflect the current development, the calculation method deviates from the calculation method applied according to the EU Directive and

the share of gross final energy consumption is mapped with the real generation of wind and hydropower as well as the actual consumption of biofuels in the transport sector.

### Economic impulses from the use of renewable energy sources

The expansion of renewable energy sources in Germany in recent years has led to a further increase in the importance of the renewable energy sector for the economy as a whole. The construction of renewable energy plants for the use of electricity and heat contributes to this. Additionally, due to the increasing number of plants, the operation of these plants represents a growing economic factor.

The investments made in renewable energy sources are determined on the basis of the capacity added or the number of plants. With the help of specific investment costs (€/kW) or average costs per plant (€/plant), the total investments per sector in the year under consideration are calculated. For plants with a construction period of several years, the investments are allocated on an accrual basis. This applies to offshore wind-powered installations, deep geothermal plants and large hydropower plants, but also to large biomass cogeneration plants and biogas plants. In this way, investments are not just attributed to the year of plant completion or commissioning.

In addition to the expenses for operation and maintenance of the plants, especially in the form of personnel costs, the provision of renewable fuels and biofuels also contributes to the economic impulses from plant operation.

The costs for maintenance and operation of the plants are determined on the basis of technology-specific valuations. Cost calculations from various scientific studies were used for this purpose. These include most importantly the research projects on the RES (especially the research reports on the RES experience report, e.g. [63]), the evaluations of the Market Incentive Programme (e.g. [64]) and the evaluations of KfW funding for renewable energy sources [65].

To determine the costs of fuel supply for electricity and heat generation, the costs of solid and liquid fuels as well as the substrates used to produce biogas are taken into account. The relevant solid biomass fuels mainly include waste wood, forest and industrial waste wood, wood pellets, wood chips, wood briquettes and the commercially traded part of firewood. The main components of substrates for biogas production are maize silage, grass silage as well as whole-plant cereal silage and minor cereals. Overall, the economic impulses from the provision of biogenic fuels were valued at €4.5 billion.

# Conversion factors

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

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

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

| Conversion factors | | | | | |
|---|---|---|---|---|---|
| | | PJ | TWh | Mtce | Mtoe |
| 1 Petajoule | PJ | 1 | 0.2778 | 0.0341 | 0.0239 |
| 1 Terawatt hour | TWh | 3.6 | 1 | 0.123 | 0.0861 |
| 1 million tonnes coal equivalent | Mtce | 29.308 | 8.14 | 1 | 0.7 |
| 1 million tonnes crude oil equivalent | Mtoe | 41.869 | 11.63 | 1.429 | 1 |

The figures refer to the heat calorific value.

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

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

* $10^{2}$ = 100; $10^{3}$ = 1,000; $10^{4}$ = 10,000; $10^{5}$ = 100,000; $10^{6}$ = 1,000,000 etc.

# List of abbreviations

| | |
|---|---|
| ACEA | European Automobile Manufacturers' Association |
| AGEB | Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen e.V.) |
| AGEE-Stat | Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik) |
| AGQM | Working Group on Biodiesel Quality Management (Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e.V.) |
| AusglMechV | Equalisation Scheme Ordinance (Ausgleichsmechanismus-Verordnung) |
| BAFA | Federal Office for Economic Affairs and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle) |
| BDEW | German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft ) |
| BDH | Federation of German Heating Industry (Bundesverband der Deutschen Heizungsindustrie) |
| Biokraft-NachV | Sustainability Ordinance (Biokraftstoff-Nachhaltigkeitsverordnung) |
| BioSt-NachV | Biomass Electricity Sustainability Ordinance (Biomassestrom-Nachhaltigkeitsverordnung) |
| BMBF | Federal Ministry of Education and Research |
| BMEL | Federal Ministry of Food and Agriculture |
| BMU | Federal Ministry for the Environment, Nature Conservation and Nuclear Safety |
| BMVI | Federal Ministry of Transport and Digital Infrastructure |
| BMWi | Federal Ministry for Economic Affairs and Energy |
| BNetzA | Bundesnetzagentur (Federal Network Agency) |
| BRICS | Brazil, Russia, India, China, South Africa |
| BSW | Bundesverband Solarwirtschaft (German Solar Association) |
| BWP | Bundesverband Wärmepumpe e.V. (German Heat Pumps Association) |
| CHP | Combined heat and power plant |
| COP-15 | Fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity |
| DBFZ | Deutsches Biomasseforschungszentrum (German Biomass Research Centre Leipzig) |
| DEPV | Deutscher Energieholz- und Pellet-Verband e.V. (German Wood and Pellet Fuel Association) |
| dena | German Energy Agency |
| ECN | Energy Research Centre of the Netherlands |
| EEG | Renewable energy sources Act (Erneuerbare-Energien-Gesetz) |
| EEWärmeG | Renewable Heat Sources Act (Erneuerbare-Energien-Wärme-Gesetz) |

| | |
|---|---|
| EnergieStG | Energy Tax Act (Energiestatistikgesetz) |
| EnSAG | Omnibus Energy Act (Energiesammelgesetz) |
| EnStatG | Energy Statistics Act (Energiestatistikgesetz) |
| ENTSO-E | Association of European Transmission System Operators |
| EU | European Union |
| Eurostat | Statistical Office of the European Union |
| EWEA | European Wind Energy Association |
| FEC | Final energy consumption |
| Fh-ISE | Fraunhofer Institute for Solar Energy Systems (Fraunhofer-Institut für Solare Energiesysteme) |
| FNR | Fachagentur Nachwachsende Rohstoffe e.V. (Agency for Renewable Resources) |
| GHG | Greenhouse gas |
| GEG | Building Energy Act (Gebäudeenergiegesetz) |
| GSR | Global Status Report |
| GWP | Global warming potential |
| HIC | Hamburg Institute |
| HH | Households |
| HP | Heating plant |
| HVO | Hydrotreated Vegetable Oil |
| IE Leipzig | Leipzig Institute for Energy (Leipziger Institut für Energie) |
| IEA | International Energy Agency |
| iLUC | indirect Land Use Change |
| IRENA | International Renewable Energy Agency |
| KBA | Federal Motor Transport Authority (Kraftfahrt-Bundesamt) |
| KfW | Kreditanstalt für Wiederaufbau |
| KWKG | Combined Heat and Power Act (Kraft-Wärme-Kopplungsgesetz) |
| LSV | Charging Column Ordinance (Ladesäulenverordnung) |
| MaStRV | Core Energy Market Data Register Ordinance (Marktstammdatenregisterverordnung) |
| MAP | Market Incentive Programme (Marktanreizprogramm) |
| N/A | Not available |
| NECP | National Energy and Climate Plan |
| NREAP | National Renewable Energy Action Plan |
| NUTS 2 | Definition of regions for regional policy measures |
| UBA | Federal Environment Agency (Umweltbundesamt) |
| UFOP | Union for the Promotion of Oil and Protein Plants (Union zur Förderung von Oel- und Proteinpflanzen e.V.) |
| PV | Photovoltaics |

| | |
|---|---|
| PEC | Primary energy consumption |
| PHEV | Plug-In-Hyprid |
| ptj | project management agency (Projektträgers Jülich) |
| PP | Power plant |
| R&D | Research and development |
| RE / RES | Renewable energy (sources) |
| REN 21 | Renewable Energy Policy Network for the 21st Century |
| SMARD | Electricity market data: information platform of the Federal Network Agency |
| StBA | Federal Statistical Office (Statistisches Bundesamt) |
| StromEinspG | Act on the Sale of Electricity to the Grid (Stromeinspeisungsgesetz) |
| SystEEm | Integration of renewable energy sources and regenerative energy supply systems (Integration erneuerbarer Energien und regenerative Energieversorgungssysteme) |
| TCS | Trade, commerce and service sector |
| TSO | Transmission system operator |
| UL | UL International GmbH |
| USD | United States Dollars |

# List of sources

[1] Arbeitsgemeinschaft Energiebilanzen (AGEB) [Working Group on Energy Balances], „AG Energiebilanzen e.V. | Bilanzen 1990–2019“ (Working Group on Energy Balances, Energy Balances 1990–2019), Sep. 2021. Available at: https://ag-energiebilanzen.de/7-1-Energy-Balance-2000-to-2019.html.

[2] Statistisches Bundesamt (StBA) [Federal Statistical Office], “Umwelt – Abfallentsorgung – Fachserie 19 Reihe 1 – 2017” (Environment – waste management – special series 19 series 1 – 2017), Federal Statistical Office, June 25 2019. Available at: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Abfallwirtschaft/Publikationen/Downloads-Abfallwirtschaft/abfallentsorgung-2190100177004.pdf.

[3] Statistisches Bundesamt (StBA) [Federal Statistical Office], “Statistische Erhebungen im Bereich Stromerzeugung und elektrische Leistung: 066K, 067, 070 und 073” (Statistical surveys on electricity generation and electrical output: 066K, 067, 070 und 073).

[4] Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen (BNetzA) [Federal Network Agency], “EEG-Statistikberichte zu den Jahresendabrechnungen 2007–2011, EEG in Zahlen 2012–2018 sowie Auswertungen des Anlagen- und PV-Melderegisters und Markstammdatenregisters (MaStR)” (Statistical reports on end-of-year calculations 2007-2011, RES in figures 2012–2018 and evaluations of the installation and Photovoltaic register and the core energy market data register), August 2021. Available at: http://www.bundesnetzagentur.de/EN/Areas/Energy/Companies/RenewableEnergy/RenewableEnergy_node.html.

[5] Informationsplattform der deutschen Übertragungsnetzbetreiber [Information platform of the German Transmission System Operators], “Jahresabrechnungen nach dem Erneuerbare-Energien-Gesetz (EEG-Jahresabrechnungen 2000–2020)” (Renewable energy sources Act annual accounts 2000-2020), August 2021. Available at: https://www.netztransparenz.de/EEG/Jahresabrechnungen.

[6] Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW) [Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg] et al., “Vorbereitung und Begleitung der Erstellung des Erfahrungsberichtes 2014 gemäß § 65 EEG, im Auftrag des Bundesministeriums für Wirtschaft und Energie (Preparation and monitoring of the drafting of the 2014 progress report in accordance with Section 65 Renewable energy sources Act, commissioned by the Federal Ministry for Economic Affairs and Energy) – Wissenschaftlicher Bericht Vorhaben I (Scientific report on projects I), July 2014.

[7] Reinholz, T.; Völler, K., “Kurzstudie – Daten für den Biomethanmarkt – Zusammenstellung und Analyse verfügbarer aktueller Daten sowie rückwirkender Zeitreihen” (Brief study – data on the bioethane market – compilation and analysis of available current data and retrospective time series), Berlin, July 2018.

[8] Bundesverband der Energie- und Wasserwirtschaft e.V. (BDEW) [Association of Energy and Water Industries], “BDEW-Strompreisanalyse Januar 2020, Haushalte und Industrie” (BDEW electricity price analysis January 2021, households and industry), January 08 2021.

[9] VDEW – Grawe, J.; Wagner, E., “Nutzung erneuerbarer Energien durch die Elektrizitätswirtschaft 1992, 1994, 1996, 1999” (Use of renewable energy in the electricity industry 1992, 1994, 1996, 1999); in: ew (Elektrizitätswirtschaft).

[10] Deutsches Biomasseforschungszentrum GmbH (DBFZ) [German Biomass Research Centre] in collaboration with Thüringer Landesanstalt für Landwirtschaft (TLL) [Thuringian State Institute for Agriculture], “Monitoring zur Wirkung des Erneuerbare-Energien-Gesetzes (EEG) auf die

Entwicklung der Stromerzeugung aus Biomasse – Endbericht zur EEG-Periode 2009-2011", (Monitoring report on the impact of the Renewable energy sources Act on electricity generation from biomass – final report on the Renewable energy sources Act period 2009-2011), research project commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, March 2012.

[11] IE – Institut für Energetik und Umwelt gGmbH (IE), Leipzig, Fichtner GmbH & Co. KG, Stuttgart, Thüringer Landesanstalt für Landwirtschaft, "Monitoring zur Wirkung des novellierten Erneuerbare-Energien-Gesetz (EEG) auf die Entwicklung der Stromerzeugung aus Biomasse" (Monitoring report on the impact of the revised Renewable energy sources Act on electricity generation from biomass), Jena.

[12] Weimar, H., "From empirical studies to bioenergy statistics: bridging the GAP of unrecorded wood-bioenergy in Germany".

[13] DEPV, Deutsches Pelletinstitut GmbH, „Pelletmarkt in Deutschland zieht spürbar an – Hoher Absatz an Feuerungen und erstmals mehr als 3 Mio. Tonnen Produktion, 2020" (Pellet market in Germany is picking up noticeably – high sales of furnaces and for the first time more than 3 million tons of production, 2020), Feb. 2021. Available at: https://www.depv.de/p/Pelletmarkt-in-Deutschland-zieht-spurbar-an-Hoher-Absatz-an-Feuerungen-und-erstmals-mehr-als-3-Mio-Tonnen-Produktion-jA6jkfSq8WrB4aVVmipgaj.

[14] Arbeitsgemeinschaft Energiebilanzen (AGEB) [Working Group on Energy Balances], "Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeeinheiten (2005–2019)" (Calorific values of energy sources and factors for the conversion of specific units of measure to heat units (2005-2019)), August 2021. Available at: https://ag-energiebilanzen.de/daten-und-fakten/zusatzinformationen/.

[15] Statistisches Bundesamt (StBA) [Federal Statistical Office], "Statistische Erhebung 2, 064, 066K, 067, 073 und Außenhandelsstatistik" (Statistical Survey 2, 064, 066K, 067, 073 and foreign trade statistics).

[16] Thünen-Institut für internationale Waldwirtschaft und Forstökonomie [Thünen Institute for International Forestry and Forest Economics], Holzeinschlag und Rohholzverwendung (Timber felling and use of raw wood). Available at: https://www.thuenen.de/en/topics/forest-management-and-wood-use/.

[17] Born, H. et al., „Analyse des deutschen Wärmepumpenmarktes – Bestandsaufnahme und Trends, 2. Aktualisierung Internationales Geothermiezentrum (GZB) im Auftrag des ZSW" (Analysis of the German heat pump market – stocktaking and trends, 2nd update International Geothermal Energy Centre on behalf of ZSW), 1 November 2017.

[18] International Energy Agency (IEA), European Solar Thermal Industry Federation (ESTIF), "Solar Heating and Cooling Programme: Common calculation method of the solar thermal energy produced worldwide available", Bochum, 15 November 2011.

[19] Fachagentur nachwachsende Rohstoffe (FNR) [Agency for Renewable Resources], "Rohstoffmonitoring Holz: Mengenmäßige Erfassung und Bilanzierung der Holzverwendung in Deutschland – Forst – Nachwachsende Rohstoffe – Broschüren" (Monitoring raw materials – Wood: quantitative survey and accounts of use of wood in Germany – forestry – regenerative raw materials – brochures), June 2018. Available at: https://mediathek.fnr.de/broschuren/nachwachsende-rohstoffe/forst/rohstoffmonitoring-holz-mengenmaessige-erfassung-und-bilanzierung-der-holzverwendung-in-deutschland.html.

[20] Döring, P.; Glasenapp, S.; Mantau, U., "Rohstoffmonitoring Holz: Energieholzverwendung in privaten Haushalten 2014; Marktvolumen und verwendete Holzsortimente; Abschlussbericht", (Monitoring raw materials – Wood: use of wood for energy in private households in 2014; market volume and types of wood used; final report), February 2016.

[21] Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) [Federal Office of Economics and Export Control], "Amtliche Mineralölstatistik" (Official oil statistics). Available at: www.bafa.de/DE/Energie/Rohstoffe/Mineraloelstatistik/mineraloel_node.html;jsessionid=FD235CA42058299AC37D8F4C106AD2DA .2_cid387.

[22] Bundesanstalt für Landwirtschaft und Ernährung (BLE) [Federal Office for Agriculture and Food]"Evaluations- und Erfahrungsbericht für das Jahr 2018 – Biomassestrom-Nachhaltigkeitsverordnung, Biokraftstoff-Nachhaltigkeitsverordnung (Evaluation and progress report for 2018 – Biomass Energy Sustainability Ordinance, Biofuels Sustainability Ordinance), Bonn, October 2019. Available at: https://www.bafa.de/DE/Energie/Rohstoffe/Mineraloelstatistik/mineraloel_node.html.

[23] Bundesanstalt für Landwirtschaft und Ernährung (BLE) [Federal Office for Agriculture and Food], "Anmeldungen auf die Treibhausgasminderungsquote – Daten für das Jahr 2020 (Nabisy Datenauszug 2021)" (Reports on the greenhouse gas emission rate – data for 2020 (Nabisy data extract 2021)).

[24] Bundesministerium der Finanzen (BMF) [Federal Ministry of Finance] and Biokraftstoffquotenstelle [Office for Biofuel Quotas], "Statistische Angaben über die Erfüllung der Biokraftstoffquote " (Statistics on the fulfilment of the biofuel quota). Available at: https://www.zoll.de/DE/Fachthemen/Steuern/Verbrauchsteuern/Treibhausgasquote-THG-Quote/Quotenverpflichtung/Erfuellung-Quotenverpflichtung/erfuellung-quotenverpflichtung_node.html.

[25] Bundesregierung (BReg) [Federal Government],"Nationale Berichte zur Umsetzung der Richtlinie 2003/30/EG vom 08.05.2003 zur Förderung der Verwendung von Biokraftstoffen oder anderen erneuerbaren Kraftstoffen im Verkehrssektor" (National reports on the implementation of Directive 2003/30/EC of 8 May 2003 to promote the use of biofuels or other renewable fuels in the transport sector). Available at: www.biomasse-nutzung.de/wp-content/uploads/germany_2011_de.pdf.

[26] Bundesregierung (BReg) [Federal Government],"Bericht der Bundesregierung über die Entwicklung der Treibhausgasminderung von Biokraftstoffen, über das Biomassepotenzial sowie über die auf dem Kraftstoffmarkt befindlichen Biomethan-Mengen" (Federal Government report on progress in reducing greenhouse gas emissions from biofuels, on biomass potential and on the quantities of biomethane in the fuel market), 10 May 2012. Available at: http://dip21.bundestag.de/dip21/btd/17/096/1709621.pdf.

[27] Bundesregierung (BReg) [Federal Government], "Verordnung über Anforderungen an eine nachhaltige Herstellung von Biokraftstoffen" (Ordinance on requirements for sustainable production of biofuels) (Federal Law Gazette I p. 2174). 30 September 2009.

[28] Bundesregierung (BReg) [Federal Government], "Verordnung über Anforderungen an eine nachhaltige Herstellung von flüssiger Biomasse zur Stromerzeugung" (Ordinance on requirements for the sustainable production of liquid biomass for electricity generation). 23 July 2009.

[29] Statistisches Bundesamt (StBA) [Federal Statistical Office], "Energiesteuerstatistik – Fachserie 14 Reihe 9.3" (Energy tax statistics – special series 14 series 9.3), latest edition: 2016. 1 June 2017.

[30] Kunze et. al., “Substitutionseffekte erneuerbarer Energien im Stromsektor – Modellierung der Substitutionseffekte erneuerbarer Energien im deutschen und europäischen Stromsektor und ihrer Auswirkungen auf die Emissionsbilanzierung erneuerbarer Energieträger” (Substitution effects of renewable energy in the electricity sector – Modelling the substitution effects of renewable energy in the German and European electricity sector and its impact on the emissions accounts of renewable energy). 1 September 2019.

[31] Fehrenbach, H.et al., “Aktualisierung der Eingangsgrößen und Emissionsbilanzen wesentlicher biogener Energienutzungspfade (BioEm)” (Updated input values and emission balances for key usage of biogenic energy sources). 1 February 2016. Available at: www.umweltbundesamt.de/publikationen/aktualisierung-der-eingangsdaten-emissionsbilanzen.

[32] Umweltbundesamt (UBA) [German Enviroment Agency], Emissionsbilanz erneuerbarer Energieträger. (Emissions balance of renewable energy sources). October 2021. Available at: https://www.umweltbundesamt.de/publikationen/emissionsbilanz-erneuerbarer-energietraeger.

[33] Bundesministerium für Wirtschaft und Energie (BMWi) [Federal Ministry for Economic Affairs and Energy], „Mieterstrombericht nach§ 99 Erneuerbare-Energien-Gesetz 2017“(Tenant electricity report according to § 99 Renewable energy sources Act 2017 “). Mai 2021. Available at: https://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/Berichte/mieterstrombericht-eeg-2017.pdf;jsessionid=2C88EB08A49AE05FCF4A405174498E0C?__blob=publicationFile.

[34] Übertragungsnetzbetreiber(ÜBN) [Transmission system operator (TOS)], “Prognose der EEG-Umlage 2021 nach EEV – Prognosekonzept und Berechnungen der ÜNB” (Forecast of EEG surcharge 2021 by final energy consumption – forcast concept and calculations of the TSOs). Available at: https://www.netztransparenz.de/portals/1/Content/EEG-Umlage/EEG-Umlage%202021/2020-10-15%20Ver%c3%b6ffentlichung%20EEG-Umlage%202021.pdf.

[35] Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) [Federal Office of Economics and Export Control], “Hintergrundinformationen zur Besonderen Ausgleichsregelung. Antragsverfahren 2018 für Begrenzung der EEG-Umlage 2019“ (Background information on the special equalisation scheme. Application procedures in 2018 for 2019). Available at: https://www.bafa.de/SharedDocs/Downloads/DE/Energie/bar_hintergrundinformationen.pdf?__blob=publicationFile&v=2.

[36]GWS, “Ökonomische Indikatoren des Energiesystems Methode, Abgrenzung und Ergebnisse für den Zeitraum 2000 – 2016” (Economic energy system indicators: method, definition and results for 2000-2016). GWS Research Report 2018/02“, Osnabrück, February 2018.

[37] DIW, DLR, GWS, „Ergebnisse aus dem laufenden Forschungsvorhaben ‚Ökonomische Indikatoren des Energiesystems‘ im Auftrag des BMWi“ („Results from the ongoing research project ‘Economic indicators of the energy system’ on behalf of the BMWi“), Mai 2021.

[38] Bundesregierung (BReg) [Federal Government],” Biokraftstoffquotengesetz (Biofuel Quota Act) of 18 December 2006 (Federal Law Gazette I p. 3180).

[39] Bundesregierung (BReg) [Federal Government],”Zwölftes Gesetz zur Änderung des Bundes-Immissionsschutzgesetzes (Twelfth Act amending the Federal Immission Control Act) of 20 November 2014.

[40] Bundeministerium für Wirtschaft und Ausfurkontrolle (BAFA) Federal Office of Economics and Export Control], „Elektromobilität (Umweltbonus), Zwischenbilanz zum Antragstand vom 01. Oktober 2021“(“Electromobility (environmental bonus), interim balance on the application status from October 01, 2021”). Available at: https://www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_zwischenbilanz.html.

[41] Kraftfahrt-Bundesamt (KBA), „Elektromobilität in Deutschland auf der Überholspur; Pressemitteilung Nr. 01/2021“. January 06 2021. Available at: https://www.kba.de/SharedDocs/Downloads/DE/Statistik/Fahrzeuge/FZ14/fz14_2020_pdf.pdf?__blob=publicationFile&v=3.

[42] Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen (BNetzA) [Federal Network Agency], „Zahlen und Daten zur öffentlichen Ladeinfrastruktur“ (Figures and data on the public charging infrastructure). Available at: https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/E-Mobilitaet/Ladesaeulenkarte/start.html.

[43] Bundesministerium für Wirtschaft und Energie (BMWi) [Federal Ministry for Economic Affairs and Energy „I „Bundesbericht Energieforschung 2021 Forschungsförderung für die Energiewende “ („2021 Federal Government Report on Energy Research “). Available at: https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/federal-government-report-on-energy-research-2021.html.

[44] Europäische Kommission, Generaldirektion Energie (European Commission, Directorate General for Energy), „Bericht der Kommission an das Europäische Parlament, den Rat, den Europäischen Wirtschafts- und Sozialausschuss und den Ausschuss der Regionen – Fortschrittsbericht ‚Erneuerbare Energiequellen‘“ (Report from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions – Renewable Energy Progress Report). October 2020. Available at: https://ec.europa.eu/transparency/documents-register/detail?ref=COM(2020)952&lang=de.

[45] Eurostat, Statistical Office of the European Communities, Luxembourg, “SHARES 2019 – Short Assessment of Renewable energy sources”, July 06 2020. Available at: http://ec.europa.eu/eurostat/web/energy/data/shares.

[46] Energy research Centre of the Netherlands (ECN), European Enviroment Agency (EEA), “Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States, Summary Report”, ECN-E–10-069, November 2011.

[47] Eurostat, Statistical Office of the European Communities, Luxembourg, Online Database, Production of electricity and derived heat by type of fuel (nrg_bal_peh), 2020”. Juni 2021. Available at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_bal_peh&lang=en.

[48] Eurostat, Statistical Office of the European Communities, Luxembourg, „Energy balances – early estimates, 2020“. Juni 2021. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_balances_-_early_estimates.

[49] Eurostat, Statistical Office of the European Communities, Luxembourg, „Online Database, Electricity production capacities for renewables and wastes (nrg_inf_epcrw), 2020“. https://ec.europa.eu/eurostat/web/main/data/database?node_code=nrg_inf_epcrw.

[50] REN21 – Renewable Energy Policy Network for the 21st Century, „Renewables 2021, Global Status Report“. Zugegriffen: Juni 17, 2021. [Online]. Verfügbar unter: https://www.ren21.net/wp-content/uploads/2019/05/GSR2021_Full_Report.pdf.

[51] European Wind Energy Association (EWEA), “Wind energy in Europe in 2019”, Wind Europe. February 2020. Available at: https://windeurope.org/about-wind/statistics/european/wind-energy-in-europe-in-2019/ .

[52] International Renewable Energy Agency (IRENA), „Renewable capacity statistics 2021“. March 2021. Available at: https://www.irena.org/publications/2021/March/Renewable-Capacity-Statistics-2021.

[53] Observatoire des énergies renouvelables (Observ'ER), „Solar thermal and concentrated solar power barometer 2021", EurObserv'ER. Available at: https://www.eurobserv-er.org/category/all-solar-thermal-and-concentrated-solar-power-barometers/.

[54] Eurostat, „Solar thermal collectors' surface, Data Explorer". Available at: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_inf_stcs&lang=en (zugegriffen Juni 08, 2021).

[55] ACEA – European Automobile Manufacturers' Association, „Fuel types of new cars: electric 10.5%, hybrid 11.9%, petrol 47.5% market share full-year 2020". January 2021. Available at: https://www.acea.auto/files/20210204_PRPC_fuel_Q4_2020_FINAL.pdf.

[56] Observatoire des énergies renouvelables (Observ'ER), "All Biofuels barometers, A study carried out by EurObserv'ER", 1 September 2018. [Online]. Available at: www.eurobserv-er.org/category/all-biofuels-barometers/ .

[57] International Renewable Energy Agency (IRENA), „World Energy Transitions Outlook, 1.5 ° C Pathway", Juli 2021. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/March/IRENA_World_Energy_Transitions_Outlook_2021.pdf.

[58] IEA International Energy Ageny, „World Energy Outlook 2020 – Analysis", IEA. Available at: https://www.iea.org/reports/world-energy-outlook-2020.

[59] REN21 – Renewable Energy Policy Network for the 21st Century – Renewable Energy Policy Network for the 21st Century, „Renewables 2021, Global Status Report". Available at: https://www.ren21.net/gsr-2020/.

[60] Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW) [Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg], „ZSW: Data Service Renewable energy sources". https://www.zsw-bw.de/en/media-center/data-service.html.

[61] International Renewable Energy Agency (IRENA), "Renewable Energy and Jobs – Annual Review 2021", October 2021. Available at: https://www.irena.org/publications/2021/Oct/Renewable-Energy-and-Jobs-Annual-Review-2021.

[62] International Renewable Energy Agency (IRENA), „Global renewables outlook, energy transformation 2050; Edition:2020". Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Global_Renewables_Outlook_2020.pdf

[63] Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW) [Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg] et al, „Vorbereitung und Begleitung bei der Erstellung eines Erfahrungsberichts gemäß § 97 EEG, im Auftrag des Bundesministeriums für Wirtschaft und Energie – Teilvorhaben II c: Solare Strahlungsenergie, Abschlussbericht, März 2019.", März 2019. Available at: https://www.zsw-bw.de/uploads/media/zsv-boschundpartner-vorbereitung-begleitung-eeg.pdf.

[64] Bundesministerium für Wirtschaft und Energie (BMWi) [Federal Ministry for Economic Affairs and Energy], Evaluation des Marktanreizprogramms zur Förderung von Maßnahmen zur Nutzung erneuerbarer Energien im Wärmemarkt im Förderzeitraum 2015 bis 2017 (Evaluation of the Market Incentive Programme to promote measures to use renewable energy in the heating market in the 2015–2017 funding period), 1 October 2018.

[65] Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW) [Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg], „Evaluierung der inländischen KfW-Programme zur Förderung Erneuerbarer Energien in den Jahren 2017 und 2018, Gutachten im Auftrag der KfW Bankengruppe“ („Evaluation of the domestic KfW programs to promote renewable energy sources in 2017 and 2018, report on behalf of KfW Bankengruppe“). Available at: www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-alle-Evaluationen/Eneuerbare-Energien-Evaluation-2017-und-2018.pdf.