Federal Ministry
for Economic Affairs
and Energy

Energie wende
Switch to the Future

Renewable Energy Sources in Figures

National and International Development, 2015

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Contents

Introduction

Dear Reader,

In the 17th edition of the publication 'Renewable Energy Sources in Figures – National and International Development', the Federal Ministry for Economic Affairs and Energy reports on the expansion of renewable energy in Germany, the European Union and worldwide in 2015.

The use of renewable energy sources in Germany continued its advance last year:

- The share of renewables in total electricity consumption rose from 27.3% in 2014 to 31.6% in 2015. This means that we have taken another major step towards achieving our goal of increasing this share to 40–45% by the year 2025.
- Renewables accounted for 13.2% of gross final energy consumption for heating, up on the preceding year's figure (12.5%). The German government's target of achieving a share of 14% by the year 2020 is thus within reach.
- Looking at transport, renewable energy sources accounted for 5.2% of total final energy consumption, slightly less than in the previous year (5.6%).

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

- In 2015, emissions of 156.1 million tonnes of CO_2 equivalent were prevented, with the electricity sector alone accounting for 117.6 million tonnes of this.
- A total of €15.0 billion was invested in the construction of renewable energy installations last year.
- The operation of renewable energy installations provided an economic stimulus of €14.7 billion.

This publication provides detailed information about the status and development of renewable energy in the fields of electricity, heat and transport.

The data used here are taken from the findings of the Working Group on Renewable Energy – Statistics (AGEE-Stat), which prepared the balance sheet for renewable energy sources in Germany on behalf of the Federal Ministry for Economic Affairs and Energy. Furthermore, it provides information about such key aspects as the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz; EEG), the Renewable Energies Heat Act (Erneuerbare-Energien-Wärmegesetz; EEWärmeG) and the funding of renewable energy in the fields of heat, transport, and research and development.

In addition to the latest statistics for Germany, this publication also documents the development made in the use of renewable energy sources in the European Union, which has also set ambitious goals for itself. The publication is rounded off with data on the use of renewables worldwide.

The information presented in this publication constitutes a snapshot of the situation as of the editorial deadline for this brochure (August 2016). However, some of the figures are provisional, especially those pertaining to the year 2015. Parallel to this brochure, the website of the Federal Ministry for Economic Affairs and Energy offers current timelines showing the development of renewable energy sources in Germany since 1990 plus a variety of diagrams. These timelines and diagrams will be updated at the end of 2016/start of 2017.

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

Yours sincerely,
The Federal Ministry for Economic Affairs and Energy

Berlin, September 2016

Working Group on Renewable Energy Statistics

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

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

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

- the Federal Ministry for Economic Affairs and Energy (BMWi),
- the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB),
- 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 Working Group on Energy Balances (AGEB) and
- the Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg (ZSW).

At the beginning of 2016, the German Environment Agency took over the office and management of the Working Group from the ZSW, which had previously run the Working Group since its launch. Michael Memmler of the German Environment Agency is now the director.

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

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

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

Further information on AGEE-Stat and renewable energy can be found on the website of the Federal Ministry for Economic Affairs and Energy at www.erneuerbare-energien.de.

Part I: Renewable energy in Germany

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

Future expansion of renewable energy

The Renewable Energy Sources Act, which entered into force in 2000 and has since been revised several times, aimed to facilitate market access for young technologies like wind energy and photovoltaics by guaranteeing their purchase at fixed rates. It thus built a platform for the expansion of renewables in the electricity sector, enabling them to emerge from being a niche to become the mainstay of Germany's power supply. With a share of 31.6% of Germany's gross electricity consumption, renewables have advanced to become the most important source of energy in Germany's electricity supply.

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

Following the successful trials, the auctions are now to be extended to cover other technologies, and particularly wind energy, under the new 2017 Renewable Energy Sources Act, which was adopted on 8 July 2016 and enters into force on 1 January 2017. The only exemption is for installations with an output of below 750 kilowatts.

In this way, the 2017 Renewable Energy Sources Act is following three main principles:

- **Sticking to the deployment corridors** for renewable energy, so that grid expansion can keep pace.
- **Continuing expansion in way that is cost-efficient** via a switch to competitive auctions, and
- M**aintaining stakeholder diversity** via an auction system which offers fair opportunities to all stakeholders.

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

A major instrument for heating/cooling is also the Renewable Energies Heat Act (EEWärmeG), the funding details of which are fleshed out in the Market Incentive Programme (MAP). Finally, the use of renewable energy in the transport sector is largely determined by the Biofuel Quota Act. When it comes to the use of electricity in transport, mention should also be made of the Electric Mobility Strategy and, from 2016, the purchase premium for electric vehicles.

Figure 1:
Renewable energy – goals of the German government

	Renewable energy shares of gross electricity consumption
2025	40 – 45 %
2035	55 – 60 %
2050	at least 80 %
	Renewable energy shares of gross final energy consumption
2020	at least 18 %
2030	30 %
2040	45 %
2050	60 %

Figure 2: Deployment corridors for installed capacity under the 2017 Renewable Energy Sources Act

Onshore wind energy	**2,800 MW** Annual gross newbuild in 2017–2019	**2,900 MW** Annual gross newbuild from 2020
Offshore wind energy	Increase in installed capacity to **6,500 MW** in 2020	Increase in installed capacity to **15,000 MW** in 2030
Solar energy	**2,500 MW** Annual gross newbuild	
Biomass	**150 MW** Annual gross newbuild in 2017–2019	**200 MW** Annual gross newbuild in 2020–2022

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

Monitoring the energy transition

The German government's Energy for the Future monitoring process regularly reviews the progress made in the transformation of Germany's energy system. The monitoring process primarily involves analysing and consolidating the many available energy statistics and putting them into an easy-to-understand form – thus providing an overview of the current status of the transformation of the energy market in an annual monitoring report. As part of this process, the German government issued the fourth Monitoring Report on the energy transition in December 2015. A panel of four experts monitors and scientifically evaluates the monitoring process.

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

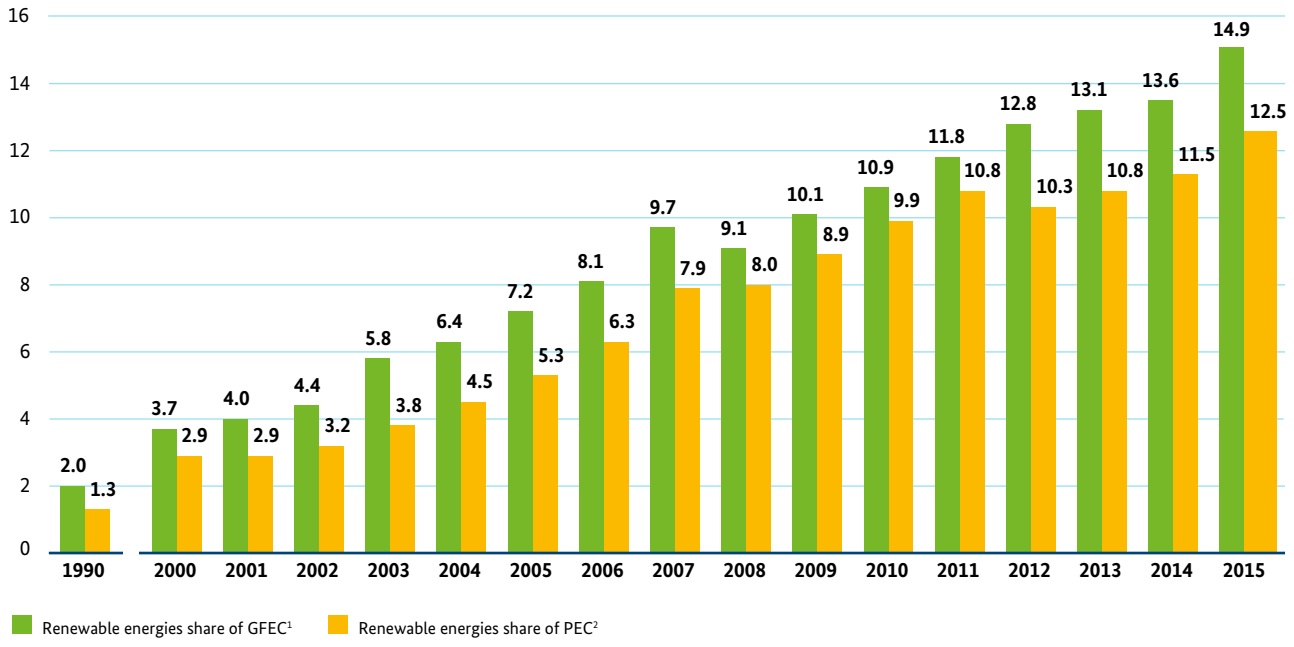
Figure 3: Renewable energy in Germany – current situation

Categories	2015	2014
Renewable energy share		
of gross final energy consumption	14.9	13.6
of gross electricity consumption	31.6	27.3
of final energy consumption in heating /cooling	13.2	12.5
of final energy consumption in transport	5.2	5.6
of primary energy consumption	12.5	11.5
Avoidance of greenhouse gas emissions through the use of renewable energy sources		
Total greenhouse gas avoidance	156 million t	137 million t
of which through electricity with remuneration under the EEG	99 million t	82 million t
Economic impetus through the use of renewable energy sources		
Investment in the construction of renewable energy plants	15.0 billion €	19.2 billion €
Costs/Revenues from the operation of renewable energy plants	14.7 billion €	14.2 billion €

Sources: BMWi on the basis of AGEE-Stat and other sources; see following figures, data provisional

Figure 4: Renewable energy shares of final and primary energy consumption in Germany

in percent



1 calculation of the share of renewable energy in gross final energy consumption without using special calculation rules set out in EU Directive 2009/28/EC See Annex, section 2 for details on how the share was calculated

2 declining share in primary energy consumption caused by a methodological change starting with the year 2012, previous years not yet revised

Sources: BMWi based on AGEE-Stat; ZSW; EEFA; AGEB [1], [2]; Eurostat [3] and other sources; see following figures, all data provisional

Electricity

Renewable energy sources expand their leading position

In 2015, nearly 187 billion kilowatt-hours of electricity (2014: 161 billion kilowatt-hours) were generated from renewable energy sources. This enabled renewables to build substantially on their leading position in the electricity mix, ahead of lignite, reaching a share of 31.6% of gross electricity consumption (2014: 27.3%). This was the first time that the share of renewables grew by more than 4 percentage points. The key factor behind this increase was a sharp rise in onshore and offshore wind energy.

Further large increase in amount of onshore wind energy

In 2015, wind energy clearly underlined its position as the most important source of electricity among the renewable sources of energy. The record year of 2014 was followed by another sharp rise in the amount of newbuild of onshore wind capacity totalling 3,802 megawatts. Deducting the capacity of the old turbines that were replaced (repowering) produces a net increase of 3,623 megawatts of onshore capacity. Also, the record amount of newbuild seen in the preceding year and good wind conditions were reflected in the volume of onshore wind power generation, which hit a new all-time high at 70.9 billion kilowatt-hours (2014: 55.9 billion kilowatt-hours).

Offshore wind energy taking off

The use of offshore wind energy from the North Sea and the Baltic also made further rapid strides in 2015. Installations with an output of 2,290 megawatts were connected to the grid for the first time in the course of the year, more than twice the volume on the grid at the end of 2014 (994 megawatts). There was therefore also a substantial rise in the volume of power generated by offshore wind farms, which reached 8.3 billion kilowatt-hours, or nearly six times the level in the preceding year (2014: 1.5 billion kilowatt-hours). Overall wind energy thus generated approx. 79 billion kilowatt-hours, or 13.3% of total German electricity consumption.

Growth of photovoltaics still below target range

Growth in new photovoltaics capacity fell further in 2015. At 1,444 megawatts of newly installed capacity, newbuild was at its lowest level since 2007, and was again roughly a quarter down on the previous year's figure (2014: 2,006 megawatts). The deployment corridor of 2,400–2,600 megawatts envisaged in the Renewable Energy Sources Act was thus not met for the second year in succession. Correspondingly, the level of power generation from photovoltaic installations (38.7 billion kilowatt-hours) was only slightly above the previous year's level (36.1 billion kilowatt-hours). This means that photovoltaics covered 6.5% of total gross electricity consumption.

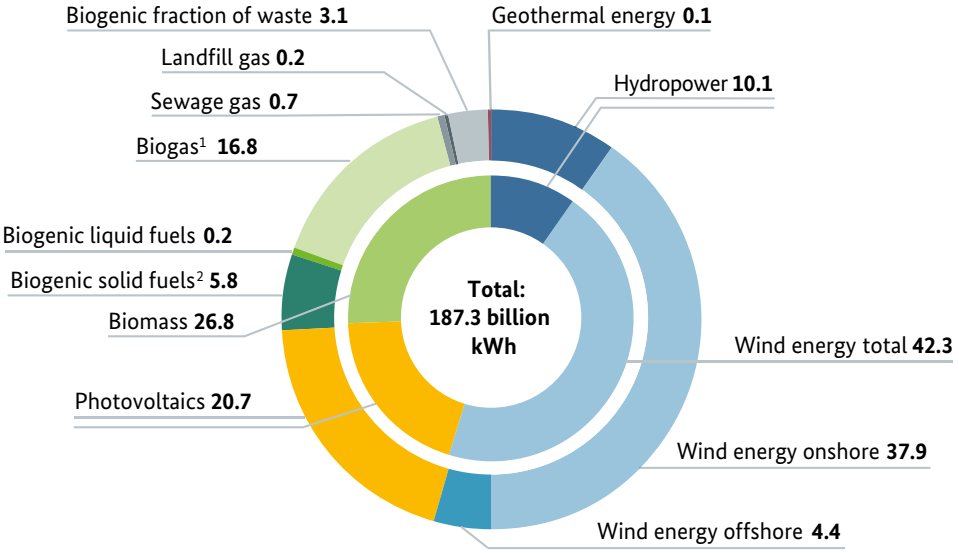
Figure 5: Electricity generation from renewable energy sources, 2014 and 2015

	Renewable energy sources 2015		Renewable energy sources 2014	
	Gross electricity generation (GWh)[5]	Share of gross electricity consumption (%)[6]	Gross electricity generation (GWh)[5]	Share of gross electricity consumption (%)[6]
Hydropower[1]	18,976	3.2	19,587	3.3
Onshore wind energy	70,922	11.9	55,908	9.5
Offshore wind energy	8,284	1.4	1,471	0.2
Photovoltaics	38,737	6.5	36,056	6.1
Biogenic solid fuels[2]	10,816	1.8	10,728	1.8
Biogenic liquid fuels	385	0.06	365	0.06
Biogas[3]	31,550	5.3	29,341	5.0
Sewage gas	1,384	0.2	1,336	0.2
Landfill gas	370	0.1	435	0.1
Biogenic fraction of waste[4]	5,784	1.0	6,069	1.0
Geothermal energy	133	0.02	98	0.02
Total	**187,341**	**31.6**	**161,394**	**27.3**

1 in the case of pumped storage power plants: electricity generation from natural inflow only
2 includes sewage sludge
3 includes biomethane
4 biogenic fraction of waste in waste incineration plants estimated at 50 percent
5 1 GWh = 1 million kWh
6 based on gross electricity consumption. 2015: 593.7 billion kWh and 2014: 591.1 billion kWh, according to AGEB [4]
Sources: BMWi on the basis of AGEE-Stat and other sources; see figure 8; data provisional

Figure 6: Electricity generation from renewable energy sources, 2015

share in percent

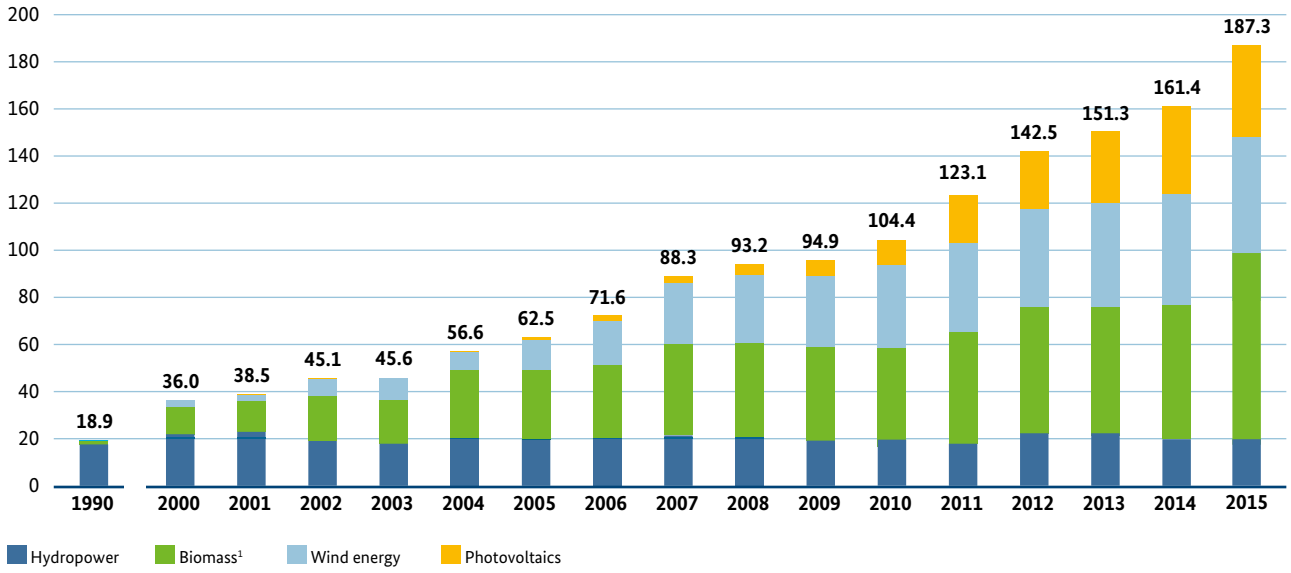


1 includes biomethane
2 includes sewage sludge

Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 8, data provisional

Figure 7: Electricity generation from renewable energy sources

in billion kWh



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

1 including solid and liquid biomass, biogas including biomethane, sewage gas, landfill gas and the biogenic fraction of waste; also including sewage sludge as of 2010

Sources: BMWi on the basis of AGEE-Stat and other sources; see figure 8, some data provisional

Figure 8: 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	71	–	1,435	1	–	**18,933**	**3.4**
1991	14,891	100	–	1,471	1	–	**16,463**	**3.1**
1992	17,397	275	–	1,558	4	–	**19,234**	**3.6**
1993	17,878	600	–	1,635	3	–	**20,116**	**3.8**
1994	19,930	909	–	1,875	7	–	**22,721**	**4.3**
1995	21,780	1,500	–	2,010	7	–	**25,297**	**4.7**
1996	21,957	2,032	–	2,098	12	–	**26,099**	**4.8**
1997	17,357	2,966	–	2,273	18	–	**22,614**	**4.1**
1998	17,216	4,489	–	3,256	35	–	**24,996**	**4.5**
1999	19,647	5,528	–	3,585	30	–	**28,790**	**5.2**
2000	21,732	9,513	–	4,731	60	–	**36,036**	**6.2**
2001	22,733	10,509	–	5,214	76	–	**38,532**	**6.6**
2002	23,124	15,786	–	6,048	162	–	**45,120**	**7.7**
2003	17,722	18,713	–	8,841	313	–	**45,589**	**7.6**
2004	20,095	25,509	–	10,471	557	0.2	**56,632**	**9.3**
2005	19,638	27,229	–	14,354	1,282	0.2	**62,503**	**10.2**
2006	20,008	30,710	–	18,700	2,220	0.4	**71,638**	**11.6**
2007	21,170	39,713	–	24,363	3,075	0.4	**88,321**	**14.2**
2008	20,443	40,574	–	27,792	4,420	18	**93,247**	**15.1**
2009	19,031	38,610	38	30,631	6,583	19	**94,912**	**16.3**
2010	20,953	37,619	176	33,924	11,729	28	**104,429**	**17.0**
2011	17,671	48,314	577	36,895	19,599	19	**123,075**	**20.3**
2012	22,091	49,949	732	43,292	26,380	25	**142,469**	**23.5**
2013	22,998	50,803	918	45,502	31,010	80	**151,311**	**25.1**
2014	19,587	55,908	1,471	48,274	36,056	98	**161,394**	**27.3**
2015	18,976	70,922	8,284	50,289	38,737	133	**187,341**	**31.6**

1 in the case of pumped storage power plants: electricity generation from natural inflow only

2 including solid and liquid biomass, biogas including biomethane, sewage gas, landfill gas and the biogenic fraction of waste (biogenic fraction of waste in waste incineration plants estimated at 50 percent); also including sewage sludge as of 2010

3 1 GWh = 1 million kWh

Sources: BMWi based on AGEE-Stat; ZSW; AGEB [1], [2], [4], [5]; BDEW; BMWi; BNetzA [6]; StBA; DBFZ; ÜNB [7]; ITAD, all data provisional

Trend towards flexibilisation of biomass installations continuing

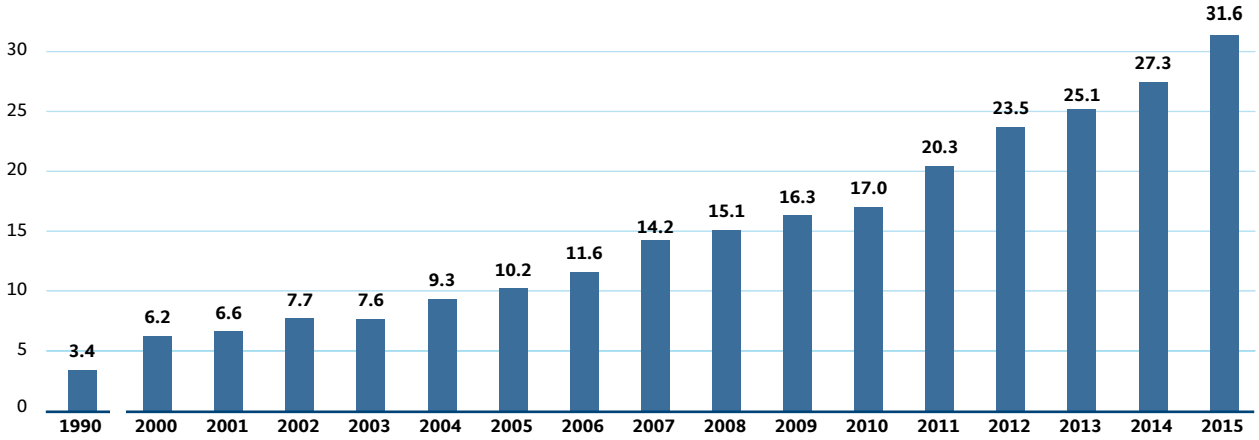
Concerning power generation from biogas, slowing expansion and the trend towards the regeneration of installations continued in 2015. In total, only around 100 megawatts of capacity were newly installed. However, more than 90% of this was added to make existing plants more flexible and does not affect the amount of electricity generated. Electricity generated from biogas therefore rose only slightly, climbing to 31.6 billion kilowatt-hours (2014: 29.3 billion kilowatt-hours). A total of 50 billion kilowatt-hours of electricity was generated from solid, liquid and gaseous biomass, including landfill gas, sewage gas and biogenic waste, or 8.5% of total gross electricity consumption.

Hydropower/Geothermal energy

As a result of the particular weather conditions experienced, the level of power generation from hydroelectric installations (nearly 19 billion kilowatt-hours) was slightly below the previous year's level (19.6 billion kilowatt-hours). Although geothermal energy generated approximately 30% more electricity than in the previous year (reaching 133 billion kilowatt-hours in total), its significance for the electricity market still remains small.

Figure 9: Electricity generated from renewable energy sources as a percentage of gross electricity consumption

share in percent

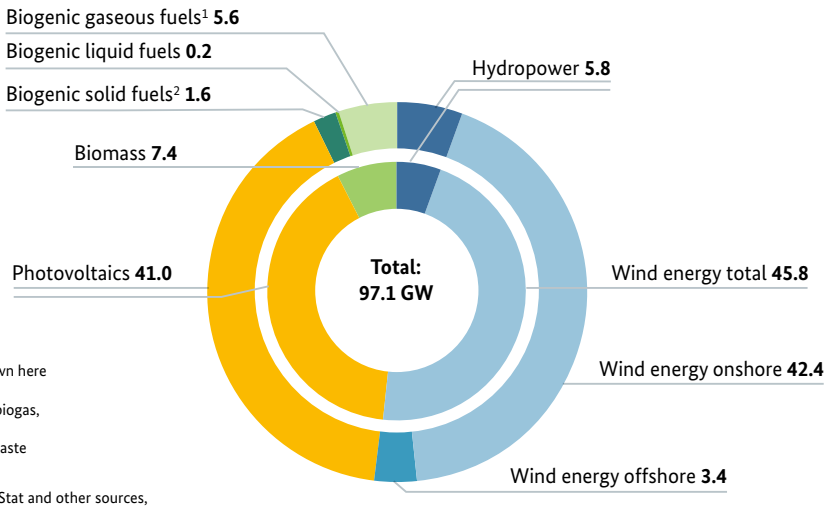


Under the 2017 Renewable Energy Sources Act (EEG), renewable energy must make up 40 to 45 percent of gross electricity consumption by 2025.

Sources: BMWi on the basis of AGEE-Stat; ZSW; AGEB [4] and other sources, see figure 8, all data provisional

Figure 10: Renewables-based installed capacity in the electricity sector, 2015

share in percent

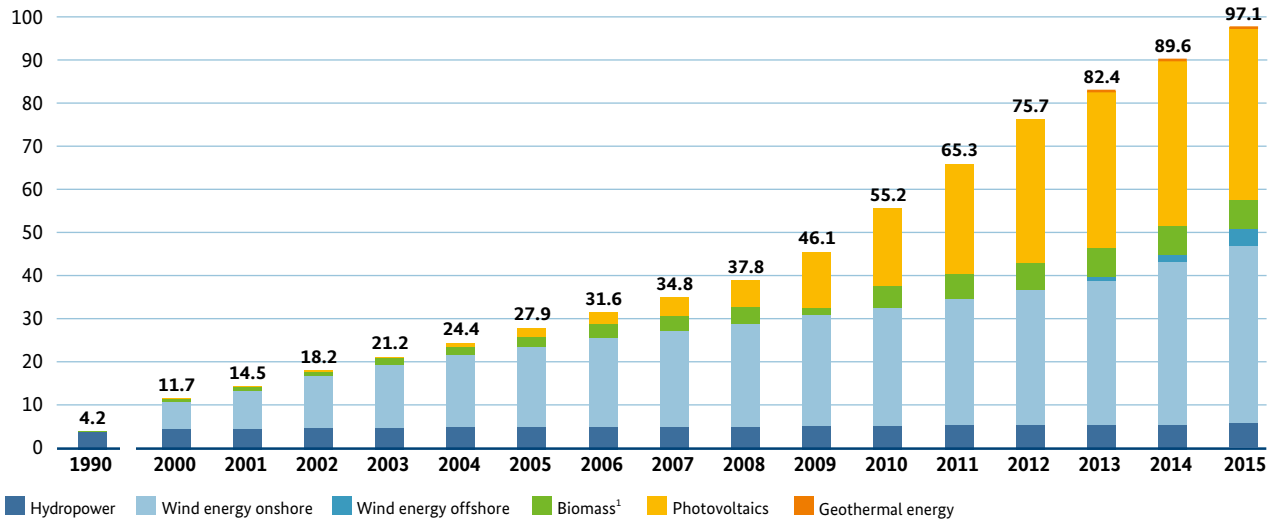


Geothermal power plants are not shown here because of their very small share.
1 including solid and liquid biomass, biogas, sewage gas and landfill gas;
2 excluding the biogenic fraction of waste

Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 12, data provisional

Figure 11: Renewables-based installed capacity in the electricity sector

in GW



1 including solid and liquid biomass, biogas including biomethane, sewage gas and landfill gas; excluding the biogenic fraction of waste

Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 12, all data provisional

Figure 12: Renewables-based installed capacity in the electricity sector

	Hydropower[1]	Wind energy onshore	Wind energy offshore	Biomass[2]	Photovoltaics	Geothermal energy	Total capacity
				(MW)[3]			
1990	3,982	55	–	129	2	–	**4,168**
1991	4,033	106	–	135	2	–	**4,276**
1992	4,049	174	–	139	6	–	**4,368**
1993	4,117	326	–	174	9	–	**4,626**
1994	4,211	618	–	208	12	–	**5,049**
1995	4,348	1,121	–	227	18	–	**5,714**
1996	4,305	1,549	–	261	28	–	**6,143**
1997	4,296	2,089	–	301	42	–	**6,728**
1998	4,369	2,877	–	461	54	–	**7,761**
1999	4,547	4,435	–	548	70	–	**9,600**
2000	4,831	6,097	–	703	114	–	**11,745**
2001	4,831	8,738	–	827	176	–	**14,572**
2002	4,937	11,976	–	1,030	296	–	**18,239**
2003	4,953	14,381	–	1,428	435	–	**21,197**
2004	5,186	16,419	–	1,687	1,105	–	**24,397**
2005	5,210	18,248	–	2,352	2,056	0.2	**27,866**
2006	5,193	20,474	–	3,010	2,899	0.2	**31,576**
2007	5,137	22,116	–	3,392	4,170	3	**34,818**
2008	5,164	22,794	–	3,673	6,120	3	**37,754**
2009	5,340	25,697	35	4,480	10,566	8	**46,126**
2010	5,407	26,823	80	4,903	17,944	8	**55,165**
2011	5,625	28,524	188	5,527	25,429	8	**65,301**
2012	5,607	30,711	268	6,088	33,033	19	**75,726**
2013	5,590	33,400	622	6,383	36,337	30	**82,362**
2014	5,580	37,563	994	7,084	38,343	34	**89,598**
2015	5,589	41,186	3,284	7,180	39,787	34	**97,060**

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 including solid and liquid biomass, biogas including biomethane, sewage gas and landfill gas; excluding the biogenic fraction of waste

3 1 MW = 0.001 GW

Sources: BMWi based on AGEE-Stat; ZSW; BDEW; BMWi; BNetzA [6]; StBA; DBFZ; DEWI [8]; GeotIS [9]; BSW; GtV; ITAD, all data provisional

Heat

Share of renewables in heat consumption rises by 0.7 percentage points

The colder spring of 2015 was a major reason why heat consumption rose slightly in Germany over the previous year – to 1,197 billion kilowatt-hours (2014: 1,168 billion kilowatt-hours).

Again, mainly as a result of the particular weather conditions experienced, the consumption of wood and wood pellets to generate heat rose in private households. Also, further progress was made on the use of heat from the sun, near-surface geothermal energy and ambient heat. In 2015, for example, more than 100,000 solar installations with a combined total of 806,000 square meters of solar collector area were newly installed; the number of electric heat pumps also grew by a further 57,000 installations, with air-to-air heat pumps accounting for around 70% – far exceeding the numbed of geothermal systems being used.

However, biomass remains the dominant renewable energy source in the heat sector, particularly the use of firewood in wood-burning stoves. The use of modern wood pellet combustion systems also continued to increase in 2015, with 32,500 new installations added.

As a result, the overall consumption of heat generated from renewable energy sources rose by 8.5% to approximately 158 billion kilowatt-hours (2014: 145.5 billion kilowatt-hours), growing faster than overall heat consumption. The share of renewables in Germany's total final energy consumption for heating and cooling therefore rose to 13.2% (2014: 12.5%).

Figure 13: Heat consumption from renewable energy sources

	Renewable energy sources 2015		Renewable energy sources 2014	
	Final energy consumption heat (GWh)[9]	Share of final energy consumption for heat[10] (%)	EFinal energy consumption heat (GWh)[9]	Share of final energy consumption for heat[10] (%)
Biogenic solid fuels (households)[1]	61,800	5.2	56,900	4.9
Biogenic solid fuels (TCS sector)[2]	11,760	1.0	7,909	0.7
Biogenic solid fuels (industry)[3]	26,577	2.2	26,577	2.3
Biogenic solid fuels (HP/CHP)[4]	5,996	0.5	5,465	0.5
Biogenic liquid fuels[5]	2,049	0.2	2,189	0.2
Biogas[6]	16,798	1.4	15,256	1.3
Sewage gas	1,978	0.2	1,820	0.2
Landfill gas	109	0.01	105	0.01
Biogenic fraction of waste[7]	11,570	1.0	11,380	1.0
Solar thermal energy	7,806	0.7	7,287	0.6
Deep geothermal energy	1,052	0.09	1,052	0.09
Near-surface geoth. energy, ambient heat[8]	10,351	0.9	9,603	0.8
Total	**157,846**	**13.2**	**145,543**	**12.5**

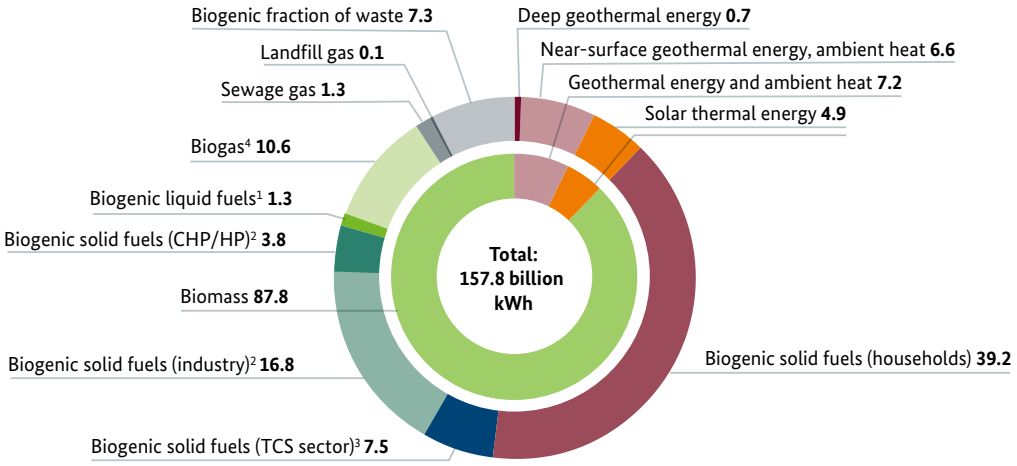
1 primarily wood, including wood pellets
2 information available for TCS sector (trade, commerce and service sector) as of 2015
3 according to Article 8 EnStatG, including sewage sludge starting; HP = heating plant, CHP = combined heat and power plant
4 according to Article 3 and Article 5 EnStatG, including sewage sludge
5 including agricultural consumption of biodiesel
6 including biomethane
7 biogenic fraction of waste in waste incineration plants estimated at 50 percent
8 renewable heat from heat pumps (air/water, water/water, brine/water, service water and gas heat pumps)
9 1 GWh = 1 million kWh
10 based on the FEC for space heating, hot water, process heat, space cooling and process cooling, 2015: 1,197.3 billion kWh and 2014: 1,67.6 billion kWh, AGEB [2]. See Annex, section 3 for details on how the share was calculated.

Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 16; data provisional

Note:
"Final energy consumption heat" always includes energy consumption for cooling applications.

Figure 14: Renewables-based heat consumption, 2015

in percent

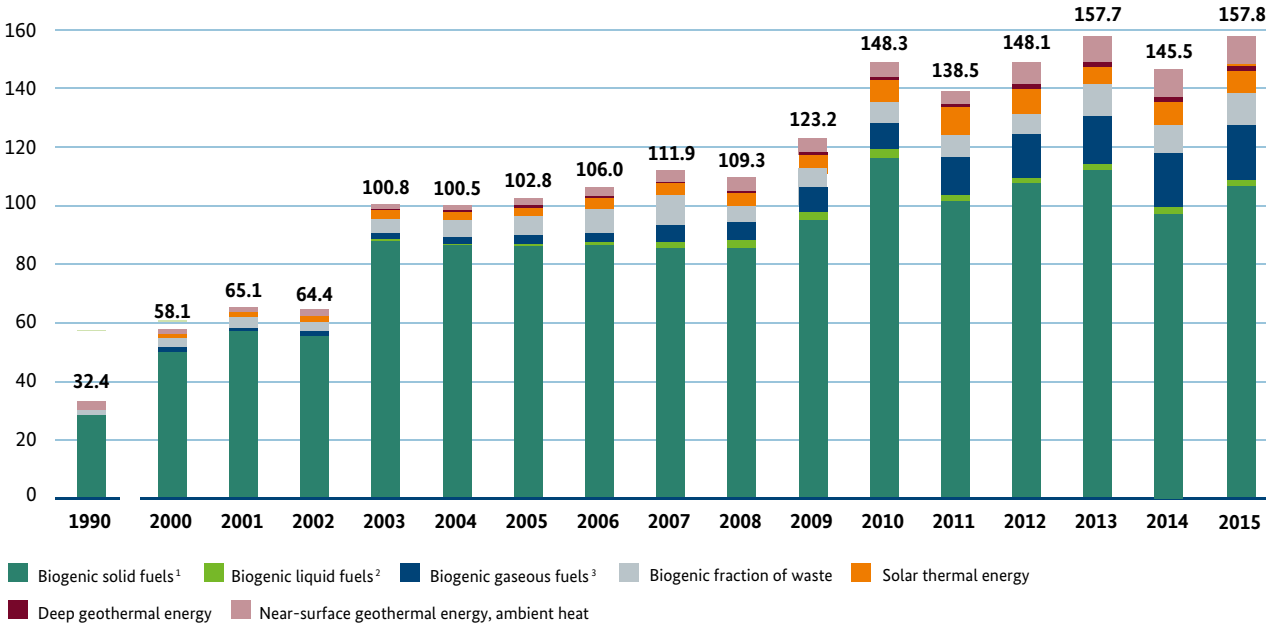


1 including agricultural consumption of biodiesel
2 including sewage sludge
3 information available for TCS sector (trade, commerce and service sector) as of 2015
4 biogas including biomethane

Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 16, data provisional

Figure 15: Renewables-based heat consumption

in billion kWh



1 including biogenic fraction of waste; including sewage sludge as of 2010; information for TCS sector (trade, commerce and service sector) available at 2003
2 including agricultural consumption of biodiesel
3 biogas including biomethane, sewage gas and landfill gas

Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 16, some data provisional

Figure 16: Renewables-based heat consumption

	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	–	–	130	1,677	**32,380**	**2.1**
1991	30,668	–	–	170	1,683	**32,521**	**2.2**
1992	30,670	–	–	220	1,694	**32,584**	**2.3**
1993	30,676	–	–	280	1,703	**32,659**	**2.3**
1994	30,683	–	–	360	1,708	**32,751**	**2.4**
1995	30,695	–	–	440	1,705	**32,840**	**2.3**
1996	30,815	–	–	550	1,712	**33,077**	**2.2**
1997	47,881	–	–	690	1,719	**50,290**	**3.4**
1998	51,807	3	1,335	830	1,744	**55,719**	**3.9**
1999	53,267	2	1,263	1,090	1,774	**57,396**	**4.3**
2000	53,604	8	1,355	1,290	1,808	**58,065**	**4.4**
2001	60,278	10	1,353	1,620	1,858	**65,119**	**4.7**
2002	59,051	48	1,438	1,910	1,936	**64,383**	**4.8**
2003	93,624	192	2,135	2,520	2,368	**100,839**	**7.5**
2004	92,670	312	2,427	2,560	2,520	**100,489**	**7.6**
2005	93,296	709	2,974	3,030	2,759	**102,768**	**8.0**
2006	94,567	1,275	3,293	3,550	3,268	**105,953**	**8.0**
2007	96,492	1,872	5,581	3,940	3,968	**111,853**	**9.5**
2008	91,999	2,645	5,422	4,490	4,763	**109,319**	**8.5**
2009	101,500	2,991	7,516	5,276	5,883	**123,166**	**10.4**
2010	122,823	2,857	10,171	5,628	6,852	**148,331**	**11.1**
2011	110,011	2,124	12,076	6,465	7,846	**138,522**	**11.4**
2012	116,599	2,015	14,063	6,696	8,715	**148,088**	**12.1**
2013	123,476	2,007	15,948	6,767	9,539	**157,737**	**12.2**
2014	108,231	2,189	17,181	7,287	10,655	**145,543**	**12.5**
2015	117,703	2,049	18,885	7,806	11,403	**157,846**	**13.2**

1 including the biogenic fraction of waste (estimated at 50 percent in waste incineration plants). The heat decline in 2008 compared with 2007 is due to a change in data collection methods which does not permit any conclusions about the actual increase in use; information for TCS sector (trade, commerce and service sector) available at from 2003, including sewage sludge as of 2010

2 including agricultural consumption of biodiese

3 biogas including biomethane, sewage gas and landfill gas

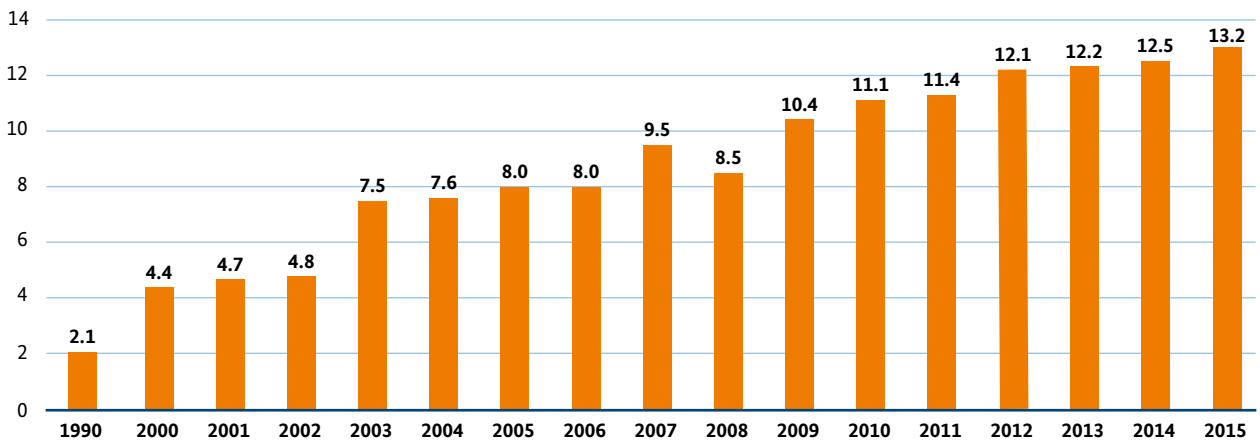
4 including heat from deep geothermal energy and renewable heat from heat pumps (air/water, water/water, brine/water, service water and gas heat pumps)

5 1 GWh = 1 million kWh

Sources: BMWi based on AGEE-Stat; ZSW; AGEB [1], [5], [10]; BMWi; StBA; DBFZ; GeotIS [9]; GZB [11]; RWI; BDH; BSW; DEPV; BWP; IEA/ESTIF [12], all data provisional

Figure 17: Renewable energy shares of heat consumption

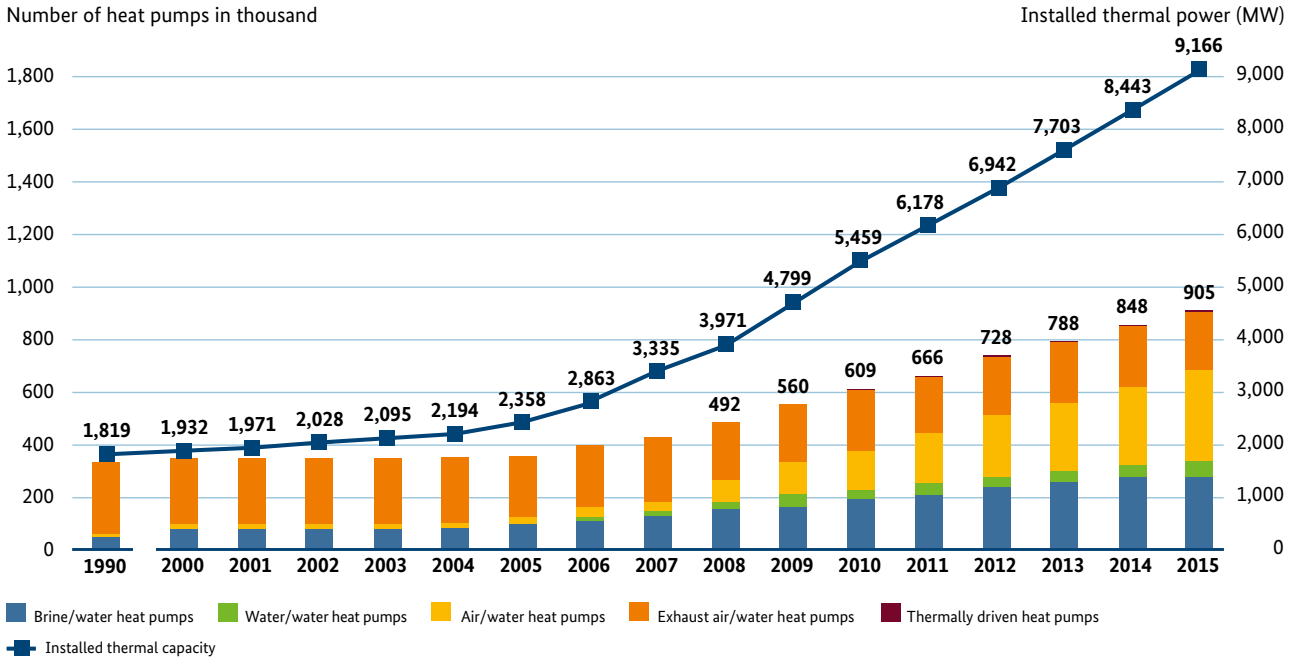
in percent



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

Sources: BMWi on the basis of AGEE-Stat; ZSW; AGEB and other sources, see figure 16, all data provisional

Figure 18: Development of heat pump stock



Sources: BMWi on the basis of AGEE-Stat; ZSW; GZB [11]; BWP

Figure 19: Additions to and capacity of solar collectors (solar heat)

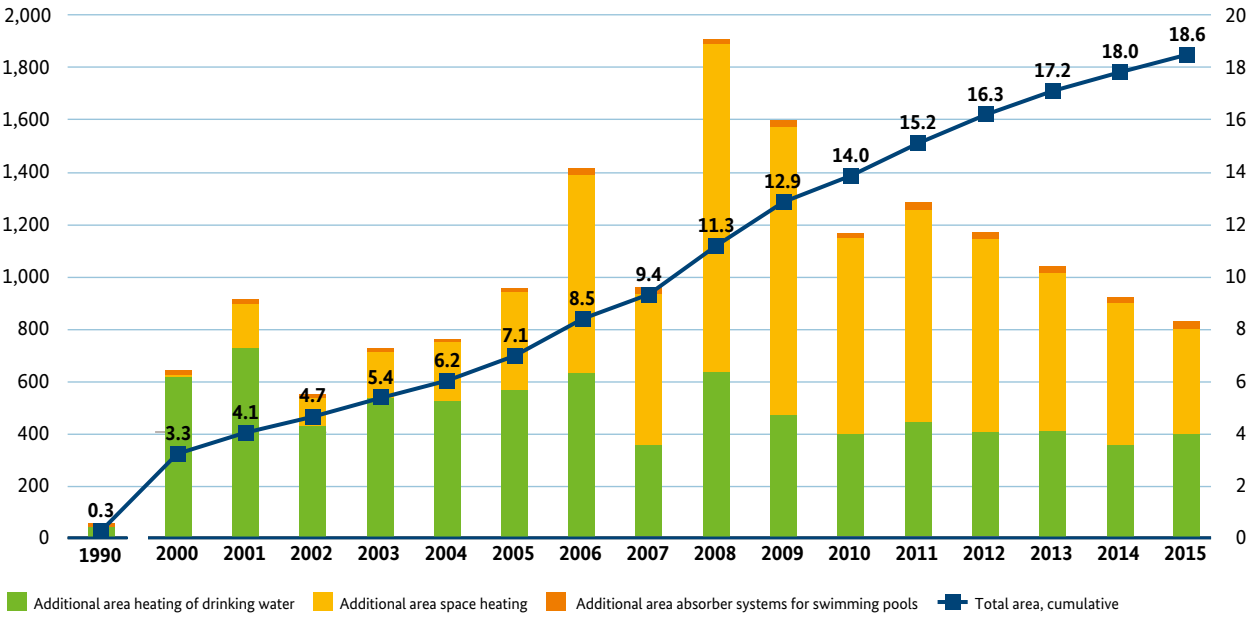


Diagram takes account of decommissioning of old installations; combined solar thermal installations: hot water heating and central heating support.

Sources: BMWi on the basis of AGEE-Stat; ZSW; BDH; BSW

Figure 20: Solar heat: area and capacity of solar collectors in Germany

		1990	2000	2002	2004	2006	2008	2010	2011	2012	2013	2014	2015
Cumulative area	(1,000 m²)	348	3,251	4,679	6,151	8,501	11,330	14,044	15,234	16,309	17,222	17,987	18,625
Cumulative output	(MW)	243	2,312	3,338	4,384	6,049	8,063	10,006	10,909	11,728	12,456	13,100	13,681

The decommissioning of old installations is included

Sources: BMWi on the basis of AGEE-Stat; ZSW; BDH; BSW; IEA/ESTIF [12]

Transport

Sales of biofuels falling

Sales of biofuels dropped by around 7% in 2015, falling to 3.21 million tonnes (2014: 3.43 million tonnes). Both the consumption of biodiesel (- 8%) and bioethanol (-5%) fell, as did that of biomethane (-9%), which declined for the first time. These decreases were partly due to the change in funding system from an energy-based system (6.25% in 2014) to a system based on a greenhouse gas (GHG) quota (3.5% in 2015) from 2015.

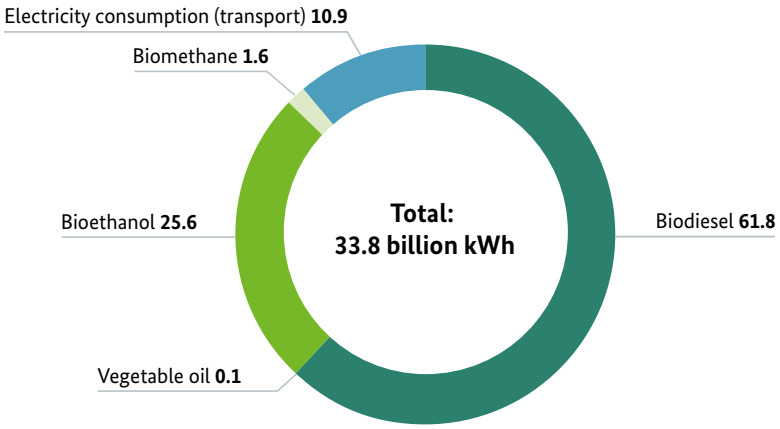
The only increase was in the consumption of renewable electricity in transport, which rose to 3.7 billion kilowatt-hours (2014: 3.2 billion kilowatt-hours) – which was basically in line with the rising proportion of renewable energy in the German electricity mix. The share of renewable energy in total final energy consumption in transport (consumption of petrol and diesel fuels, liquefied gas, natural gas and electricity in rail and road transport plus aviation gasoline and jet fuel in Germany) thus fell substantially, declining to 5.2% (2014: 5.6%).

Figure 21: Renewables-based consumption in transport sector

	Renewable energy sources 2015		Renewable energy sources 2014	
	Final energy consumption of transport (GWh)[3]	Share of FEC of transport (%)[4]	Final energy consumption of transport (GWh)[3]	Share of FEC of transport (%)[4]
Biodiesel[1]	20,871	3.20	22,760	3.60
Vegetable oil	21	0.03	63	0.01
Bioethanol	8,648	1.30	9,061	1.40
Biomethane	530	0.10	580	0.10
RE electricity consumption in transport[2]	3,697	0.60	3,163	0.50
Total	**33,767**	**5.23**	**35,627**	**5.61**

1 consumption of biodiesel (including HVO) in the transport sector
2 see figure 25 for renewable share of electricity in 2014, AGEB [1], [2], [4], BDEW
3 1 GWh = 1 million kWh
4 based on final energy consumption in transport, 2015: 648 billion kWh and 2013: 638 billion kWh, BAFA and AGEB [1], [2]
Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 25; data provisional

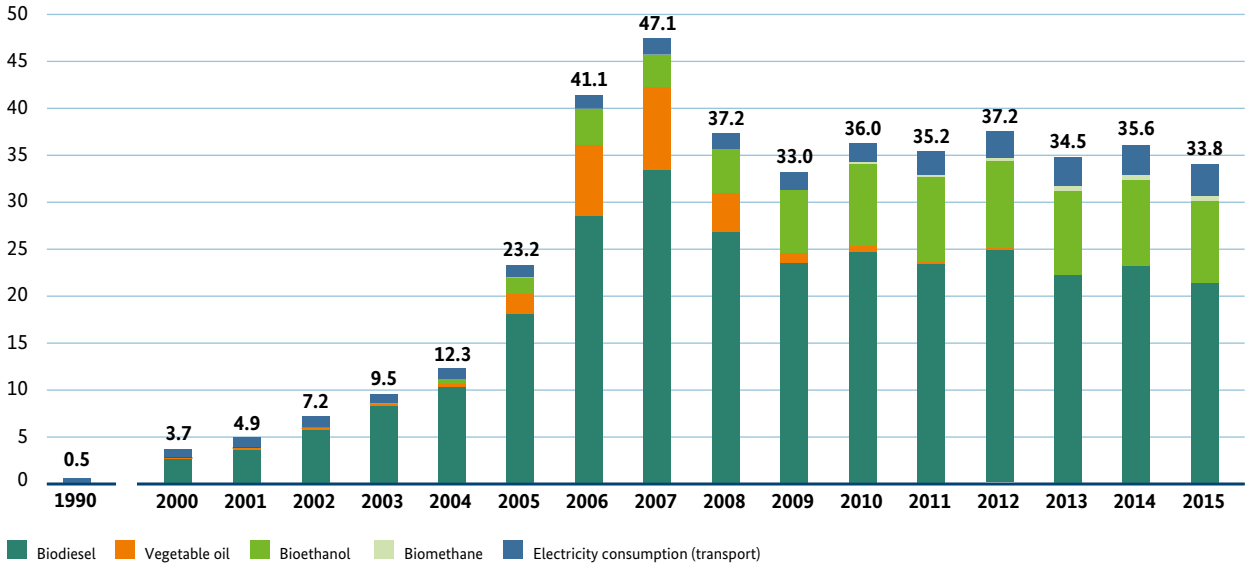
Figure 22: Renewables-based consumption in transport sector, 2015
in percent



Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 25, data provisional

Figure 23: Renewables-based consumption in transport sector

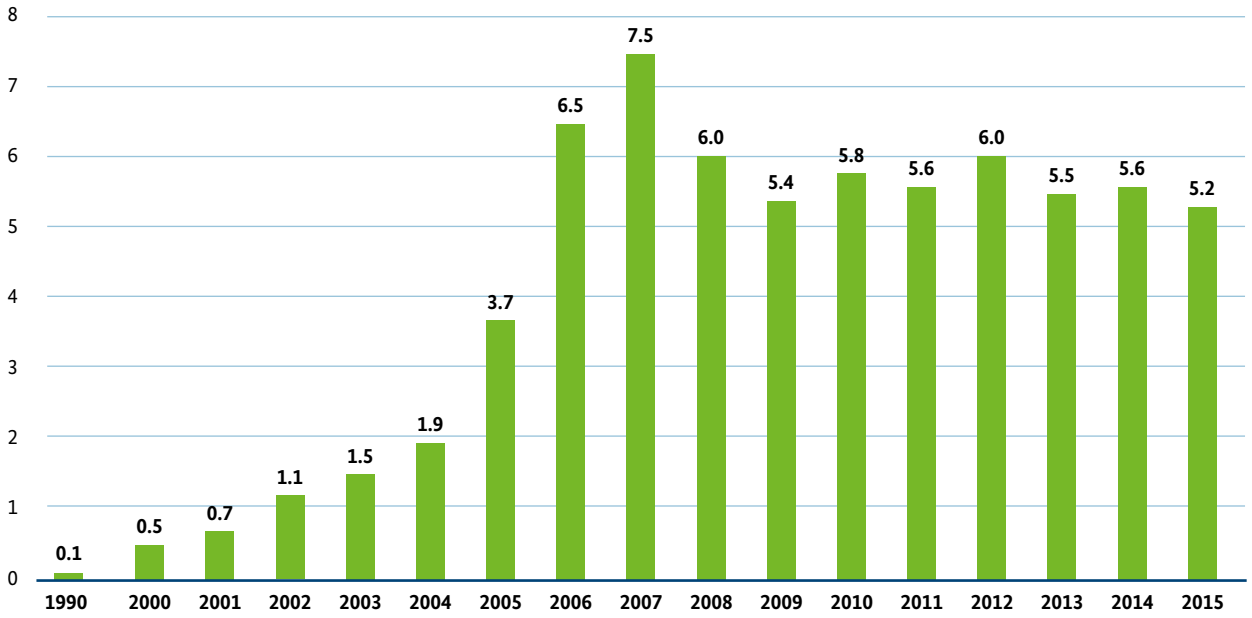
final energy consumption for transport in billion kWh



Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 25, some data provisional

Figure 24: Renewable energy shares of final energy consumption in transport

share in percent



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

Sources: BMWi on the basis of AGEE-Stat; ZSW; AGEB [1], [2], BAFA; BMUB and other sources, see figure 25, some data provisional

Figure 25: Renewables-based consumption in transport sector

	Biodiesel[1]	Vegetable oil	Bioethanol	Biomethane	RE electricity consumption[2]	FEC of transport	Share of FEC of transport
			(GWh)[3]			(GWh)[3]	(%)
1990	–	–	–	–	465	**465**	**0.1**
1991	2	–	–	–	475	**477**	**0.1**
1992	52	21	–	–	536	**609**	**0.1**
1993	52	31	–	–	570	**653**	**0.1**
1994	289	31	–	–	662	**982**	**0.2**
1995	362	52	–	–	761	**1,175**	**0.2**
1996	568	52	–	–	794	**1,414**	**0.2**
1997	930	104	–	–	691	**1,725**	**0.3**
1998	1,033	115	–	–	724	**1,872**	**0.3**
1999	1,343	146	–	–	823	**2,312**	**0.3**
2000	2,583	167	–	–	986	**3,736**	**0.5**
2001	3,617	209	–	–	1,082	**4,908**	**0.7**
2002	5,683	251	–	–	1,247	**7,181**	**1.1**
2003	8,254	292	–	–	995	**9,541**	**1.5**
2004	10,287	345	486	–	1,202	**12,320**	**1.9**
2005	18,046	2,047	1,780	–	1,343	**23,216**	**3.7**
2006	28,364	7,426	3,828	–	1,475	**41,093**	**6.5**
2007	33,182	8,752	3,439	–	1,743	**47,116**	**7.5**
2008	26,630	4,188	4,673	4	1,682	**37,177**	**6.0**
2009	23,411	1,044	6,669	15	1,896	**33,035**	**5.4**
2010	24,474	637	8,711	162	2,060	**36,044**	**5.8**
2011	23,244	209	9,090	190	2,467	**35,200**	**5.6**
2012	24,530	261	9,208	404	2,840	**37,243**	**6.0**
2013	21,998	10	8,891	557	3,008	**34,464**	**5.5**
2014	22,760	63	9,061	580	3,163	**35,627**	**5.6**
2015	20,871	21	8,648	530	3,697	**33,767**	**5.2**

1 consumption of biodiesel (including HVO) in the transport sector

2 see figure 8 for renewable share of electricity in 2015, ZSW based on AGEB [1], [3], [4], BDEW

3 1 GWh = 1 million kWh

Sources: BMWi on the basis of AGEE-Stat; ZSW; BMF [13]; DIW [14]; BMELV [15]; BAFA; BMUB; StBA [16]; erdgas mobil; DBFZ; AGQM; UFOP; BReg [17], [18], [19]; FNR, some data provisional

Figure 26: Renewables-based fuel consumption in transport sector

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
								(1,000 tonnes)								
Biodiesel[1]	250	350	550	800	997	1,749	2,749	3,216	2,581	2,269	2,372	2,263	2,314	2,064	2,156	2,002
Vegetable oil	16	20	24	28	33	196	711	838	401	100	61	20	25	1	6	2
Bioethanol	0	0	0	0	65	238	512	460	625	892	1,165	1,233	1,249	1,206	1,229	1,173
Biomethane[2]	0	0	0	0	0	0	0	0	0	1	11	12	26	36	38	34
Total	**266**	**370**	**574**	**828**	**1,095**	**2,183**	**3,972**	**4,514**	**3,607**	**3,262**	**3,609**	**3,528**	**3,614**	**3,307**	**3,429**	**3,211**

1 consumption of biodiesel (including HVO) in the transport sector

2 calculated according to EU Directive 2009/28/EC with a calorific value of 50 MJ/kg

Sources: BMWi on the basis of AGEE-Stat and other sources, see figure 25, some data provisional

Emissions prevented through the use of renewable energy sources

Renewable energy growth plays a significant role in meeting our climate targets. Emissions with a total global warming potential (GWP) of approximately 156 million tonnes of CO_2 equivalent were prevented in 2015. The power sector accounted for just under 118 million tonnes of these savings, including around 99 million tonnes of renewable electricity which were eligible for funding under the Renewable Energy Sources Act. The release of approximately 34 million tonnes was prevented in the heat sector and, through the use of biofuels in transport, some 4 million fewer tonnes of CO_2 equivalent were emitted (Figure 27).

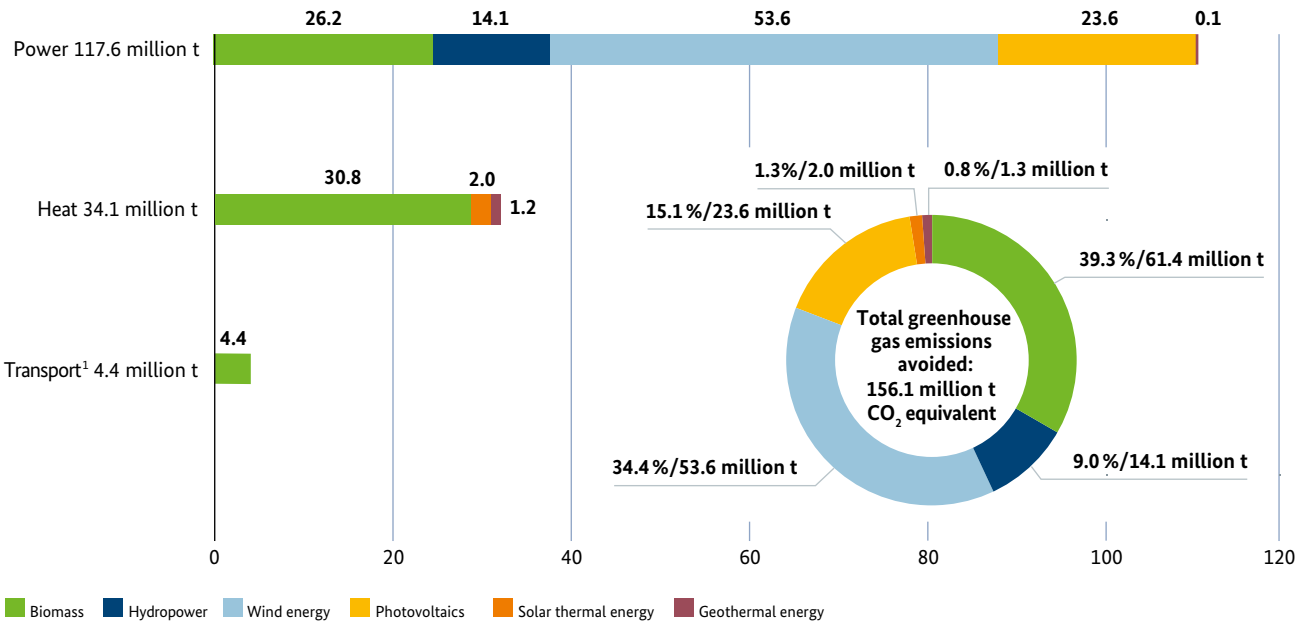
The results for electricity and heat depend heavily on the specific fossil and nuclear fuels that the renewable energy sources replace. In the current balance, the differences in the efficiency of renewable and conventional heating systems are considerated. The emissions avoided by the provision of heat from renewable energy sources are correspondingly lower.

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

The emissions balance [21] for the use of biomass also depends on the nature and provenance of the raw materials. If the raw materials are not waste or biogenic waste, the calculations must take account of changes in land use resulting from the agricultural cultivation of energy crops. However, indirect displacement effects were not taken into account due to insufficient data bases in the calculations.

The sharp increase in the use of energy crops in Germany went hand-in-hand with both direct and indirect changes in land use, which caused carbon emissions to rise. (Under

Figure 27: Net balance of greenhouse gas emissions avoided through the use of renewable energy sources, 2015



1 biofuels in transport sector

Sources: UBA [22] based on the sources quoted therein

Note:
Please see the UBA publication "Emissionsbilanz erneuerbarer Energieträger – Bestimmung der vermiedenen Emissionen 2014" [22] for a detailed explanation of the basic methods used to calculate the emission balances for renewable energy sources (in German).

the sustainability ordinances that have been put in place, direct changes in land use for the purposes of producing biofuels and bioliquids have been banned since 2011.) However, it is difficult to quantify these effects. As a consequence, these changes have not been taken into account in calculating emission balances to date. Estimates, however, indicate that indirect changes in land use in particular cause significant greenhouse gas emissions and may actually partially or fully cancel out greenhouse gas emissions savings generated, for instance, by individual biofuels. In future, fuel suppliers will also take into account the average preliminary estimates for emissions resulting from indirect changes in land use when they report greenhouse gas emissions per unit of energy and other similar statistics. When reporting on the greenhouse gas emissions savings achieved, the European Commission will also include the average preliminary estimates regarding indirect land-use changes in Annex VIII of Directive 2009/28/EC [23].

The calculations of the emissions savings arising from the use of renewable energy sources are based on net figures. This is done by setting off the volume of emissions caused by the use of renewables (final energy supply) against the volume of gross emissions that are no longer being released thanks to fossil and nuclear energy sources having been replaced with renewables. All upstream process chains involved in the production and supply of the various energy sources and in plant construction and operation (but not dismantling) are also taken into account.

Figure 28 shows the balance for greenhouse gas emissions and air pollutants. Greenhouse gas abatement is particularly high in the electricity generation segment. The balances are negative for precursors of ground-level ozone, mainly due to the use of biogas. Emissions associated with heating have risen as more wood is burned in old stoves and tiled ovens. However, under current legislation, these units will have to be gradually taken out of use or replaced. The negative balances for carbon monoxide, volatile organic compounds and dust emissions (all particle sizes) are particularly significant. When it comes to biofuels, there was an increase in nitrous oxide and methane emissions from the cultivation of energy crops.

Figure 28: Net emission balance of renewable energy sources in the power, heat and transport sector, 2015

		Renewables-based electricity generation total: 187,341 GWh		Renewables-based heat consumption total: 157,846 GWh		Renewables-based consumption in transport total: 33,070 GWh[5]	
	Greenhouse gas/ air pollutant	Avoidance factor	Avoided emissions	Avoidance factor	Avoided emissions	Avoidance factor	Avoided emissions
		(g/kWh)	(1,000 t)	(g/kWh)	(1,000 t)	(g/kWh)	(1,000 t)
Greenhouse effect[1]	CO_2	612	114,622	224	35,236	194	5,834
	CH_4	0.95	177.7	-0.16	-25.1	-0.17	-5.17
	N_2O	-0.03	-5.0	-0.01	-1.8	-0.14	-4.29
	CO_2 equivalent	628	117,572	217	34,069	147	4,421
Acidification[2]	SO_2	0.14	26.8	0.15	23.6	-0.03	-0.83
	NO_X	0.08	14.8	-0.18	-28.7	-0.24	-7.33
	SO_2 equivalent	0.2	37.1	0.02	3.6	-0.20	-5.94
Ozone[3] Particulates[4]	CO	-0.44	-82.6	-3.81	-598.7	-0.03	-1.0
	NMVOC	0	-0.3	-0.19	-30.6	0.02	0.63
	Particulates	0.003	0.5	-0.15	-22.9	-0.01	-0.40

1 no account is taken of other greenhouse gases (SF_6, PFC, HFC)
2 no account is taken of other acidifying air-pollutants (NH_3, HCl, HF)
3 NMVOC and CO are important precursor substances for ground-level ozone, which makes a major contribution to photochemical smog
4 here particulates comprise all emissions of suspended particulates of all sizes
5 not counting electricity consumption in the transport sector

Source: UBA [22] based on the sources quoted therein

Reduction in the use of fossil fuels thanks to renewable energy

Figures 29 and 30 show the amount of fossil fuels saved by using renewable energy sources for electricity, heat and transport in 2015 and from 2007 to 2015. Total savings have risen continuously in recent years.

Since Germany has to import a large proportion of its fossil (i.e. non-renewable) fuels such as oil, natural gas and coal, these savings also lead to a reduction in German energy imports. Being a country that is poor in resources, Germany still had to import 98% of its oil and 88% of its natural gas in 2015. Relying on energy imports can carry a certain level of risk, depending on the country of origin. This relates to the quantity of imports available (loss of producers due to disaster or war) and to price (unexpected rises in prices). Renewable energy sources can greatly reduce reliance on imports and thereby improve energy security.

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

The Renewable Energy Sources Act was adopted on 1 April 2000. It is the central instrument for developing renewable energy for power generation.

Since the entry into force of the 2014 Renewable Energy Sources Act, operators of new installations based on renewables have normally had to market the electricity produced themselves. For every kilowatt-hour fed in, they receive a

Figure 29: Primary energy savings due to the use of renewables, 2015

	Lignite	Hard coal	Natural gas	Petroleum/ heating oil	Diesel fuel	Petrol	Total
				Primary energy (billion kWh)			
Electricity	–	265.0	125.7	–	–	–	**390.7**
Heat	11.9	12.7	60.6	49.1	0.6	–	**134.9**
Transport	–	–	0.6	–	8.6	4.3	**13.5**
Total	**11.9**	**277.8**	**186.9**	**49.1**	**9.2**	**4.3**	**539.1**
				Primary energy (PJ)			
Total	**42.8**	**999.9**	**672.8**	**176.6**	**33.3**	**15.3**	**1,940.7**
which corresponds to[1]:	3.5 million t[2]	36.5 million t[3]	19,124 million m³	4,941 million litres	928 million litres	472 million litres	

The savings in fossil fuels are calculated on the same lines as the emission balances, see UBA [22]
1 primary energy savings were calculated using the net calorific values determined by the AGEB [10]
2 including approx. 2.6 million tonnes lignite, approx. 0.2 million tonnes lignite briquettes and approx. 0.7 million tonnes pulverised coal
3 including approx. 36.4 million tonnes hard coal and approx. 0.1 million tonnes coke from hard coal

Quelle: UBA [22] auf Basis dort zitierter Quellen

Figure 30: Fossil fuel savings resulting from the use of renewables

	Electricity	Heat	Transport	Total
		Primary energy (billion kWh)		
2007	201.7	91.8	15.6	309.1
2008	206.2	89.5	11.2	306.9
2009	212.3	102.3	8.7	323.3
2010	228.7	124.4	9.4	362.5
2011	270.3	117.3	11.0	398.6
2012	300.4	123.7	14.8	439.0
2013	318.7	132.7	14.8	466.2
2014	336.4	124.8	14.6	475.7
2015	390.7	134.9	13.5	539.1

Source: UBA [22] based on the sources quoted therein

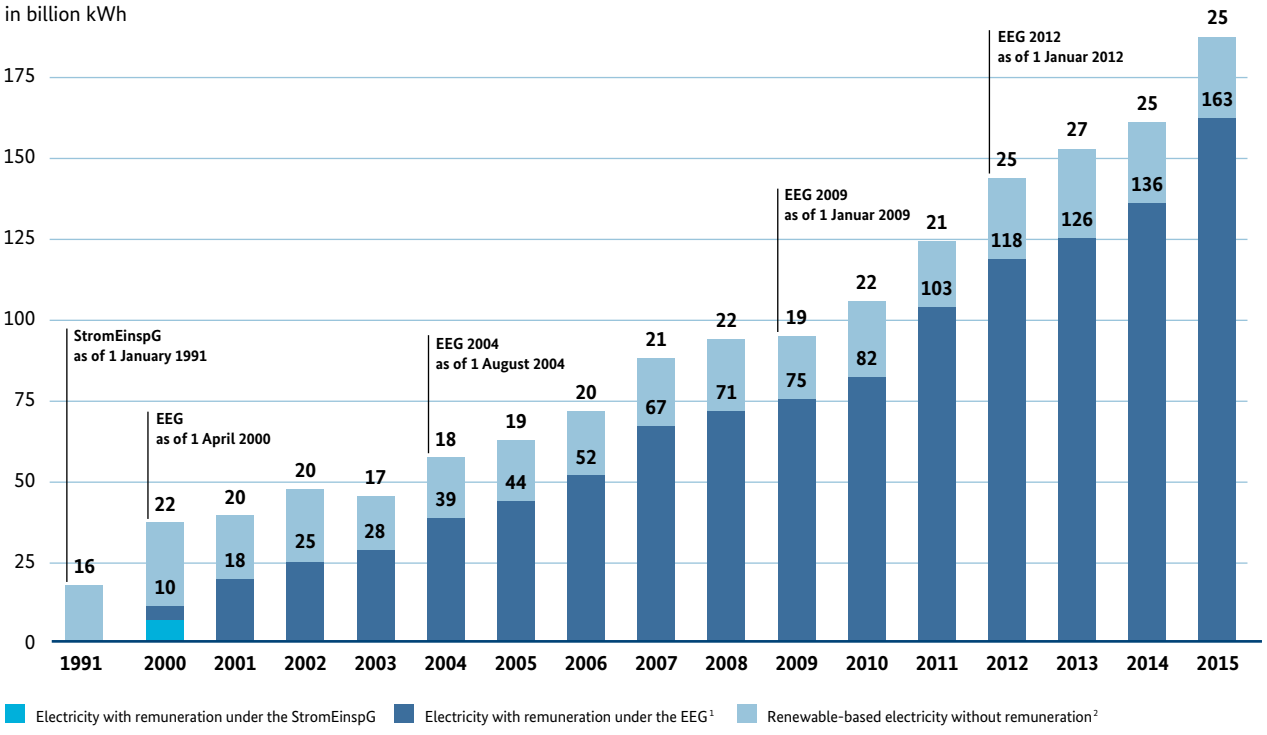
'market premium'. Such operators are generally entitled to receive these payments for 20 years. In future, remuneration is to be determined via competitive auctions. The EEG 2017 and the wind-at-sea law will switch the tenders for photovoltaic, wind on land and at sea and biomass from 2017. Furthermore, the EEG states that green electricity should be fed into the electricity grid before all other types of electricity. To qualify for EEG funding, installations must generate electricity from a renewable energy source, such as wind or solar energy. The level of remuneration may vary depending on the actual size of the installation.

The EEG has so far proven a most effective instrument in promoting greater use of renewable energy sources. Since the Act was first introduced back in 2000, the production of electricity from renewable energy sources has increased significantly, growing from 36 billion kilowatt-hours to more than 187 billion kilowatt-hours in 2015. The EEG has driven the growth of wind, photovoltaic and biomass capacity in particular. Power generation based on photovoltaics, for example, has grown many times over, climbing from nearly 0.1 billion kilowatt-hours in 2000 to over 38 billion kilowatt-hours.

The EEG does not, however, incentivise all electricity generated from renewable energy sources. For example, it does not provide for support for large hydropower plants or conventional power stations that incinerate biomass alongside their regular fuel. Electricity incentivised under the EEG is only part of the total electricity generated from renewable energy sources, as shown in Figure 31. The amount of electricity being generated (that is remunerated under the EEG) has risen from some 10 billion kilowatt-hours in 2000 to 163 billion kilowatt-hours.

More information is available on the website of the German Transmission Operators information platform at www.netztransparenz.de and on the information platform operated by the Federal Ministry for Economic Affairs and Energy at www.erneuerbare-energien.de (see document 'EEG in Zahlen: Vergütungen, Differenzkosten und EEG-Umlage 2000 bis 2016' (in German only) under Recht und Politik>Erneuerbare-Energien-Gesetz (EEG)>EEG: Daten und Fakten).

Figure 31: Electricity generation from renewable energy sources with remuneration under the StromEinspG and the EEG and without remuneration



1 electricity consumed on-site, fed into the grid and remunerated under the EEG

2 electricity generated from large hydropower plants and biomass (combusted alongside regular fuel in conventional power stations, including the biogenic fraction of waste) and feed-in and self-consumption of solar electricity that is not eligible for EEG payments.

Sources: BMWi, based on German transmission system operators (TSOs)

The renewable energy surcharge (EEG surcharge)

Operators of wind, solar, biomass and other installations generally market their own electricity or sell it via service providers. They receive a market premium from the grid operators as a subsidy. The market premium compensates for the difference between the feed-in tariff and the average trading price for electricity. It largely determines the level of financing for renewable energy, known as the EEG differential costs.

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

Aggregate EEG surcharge = **Forecasted financing needs** in the following year
+ **Account settlement** (EEG accout settled on 30 September)
+ **Liquidity reserve** (no more than ten percent of the support costs)

The aggregate EEG surcharge and the EEG surcharge rose slightly in 2016 compared with 2015. A major reason is the drop in the electricity price at the power exchange and the ensuing fall in market revenues for green electricity.

In future, the remuneration rates for new installations funded under the Renewable Energy Sources Act are to be determined via competitive auctions. These auctions will also permit quantitative steering, ensuring that expansion targets are adhered to effectively. As a result the continued expansion of renewable energy sources can be expected to be more predictable, reliable and, most importantly, more cost-effective.

In general the EEG requires every electricity utility and self-consumer to pay the EEG surcharge. Electricity utilities routinely pass this cost on to the final consumer. However, it is beneficial to exempt some consumers from paying the EEG surcharge – namely, large energy-intensive companies that compete internationally, as well as railroad companies. The Special Equalisation Scheme was introduced in 2004 to minimise the impact of the EEG surcharge on the global competitiveness of large electro-intensive enterprises and the intermodal competitiveness of railroad companies [25].

In 2015, the scheme exempted a total of 2,239 companies that consume around 112 billion kilowatt-hours of electricity from some of their EEG surcharges. This group accounts for roughly 24% of total final consumption in Germany (net electricity consumption minus electricity generated and consumed on-site). It should be noted that the companies were not exempted from all of their EEG surcharges; privileged companies have to pay a proportion of the EEG surcharge – 15% as a rule – and thus contribute to EEG financing. All told, Germany's industrial sector (both privileged and non-privileged companies together) will pay nearly one-third (€7.2 billion) of the aggregate EEG surcharge in 2016 [26]. However, the exemptions still concentrate the aggregate EEG surcharge onto a smaller amount of electricity known as 'non-privileged final consumption'. For details, please see 'Hintergrundinformationen zur Besonderen Ausgleichsregelung' available at the information platform www.erneuerbare-energien.de (in German only).

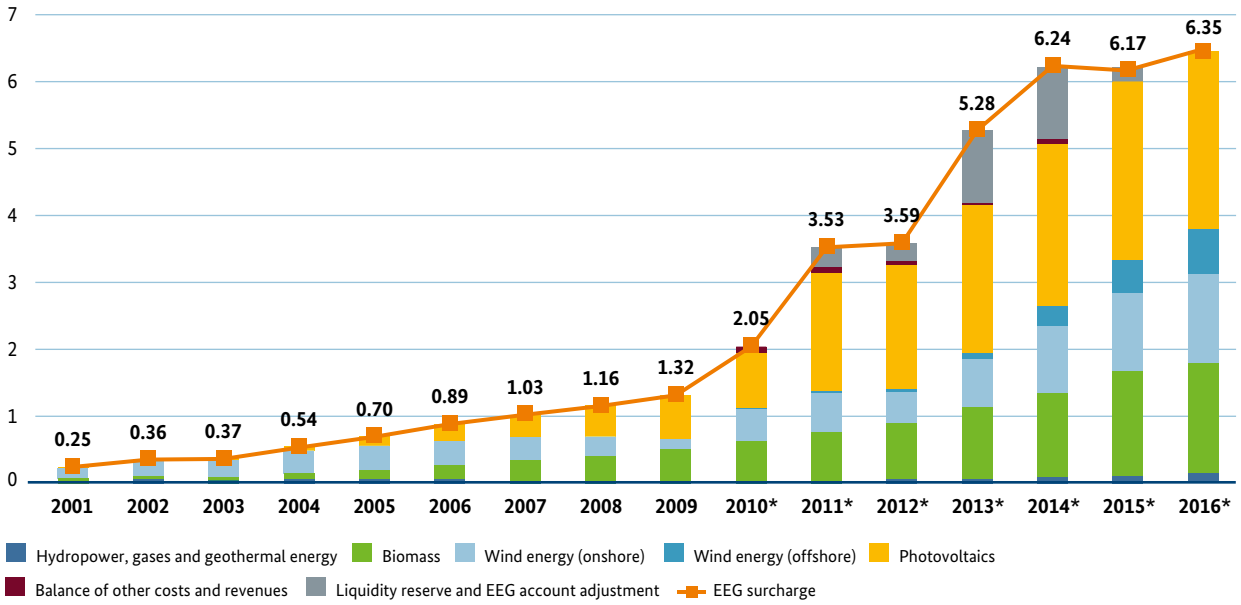
The EEG surcharge is calculated by allocating the aggregate EEG surcharge to non-privileged final consumption. The final consumption subject to the surcharge equates to the electricity consumption not exempted from the payment of the EEG surcharge. The forecast aggregate EEG surcharge for 2016 amounts to €22.9 billion and the (forecast) final consumption subject to the surcharge is 360 billion kilowatt-hours. This produces a 2016 EEG surcharge of 6.35 cents per kilowatt-hour.

$$\text{EEG surcharge} = \frac{\text{Aggregate EEG surcharge}}{\text{Non-privileged final consumption}}$$

The aggregate EEG surcharge has risen steadily since 2000 and so has the EEG surcharge. The technologies that represent the largest share of the 2016 EEG surcharge are photovoltaics (41%), biomass (26%) and onshore wind energy (21%).

Figure 32: Development of EEG surcharge

Cents per kWh

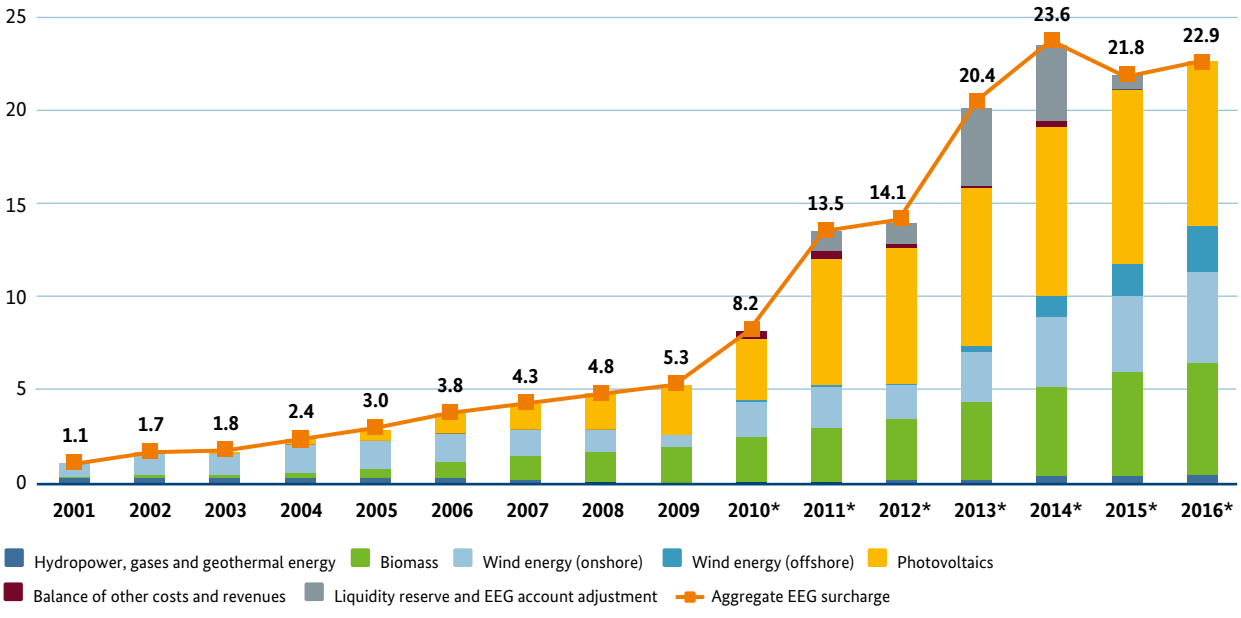


Calculated EEG differential costs of all electricity suppliers for 2001 to 2009 based on transmission system operators' annual statements and the assumptions concerning the average value of EEG electricity
* from 2010 transmission system operators' forecast of EEG surcharge in accordance with the Equalisation Scheme Ordinance (AusglMechV), published on www.netztransparenz.de
The item "Balance of other costs and revenues" includes revenues from paying the minimum surcharge due to privileged final consumption, cost of green electricity privilege and expenditure by transmission system operators on profile service; exchange listing admission, trading platform connectivity and interest charges.

Source: BMWi based on German transmission system operators (TSOs), details at www.erneuerbare-energien.de

Figure 33: Development of the aggregate EEG surcharge

in billion Euro



See the notes on figure 32

Source: BMWi based on German transmission system operators (TSOs), details at www.erneuerbare-energien.de

Economic impetus from the construction and operation of RE plants

Renewable energy as an economic factor

Investments in installations for the use of renewable energy are of considerable importance for Germany's economy, since a large part of the added value is generated in the country itself. From 2000, investment in renewable energy installations has risen steadily, peaking at just over €27.6 billion in 2010. By 2015, it had dropped back to €15.0 billion, although 2014 was an exceptional year with investment shooting up to over €19 billion.

As in the preceding year, the segment with the greatest investment in 2015 was wind energy. At €9.7 billion, it accounted for two-thirds of total investment. Compared with 2014, which was an exceptional year for the wind power industry, investment in wind energy (onshore and offshore) dropped by around 20% and thus returned to the pace of increase mapped out by the long-term trend curve. The growth in wind energy offset at least part of the falls in other segments (particularly PV and biomass). The sharp increase in new offshore plants was a particular factor in this growth; here, the volume of newbuild dropped by less than that of onshore wind. The sharp decline in total investment after 2010 was primarily due to the trend in photovoltaics which saw installation prices fall in 2011 and 2012 while new plants continued to be installed at an unchanged pace. Since 2013, however, prices have remained largely stable while the installation of new photovoltaic capacity has plummeted. Compared to the years 2007 to 2012, when investment in photovoltaic plants constituted up to 70% of total investment, this share fell to nearly 11% by 2015. This corresponds to an investment volume of €1.6 billion.

Investment in the other fields (electricity and heat from biomass, hydropower, solar and geothermal heat) totalled €3.7 billion in 2015, or just fewer than 25% of total investment. These fields have remained largely stable in recent years with the exception of investment in biomass plants for power generation which has been on the decline since 2012.

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

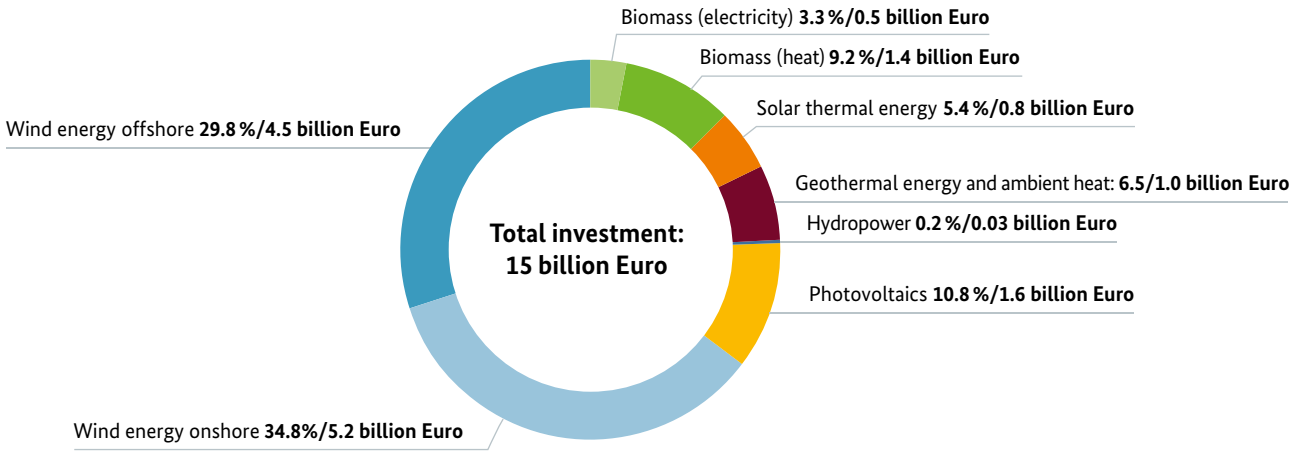
At 79.4%, most of the investments went into electricity generation plants that qualify for EEG payments. Nonetheless, this portion dropped approx. 3.6 percentage points compared to the preceding year.

Figure 34: Investment in construction of renewable energy plants

	Hydropower	Wind energy onshore	Wind energy offshore	Photovoltaics	Solar thermal energy	Geoth. energy, ambient heat	Biomass electricity	Biomass heat	Total
					(billion Euro)				
2000	0.5	1.9	–	0.3	0.5	0.1	0.3	0.9	**4.5**
2001	0.7	3.1	–	0.4	0.7	0.2	0.5	0.9	**6.4**
2002	0.0	3.9	–	0.7	0.4	0.2	0.7	1.0	**6.9**
2003	0.1	3.3	–	0.8	0.6	0.2	0.7	1.1	**6.6**
2004	0.1	2.7	–	3.5	0.6	0.3	0.6	1.2	**9.0**
2005	0.1	2.5	–	4.8	0.7	0.3	2.2	1.3	**12.0**
2006	0.1	3.2	–	4.0	1.1	0.9	2.1	2.0	**13.2**
2007	0.2	2.5	–	5.3	0.7	0.7	1.5	1.7	**12.6**
2008	0.1	2.5	–	8.0	1.4	1.2	1.2	1.6	**16.0**
2009	0.4	2.8	0.3	13.6	1.2	1.1	2.5	1.6	**23.5**
2010	0.3	2.1	0.5	19.5	0.9	1.0	2.0	1.4	**27.6**
2011	0.2	2.8	0.2	15.0	1.1	1.2	2.3	1.4	**24.2**
2012	0.1	3.4	0.5	11.2	1.0	1.1	1.6	1.6	**20.5**
2013	0.2	4.3	2.2	4.3	0.9	1.0	1.4	1.6	**16.1**
2014	0.02	6.7	5.4	2.4	0.9	1.0	1.5	1.5	**19.2**
2015	0.03	5.2	4.5	1.6	0.8	1.0	0.5	1.4	**15.0**

Source: Calculations performed by ZSW, rounded data

Figure 35: Investment in construction of renewable energy plants, 2015



This largely concerns investment in new plants, and to a small extent the expansion or refurbishment of plants, such as the reactivation of old hydropower plants. The figures include not only investment by utilities, but also investment by industrial businesses, skilled trades, commercial enterprises and private households.

Source: Calculations performed by ZSW, rounded data

Stimulus from operation of installations exceeds investment

In addition to construction, plant operation is a further economic factor. Due to the attendant need for personnel, electricity (ancillary energy), replacement parts and fuel, operating (and maintaining) plants sends economic impulses to other sectors as well. The operating expenses incurred by the operator lead to corresponding amounts of revenue for suppliers. The economic stimulus from plant operation has risen steadily in past years in tandem with the growing number of installations. For example, since 2000 revenues rose almost constantly, climbing from €2.2 billion to €14.7 billion in 2015. This means that the economic stimulus from plant operation exceeded investment in installations for the first time.

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

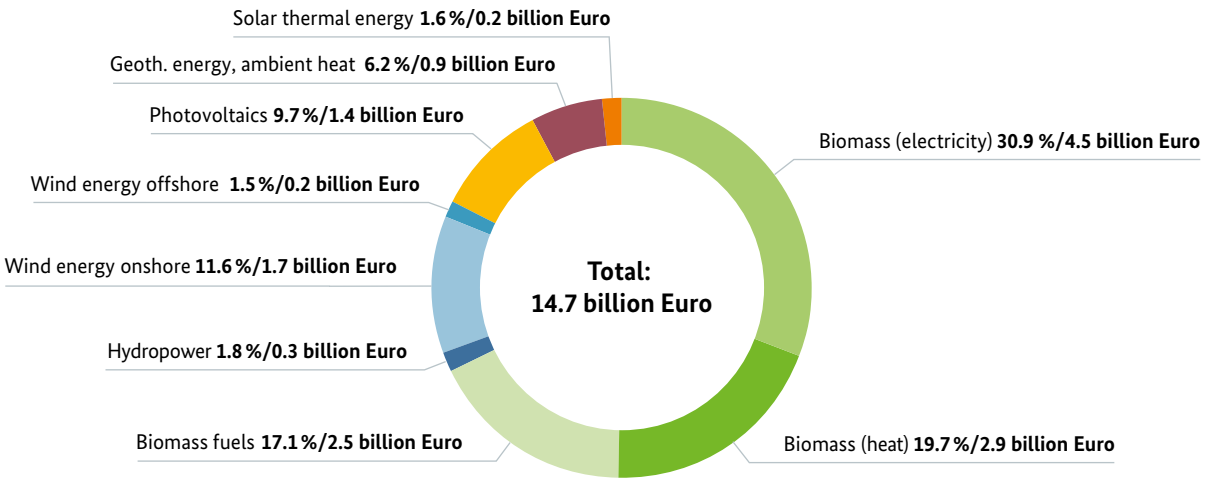
More information on the method used can be found in section 4 of the Annex.

Figure 36: Economic impetus from the operation of renewable energy plants

	Hydropower	Wind energy onshore	Wind energy offshore	Photovoltaics	Solar thermal energy	Geoth. energy, ambient heat	Biomass electricity	Biomass heat	Biomass fuels	Total
					(billion Euro)					
2000	0.3	0.2	-	0.01	0.04	0.2	0.2	1.2	0.2	**2.2**
2001	0.3	0.2	-	0.01	0.1	0.2	0.2	1.2	0.3	**2.4**
2002	0.3	0.3	-	0.02	0.1	0.2	0.3	1.2	0.5	**2.8**
2003	0.3	0.4	-	0.03	0.1	0.2	0.4	1.2	0.7	**3.3**
2004	0.3	0.5	-	0.1	0.1	0.2	0.5	1.3	0.9	**3.8**
2005	0.3	0.6	-	0.1	0.1	0.2	0.7	1.5	1.8	**5.2**
2006	0.3	0.6	-	0.2	0.1	0.3	1.1	1.7	3.2	**7.4**
2007	0.3	0.7	-	0.3	0.1	0.4	1.6	1.9	3.8	**9.0**
2008	0.3	0.8	-	0.4	0.1	0.5	1.9	2.0	3.5	**9.5**
2009	0.3	0.9	-	0.5	0.2	0.5	2.3	2.3	2.4	**9.4**
2010	0.3	1.0	0.01	0.8	0.2	0.6	2.8	2.7	2.9	**11.2**
2011	0.3	1.1	0.02	1.0	0.2	0.7	3.2	2.7	3.7	**12.9**
2012	0.3	1.2	0.02	1.2	0.2	0.8	3.9	2.9	3.7	**14.3**
2013	0.3	1.4	0.1	1.3	0.2	0.9	4.0	3.1	3.1	**14.3**
2014	0.3	1.5	0.1	1.4	0.2	0.9	4.3	2.7	2.7	**14.2**
2015	0.3	1.7	0.2	1.4	0.2	0.9	4.5	2.9	2.5	**14.7**

Source: Calculations performed by ZSW, rounded data

Figure 37: Economic impetus from the operation of renewable energy plants, 2015



Source: Calculations performed by ZSW, rounded data

Promotion of renewable energy in the heating sector

Renewable Energies Heat Act

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

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

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

This year, there are plans to restructure the Energy Conservation Act, the Energy Conservation Ordinance and the Renewable Energies Heat Act and to merge them in a single coordinated set of rules [27].

The Market Incentive Programme

The Market Incentive Programme is intended to support the attainment of the goals of the Renewable Energies Heat Act by promoting sales of technologies which use renewable energy. The Programme is subject to ongoing evaluation by experts [28] in order to assess the impact of the funding. The Programme was revised in 2015, and the new 'Guidelines Promoting Measures for Use of Renewable Energy in the Heating Market' [29] have been in force since 1 April 2015.

This revision sets new standards for the heating sector through its innovative elements that include the establishment of output-based support for solar thermal power and rigorous efficiency criteria. The expansion of renewable energy sources in the heating market is to be stepped up with the help of improved incentives. The revision has also opened up the programme to an even greater degree to the commercial/industrial sector.

The Market Incentive Programme provides two kinds of support. Depending on the nature and size of the plant:

- investment grants are made through the Federal Office of Economics and Export Control for small installations, primarily in existing buildings; such applications mainly come from private investors in the single-family or two-family homes segment, and

- repayment grants for low-interest KfW loans from the KfW's Renewable Energy programme (premium variant) for larger heating solutions and for heating grids and storage solutions. Investments of this kind are mostly made in solutions for commercial or local government use.

From 2000 to 2015, the funding element of the investment grants (from the Federal Office for Economic Affairs and Export Control) amounted to approximately €1.37 billion of investment grants towards some 1.15 million solar thermal plants and approximately €701 million for some 383,000 small-scale biomass heating systems, e.g. pellet boilers. The resulting investment totalled about €10.11 billion in the solar segment and approximately €5.50 billion in the biomass segment.

Efficient heat-pump heating systems have been eligible for assistance since 2008. From 2008 to 2015, some 93,700 investment grants totalling roughly €234 million were approved. The resulting volume of investment totalled around €1.64 billion.

The KfW Renewable Energy Premium programme approved 20,540 reduced-interest loans with repayment grants from 2000 to 2015. The total volume of loans granted came to around €3.15 billion and the volume of repayment grants totalled some €764 million. This assistance is provided, for example, for solar thermal plants with larger collector areas, biomass plants with relatively high outputs, deep geothermal plants, and for heating grids and heat storage facilities supplied with heat from renewable energy sources.

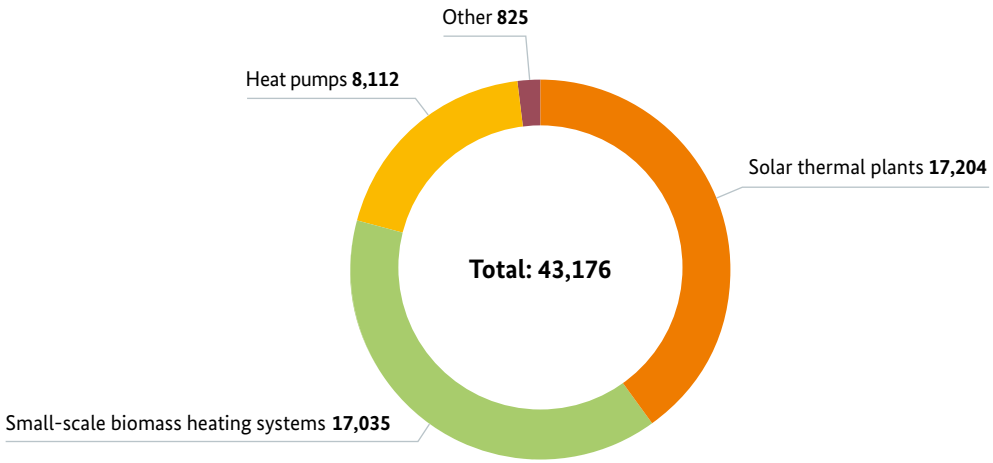
The numbers of approvals in 2015 for the two parts of the Market Incentive Programme (Federal Office for Economic Affairs and Export Control; KfW) are presented in figures 38 and 39.

More information regarding the Market Incentive Programme is available on the website of the Federal Ministry for Economic Affairs and Energy at www.bmwi.de and the ministry's renewable energy information portal at www.erneuerbare-energien.de. Information on investment

grants under the Market Incentive Programme is available from the Federal Office of Economics and Export Control, www.bafa.de and www.heizen-mit-erneuerbaren-energien.de

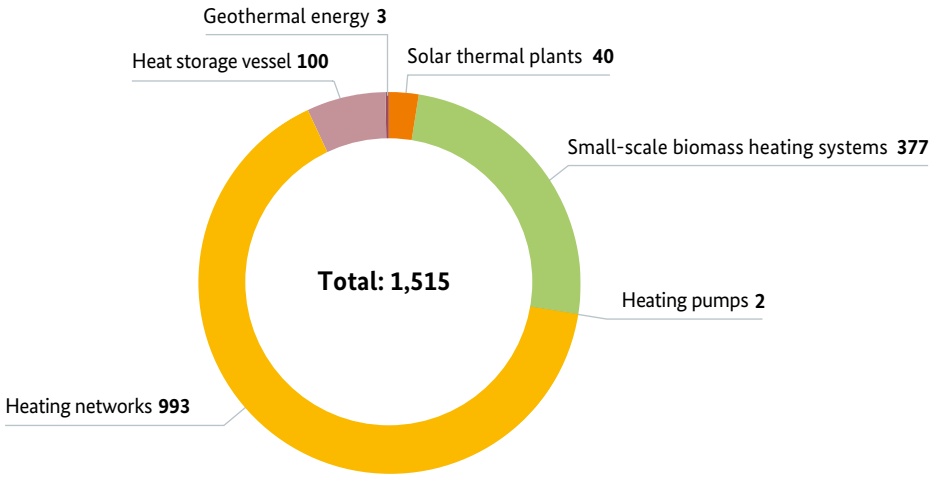
Details on the KfW Renewable Energy Premium programme under the umbrella of the Market Incentive Programme are available on the KfW website at www.kfw.de

Figure 38: Market Incentive Programme 2015 – Investment grants



Source: Federal Ministry for Economic Affairs and Energy (BMWi)

Figure 39: Market Incentive Programme 2015 – Repayment grants, number of approvals, KfW Premium part



Source: Federal Ministry for Economic Affairs and Energy (BMWi)

Promotion of renewable energy in the transport sector

Biofuel

Biofuels were initially subsidised solely via tax concessions in Germany.

The first Biofuel Report by the Federal Finance Ministry [30] found that considerable overfunding for biofuel had occurred in 2006 (the tax refund was much higher than the difference in production costs). For this reason, biofuel funding was shifted onto basis that would be viable and reliable in the long term by moving away from a purely tax-based to a purely regulatory support system [31] [32]. The new biofuel quota introduced in this context required the oil industry to market a minimum proportion of biofuels – in terms of a company's total annual sales of gasoline, diesel and biofuel. From 2010-2014, the overall quota stood at 6.25% (in terms of energy content); the sub-quotas for biofuel substituting diesel fuel were 4.4% (energy content) and for biofuel substituting gasoline 2.8% (energy content). From 2011, it was possible to give certain biofuels (particularly biofuels produced from waste and residues) a double weighting when calculating the biofuel quota.

Biofuels marketed in Germany since the beginning of 2011 can only be subsidised via the biofuel quota or until end of 2015 via taxes if they meet the requirements of the Biofuel Sustainability Ordinance.

As of 1 January 2015, the reference basis for the quota was switched from the energy content to the net reduction in greenhouse gas emissions. This is 3.5% for 2015 and 2016, 4% for 2017-2019, and 6% from 2020 [33]. This should ensures that the target for the use of biofuels and electric mobility of 10% in 2020, which applies equally to all EU Member States pursuant to Directive 2009/28/EC, will be attained.

The quantitative development in the various biofuels (Figure 26) is closely related to the changes in funding arrangements since 2004.

In the case of gas-fuelled vehicles, biomethane was exempted from taxation until the end of 2015. Since the beginning of 2016, biomethane has been subject to the reduced energy tax rate for natural gas. The use of hydrogen in fuel cell vehicles is not taxed. This therefore also applies to hydrogen that is produced synthetically (power to gas).

Electric mobility

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

The package also includes an extension of the road tax exemption from 5 to 10 years for vehicles first registered between 1 January 2016 and 31 December 2020, and a tax exemption for the advantage gained where employers permit private electric vehicles to be charged up at work.

Promotion of renewable energy research and development

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

Research and development projects on energy technology receive funding under the German government's Energy Research Programme. The Federal Ministry for Economic Affairs and Energy is responsible for providing the funding for applied research and development projects relating to renewable energy.

Research and development also relates to site attractiveness and labour market conditions in order to strengthen focuses on competitiveness and leading international position of German companies and research institutions.

The overarching aims of research funding are:

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

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

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

In 2015, the Federal Ministry for Economic Affairs and Energy approved a total of 412 new projects with an overall volume of nearly €263 million in the following fields: photovoltaics, geothermal energy, wind energy, SystEEm (integration of renewable energy sources and regenerative energy supply systems), low-temperature solar thermal energy, solar thermal power plants, marine energy, international cooperation, supporting ecological research and cross-sectoral issues (see figure 40).

For information, please see the ministry's 2015 annual 'Innovation durch Forschung' (Innovation through Research) report.

The website (www.ptj.de) of Projektträger Jülich, the project executing agency commissioned by the ministry, includes information on funding and on how to apply for funding programmes for research in the area of renewable energy.

Figure 40: Recently approved renewable energy projects

	2012			2013			2014			2015		
	Number	1,000 Euro	Share in %	Number	1,000 Euro	Share in %	Number	1,000 Euro	Share in %	Number	1,000 Euro	Share in %
Photovoltaics	80	65,430	24.7	35	33,990	21.8	90	66,910	35.4	106	84,248	32.0
Wind energy	75	78,310	29.5	56	36,750	23.6	63	38,510	20.4	111	91,113	34.6
Geothermal energy	29	17,430	6.7	25	19,210	12.4	15	12,650	6.7	23	17,441	6.6
Low-temp. solar thermal energy	29	9,981	3.8	25	9,945	6.4	15	6,500	3.4	21	9,675	3.7
Solar thermal power plants	25	18,020	6.8	14	8,650	5.6	22	7,440	3.9	17	3,845	1.5
SystEEm1	80	65,571	24.7	66	38,519	24.8	114	51,881	27.5	128	54,577	20.7
Cross-sectoral research	13	4,780	1.8	16	4,101	2.6	12	2,673	1.4	0	0	0.0
Other	10	5,733	2.0	7	4,375	2.8	10	2,424	1.3	6	2,355	0.9
Total	**341**	**265,255**	**100.0**	**244**	**155,540**	**100.0**	**341**	**188,988**	**100.0**	**412**	**263,254**	**100.0**

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

Source: Federal Ministry for Economic Affairs and Energy

Part II: Renewable energy in the European Union

The Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, which entered into force in June 2009, sets ambitious targets: renewable sources are to account for 20% of gross final energy consumption and at least 10% of energy requirements in the transport sector by 2020.

Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources has been in force since 25 June 2009. It is part of the European climate and energy package which was based on the resolutions passed on 9 March 2007 at the spring summit of the heads of state and government (European Council). The binding objective of this Directive is to raise the renewables-based share of total gross final energy consumption in the EU from what was about 8.5% in 2005 to 20% in 2020.

To underpin the EU's 20% target, this Directive also lays down binding national targets for the share of energy from renewable sources in gross final consumption of energy in 2020. These were determined on the basis of the 2005 baseline figures and each country's individual potential, and therefore differ greatly. For example, Malta has to achieve 10%, Sweden 49%. Germany's national target is 18%. The calculation of the shares is based on certain rules: power generation from hydroelectric and wind energy, which fluctuates across the year due to the weather, is normalised, i.e. calculated on the basis of average precipitation and wind conditions.

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

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

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

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

As part of the 2030 Climate and Energy Framework, which was adopted in October 2014, the European Council laid down a binding EU target of achieving a minimum 27% share of renewable energy in 2030. This is to be implemented in the period after 2020, not least with the assistance of a revised European directive on the promotion of renewable energy. The European Commission has announced that it will present a proposal for this towards the end of 2016.

General note:

European and international statistics on the generation and use of renewable energy in Germany do not always match the statistics provided by German sources. This is due to the use of different data sources and accounting methods.

To ensure consistency, the international statistics are used for Germany in this section on Europe.

Progress reports pursuant to Directive 2009/28/EC

On the basis of the EU Directive on the promotion of the use of energy from renewable sources, Member States have adopted national action plans for achieving their targets and, pursuant to Article 22 of the Directive, must report their progress to the Commission every two years. The Member States have now submitted their third progress reports for reference years 2013 and 2014. These are available for download at https://ec.europa.eu/energy/node/70.

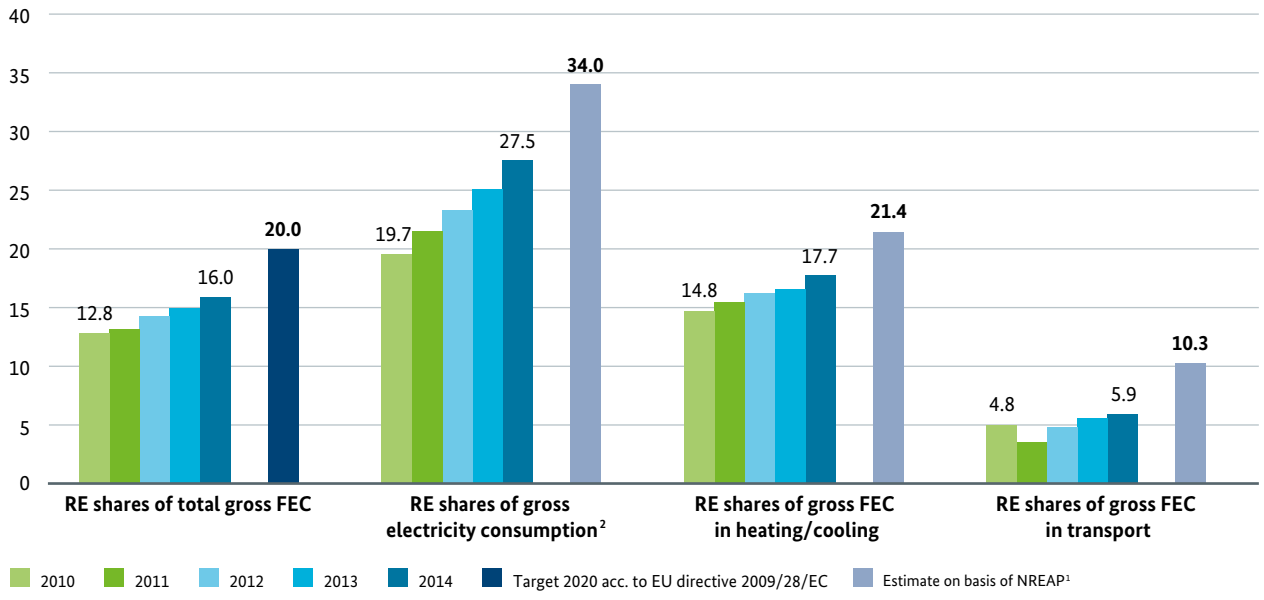
In accordance with Article 23 of the Directive, the European Commission also prepares a progress report every two years documenting the progress made by each country in reaching the targets set out in the EU directive. The European Commission published its latest (third) progress report in June 2015 [34]. This contains a mid-term evaluation of the progress made by the EU and its Member States on the renewables targets up to the year 2020. It finds that, compared with the level of expansion in 2014, the large majority of Member States are making good progress towards attaining the 2020 targets.

Only France and the Netherlands narrowly missed the interim targets for 2011/12, and 25 Member States hit their interim targets for 2013/14. The European Commission notes a delay in most of the countries in attaining the renewable energy usage targets for the transport sector.

The Commission finds that the attainment of the targets for 2020 for the EU as a whole and the majority of the Member States is still fully possible even if the target curve became significantly steeper in the coming years. A number of Member States, including Germany, could actually exceed their targets, whilst the Commission believes that others need to consider whether the measures adopted so far will be sufficient to attain the 2020 targets.

The European Commission's current progress report is available for download at https://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports.

Figure 41: Renewables-based shares of gross final energy consumption and in the electricity, heat and transport sector in the EU according to Directive 2009/28/EC



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 (NREAP). The resulting renewable energy shares for heating/cooling, electricity and transport are entered here as target values. The share for the transport sector calculated in the NREAP, is slightly higher, as the target in the Directive 2009/28/EC.

2 electricity production from wind and hydropower was calculated using the normalisation rule defined in the EU Directive for the purpose of calculating the share of renewable energy in gross electricity consumption.

Sources: Eurostat [3]; ECN [35]

Figure 42: Renewable shares of gross final energy consumption and of gross final energy consumption for electricity

	RE shares of gross final energy consumption (%)							RE shares of gross final energy consumption for electricity[1] (%)					
	2005	2010	2011	2012	2013	2014	Target	2005	2010	2011	2012	2013	2014
Austria	23.8	30.6	30.8	31.6	32.3	33.1	**34**	62.4	65.7	66.0	66.5	68.0	70.0
Belgium	2.3	5.5	6.2	7.2	7.5	8.0	**13**	2.4	7.1	9.1	11.3	12.4	13.4
Bulgaria	9.4	14.1	14.3	16.0	19.0	18.0	**16**	9.3	12.7	12.9	16.1	18.9	18.9
Croatia	23.8	25.1	25.4	26.8	28.1	27.9	**20**	35.8	37.6	37.6	38.8	42.2	45.3
Cyprus	3.1	6.0	6.0	6.8	8.1	9.0	**13**	n.a.	1.4	3.4	4.9	6.6	7.4
Czech Republic	6.0	9.5	9.5	11.4	12.4	13.4	**13**	3.7	7.5	10.6	11.6	12.8	13.9
Denmark	16.0	22.1	23.5	25.6	27.3	29.2	**30**	24.6	32.7	35.9	38.7	43.1	48.5
Estonia	17.5	24.6	25.5	25.8	25.6	26.5	**25**	1.1	10.4	12.3	15.8	13.0	14.6
Finland	28.8	32.4	32.8	34.4	36.7	38.7	**38**	26.9	27.7	29.4	29.5	30.9	31.4
France	9.6	12.6	11.1	13.4	14.0	14.3	**23**	13.7	14.8	16.3	16.4	16.8	18.3
Germany	6.7	10.5	11.4	12.1	12.4	13.8	**18**	10.5	18.1	20.9	23.6	25.3	28.2
Greece	7.0	9.8	10.9	13.4	15.0	15.3	**18**	8.2	12.3	13.8	16.4	21.2	21.9
Hungary	4.5	8.6	9.1	9.6	9.5	9.5	**13**	4.4	7.1	6.4	6.1	6.6	7.3
Ireland	2.9	5.6	6.6	7.1	7.7	8.6	**16**	7.2	14.5	17.2	19.5	20.8	22.7
Italy	7.5	13.0	12.9	15.4	16.7	17.1	**17**	16.3	20.1	23.5	27.4	31.3	33.4
Latvia	32.3	30.4	33.5	35.7	37.1	38.7	**40**	43.0	42.1	44.7	44.9	48.8	51.1
Lithuania	17.0	19.8	20.2	21.7	23.0	23.9	**23**	3.8	7.4	9.0	10.9	13.1	13.7
Luxembourg	1.4	2.9	2.9	3.1	3.6	4.5	**11**	3.2	3.8	4.1	4.6	5.3	5.9
Malta	0.2	1.1	1.9	2.9	3.7	4.7	**10**	0.0	1.0	0.5	1.1	1.6	3.3
Netherlands	2.5	3.9	4.5	4.7	4.8	5.5	**14**	6.3	9.6	9.8	10.4	10.0	10.0
Poland	6.9	9.2	10.3	10.9	11.3	11.4	**15**	2.7	6.6	8.2	10.7	10.7	12.4
Portugal	19.5	24.2	24.7	25.0	25.7	27.0	**31**	27.7	40.7	45.9	47.6	49.1	52.1
Romania	17.6	23.4	21.4	22.8	23.9	24.9	**24**	28.8	30.4	31.1	33.6	37.5	41.7
Slovakia	6.4	9.1	10.3	10.4	10.1	11.6	**14**	15.7	17.8	19.3	20.1	20.8	23.0
Slovenia	16.0	20.5	20.2	20.9	22.5	21.9	**25**	28.7	32.2	31.0	31.6	33.1	33.9
Spain	8.4	13.8	13.2	14.3	15.3	16.2	**20**	19.1	29.8	31.6	33.5	36.7	37.8
Sweden	40.6	47.2	49.0	51.1	52.0	52.6	**49**	50.9	56.0	59.9	60.0	61.8	63.3
United Kingdom	1.4	3.7	4.2	4.6	5.6	7.0	**15**	4.1	7.4	8.8	10.7	13.8	17.8
EU 28	**9.0**	**12.8**	**13.1**	**14.3**	**15.0**	**16.0**	**20**	**14.9**	**19.7**	**21.7**	**23.5**	**25.4**	**27.5**

See Annex Section 2 regarding the calculation of shares

1 electricity production from wind and hydropower was calculated using the normalisation rule defined in the EU Directive for the purpose of calculating the share of renewable energy in gross electricity consumption

Source: Eurostat [3]

Figure 43: Renewable energy shares of gross final energy consumption in the heating/cooling sector and in the transport sector

	RE shares of gross FEC in heating and cooling (%)					RE shares of gross FEC for transport (%)					
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014	Target
Austria	29.8	30.2	31.2	32.7	32.6	8.7	7.7	7.8	7.8	8.9	
Belgium	5.8	6.7	7.3	7.5	7.8	4.2	4.0	4.4	4.3	4.9	
Bulgaria	24.4	24.9	27.5	29.2	28.3	1.0	0.4	0.3	5.6	5.3	
Croatia	32.8	33.7	36.5	37.2	36.2	0.6	0.4	0.4	2.2	2.1	
Cyprus	18.2	19.2	20.8	21.7	21.8	2.0	N/A	N/A	1.1	2.7	
Czech Republic	12.6	13.2	14.1	15.4	16.7	4.5	0.5	5.5	5.6	6.1	
Denmark	30.9	32.3	33.6	34.9	37.8	0.9	3.3	5.5	5.7	5.8	
Estonia	43.3	44.1	43.1	43.2	45.2	0.2	0.2	0.3	0.2	0.2	
Finland	44.3	46.0	48.5	50.8	51.9	3.8	0.4	0.4	9.6	21.6	
France	15.9	15.9	16.9	17.8	17.8	6.1	0.5	7.0	7.2	7.8	
Germany	9.8	10.5	10.4	10.6	12.2	6.0	5.9	6.9	6.4	6.6	
Greece	17.8	19.4	23.3	26.5	26.9	1.9	0.7	1.0	1.0	1.4	
Hungary	11.0	12.3	13.5	12.6	12.4	5.4	5.4	5.2	5.6	6.9	
Ireland	4.5	4.9	5.1	5.4	6.6	2.4	3.8	4.0	4.9	5.2	
Italy	15.6	13.8	17.0	18.1	18.9	4.6	4.7	5.7	4.9	4.5	
Latvia	40.7	44.7	47.3	49.7	52.2	3.3	3.2	3.1	3.1	3.2	All countries 10%
Lithuania	33.2	33.7	35.5	37.7	41.6	3.6	3.7	4.8	4.6	4.2	
Luxembourg	4.8	4.8	5.0	5.8	7.4	2.0	2.1	2.2	3.8	5.2	
Malta	7.4	10.7	13.1	14.6	14.6	0.0	2.1	3.2	3.5	4.7	
Netherlands	3.1	3.7	3.9	4.1	5.2	3.0	4.5	4.5	4.6	5.7	
Poland	11.7	13.1	13.4	14.1	13.9	6.2	6.4	6.0	6.0	5.7	
Portugal	33.9	35.2	34.0	34.5	34.0	5.3	0.4	0.4	0.7	3.4	
Romania	27.2	24.3	25.8	26.2	26.8	3.2	2.1	4.0	4.6	3.8	
Slovakia	7.9	9.3	8.8	7.9	8.7	4.8	5.0	4.8	5.3	6.9	
Slovenia	28.3	30.2	31.7	33.7	33.3	2.8	2.1	2.9	3.5	2.6	
Spain	12.6	13.6	14.1	14.1	15.8	4.7	0.4	0.4	0.5	0.5	
Sweden	60.9	62.5	65.8	67.1	68.1	7.2	10.0	12.6	17.0	19.2	
United Kingdom	2.8	3.1	3.3	3.8	4.5	3.1	2.9	3.6	4.4	4.9	
EU 28	**14.8**	**15.4**	**16.2**	**16.6**	**17.7**	**4.8**	**3.4**	**5.0**	**5.4**	**5.9**	**10.0**

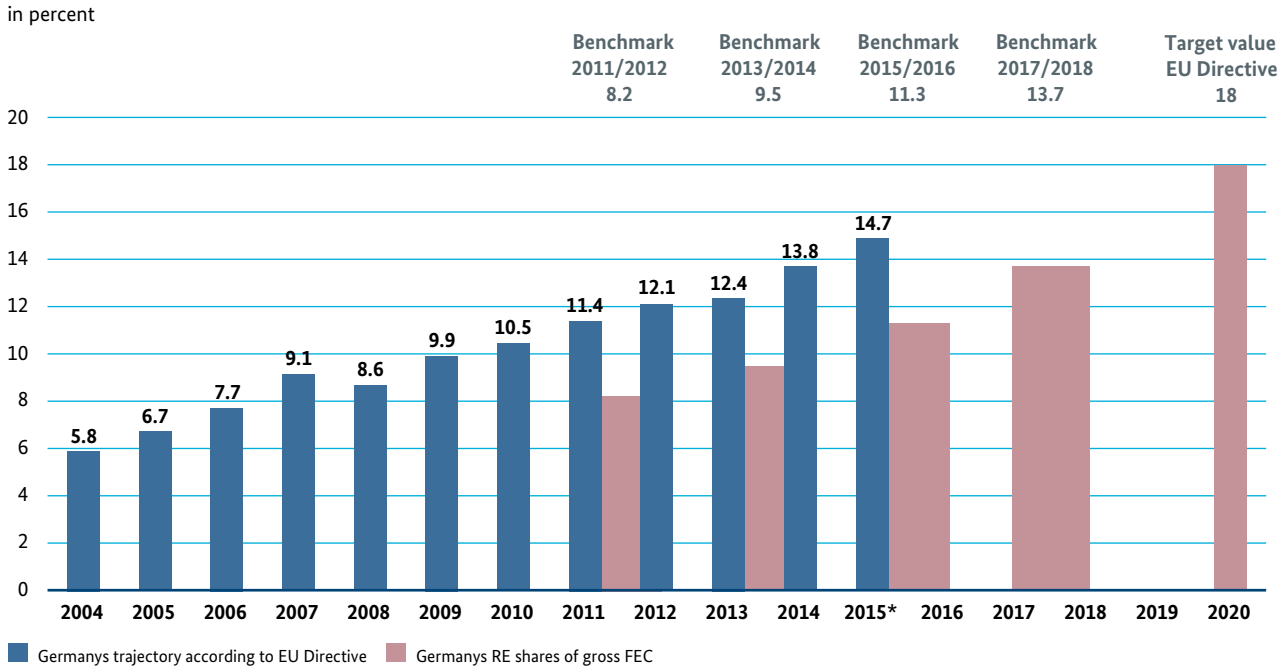
See Annex Section 2 regarding the calculation of shares

Source: Eurostat [3]

Estimate of the shares of renewable energy in gross final energy consumption in Germany in 2015

Initial estimates and calculations indicate that renewable energy made up 14.7% of gross final energy consumption in 2015, based on the calculation method set out in the EU Directive. Once again, the previous year's level (13.8%) was exceeded. The level Germany reached in 2015 actually exceeded the national interim target laid down in EU Directive 2009/28/EC for 2015/2016 (9.46%). Germany is thus on course to reach its ambitious targets for renewable energy growth in 2020.

Figure 44: Shares of renewable energy sources of gross final energy consumption in Germany and trajectory according to EU Directive

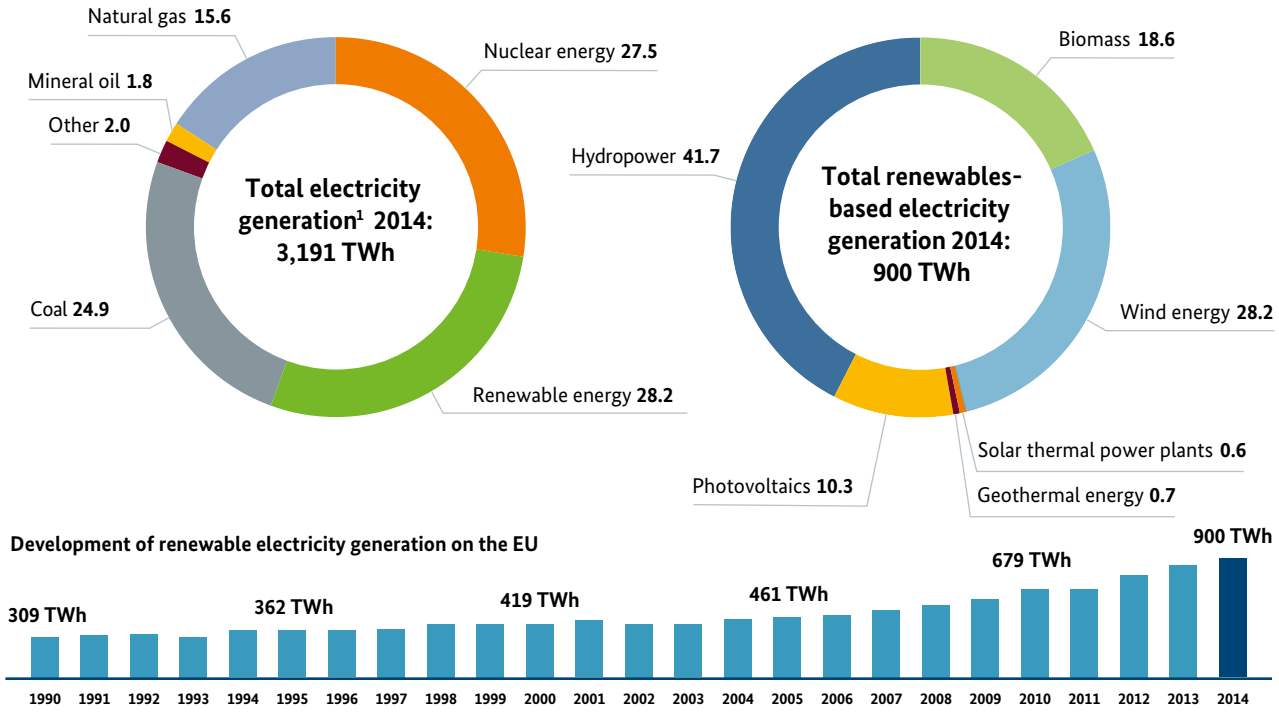


The directive contains detailed instructions on how to calculate the share of renewable energy in gross final energy consumption.
The data shown in this figure cannot be compared to data on national trends (see pages 8 et seq.) due to the methodology set out in the EU directive.
For explanations of the method used in the EU directive, see Section 2 of the Annex to this brochure.

Sources: BMWi on the basis of AGEE-Stat, ZSW; data as of August 2016 (*provisional); deviations compared with Eurostat due to data updates.

Figure 45: Electricity generation in the EU, 2014

in percent



Other = industrial waste, non-renewable municipal waste, pumped storage, etc.
marine energy is not shown due to the small quantities involved.

1 does not include net imports

Source: Eurostat [36]

Electricity generation from renewable energy sources

Figure 46: Renewables-based electricity generation in the EU

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
						(TWh)					
Biomass[1]	69.9	79.1	87.6	97.5	107.6	123.8	132.7	148.5	157.2	166.9	
Hydropower[2]	312.9	316.2	314.5	332.3	335.8	376.9	312.2	335.9	371.6	375.0	
Wind energy	70.5	82.3	104.4	119.5	133.1	149.4	179.7	206.0	236.8	253.2	303.5
Geoth. energy	5.4	5.6	5.8	5.7	5.5	5.6	5.9	5.8	5.9	6.2	
Photovoltaics	1.5	2.5	3.8	7.4	14.0	22.5	45.3	67.4	80.9	92.3	100.5
Solar thermal energy	0.0	0.0	0.0	0.0	0.1	0.8	2.0	3.8	4.8	5.5	
Ocean energy	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.4	0.5	
RE total	460.6	486.1	516.5	563.0	596.5	679.4	678.2	767.7	857.6	899.5	
RE share of gross electricity consumption[3] (%)	**13.8**	**14.4**	**15.2**	**16.5**	**18.4**	**20.1**	**20.5**	**23.2**	**26.1**	**28.1**	
EU gross final electricity generation	3,325.4	3,371.3	3,383.4	3,386.9	3,222.1	3,366.4	3,297.7	3,297.5	3,270.6	3,190.7	
Import	335.2	319.5	325.9	317.4	298.9	298.7	329.8	363.0	349.6	386.9	
Export	319.4	311.0	309.5	294.3	278.7	291.2	322.6	344.4	337.0	371.4	
Final consumption	2,785.1	2,835.5	2,852.5	2,864.7	2,715.4	2,842.0	2,788.7	2,792.9	2,771.0	2,706.3	

1 including biogas, liquid biogenic fuels and the renewable fraction of municipal waste

2 in the case of pumped storage systems, generation from natural inflow only

3 gross electricity consumption = gross electricity generation plus imports minus exports; not calculated as set out in the EU directive

This overview reflects the present state of available statistics (Eurostat until 2014, EurObserv'ER 2015).

Source: Eurostat [36], EurObserv'ER

Figure 47: Renewables-based electricity generation in the EU, 2014

	Hydropower	Wind energy	Biomass[1]	Biogas[2]	Liquid biogenic fuels	Photo-voltaics	Solar thermal power plants	Geoth. energy	Ocean energy	Total	RE share of gross elec. consumption[3]
					(TWh)						(%)
Austria	41.0	3.8	3.7	0.6	0.02	0.8	–	0.001	–	**50.0**	**66.9**
Belgium	0.3	4.6	3.5	0.9	0.1	2.9	–	–	–	**12.3**	**13.6**
Bulgaria	4.6	1.3	0.1	0.1	–	1.3	–	–	–	**7.4**	**19.4**
Cyprus	–	0.2	–	0.1	–	0.1	–	–	–	**0.3**	**7.3**
Czech Republic	1.9	0.5	2.1	2.6	–	2.1	–	–	–	**9.2**	**13.2**
Denmark	0.02	13.1	3.9	0.4	–	0.6	–	–	–	**18.1**	**51.6**
Estonia	0.03	0.6	0.7	0.04	–	–	–	–	–	**1.4**	**14.4**
Finland	13.4	1.1	11.4	0.4	–	0.01	–	–	–	**26.3**	**30.5**
France	62.8	17.2	3.5	1.5	–	5.9	–	–	0.5	**91.5**	**18.5**
Germany	19.6	57.4	17.9	31.1	0.4	36.1	–	0.1	–	**162.6**	**27.4**
Greece	4.5	3.7	–	0.2	–	3.8	–	–	–	**12.2**	**20.5**
Hungary	0.3	0.7	1.8	0.3	–	0.1	–	–	–	**3.1**	**7.3**
Ireland	0.7	5.1	0.3	0.2	–	–	–	–	–	**6.4**	**22.4**
Italy	58.5	15.2	6.2	8.2	4.3	22.3	–	5.9	–	**120.7**	**37.3**
Latvia	2.0	0.1	0.3	0.4	0.001	–	–	–	–	**2.8**	**37.7**
Lithuania	0.4	0.6	0.3	0.1	–	0.1	–	–	–	**1.5**	**12.6**
Luxembourg	0.1	0.1	0.1	0.1	–	0.1	–	–	–	**0.4**	**5.1**
Malta	–	–	–	0.007	–	0.07	–	–	–	**0.1**	**3.3**
Netherlands	0.1	5.8	4.2	1.0	0.4	0.8	–	–	–	**12.4**	**10.5**
Poland	2.2	7.7	9.2	0.9	0.001	0.01	–	–	–	**19.9**	**12.3**
Portugal	15.6	12.1	2.8	0.3	–	0.6	–	0.2	–	**31.6**	**58.8**
Romania	18.8	6.2	0.5	0.1	–	1.6	–	–	–	**27.1**	**46.3**
Slovakia	4.2	0.01	0.9	0.5	–	0.6	–	–	–	**6.2**	**21.9**
Slovenia	6.1	0.004	0.1	0.1	0.004	0.3	–	–	–	**6.6**	**45.0**
Spain	39.2	52.0	4.7	0.9	–	8.2	5.5	–	–	**110.4**	**40.1**
Sweden	63.8	11.2	10.7	0.01	0.05	0.05	–	–	–	**85.8**	**62.2**
United Kingdom	5.9	32.0	16.8	5.9	–	4.1	–	–	0.002	**64.7**	**18.0**
EU 28	**375.0**	**253.2**	**105.4**	**56.7**	**4.8**	**92.3**	**5.5**	**6.2**	**0.5**	**899.5**	**28.1**

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

1 including the biogenic fraction of municipal waste

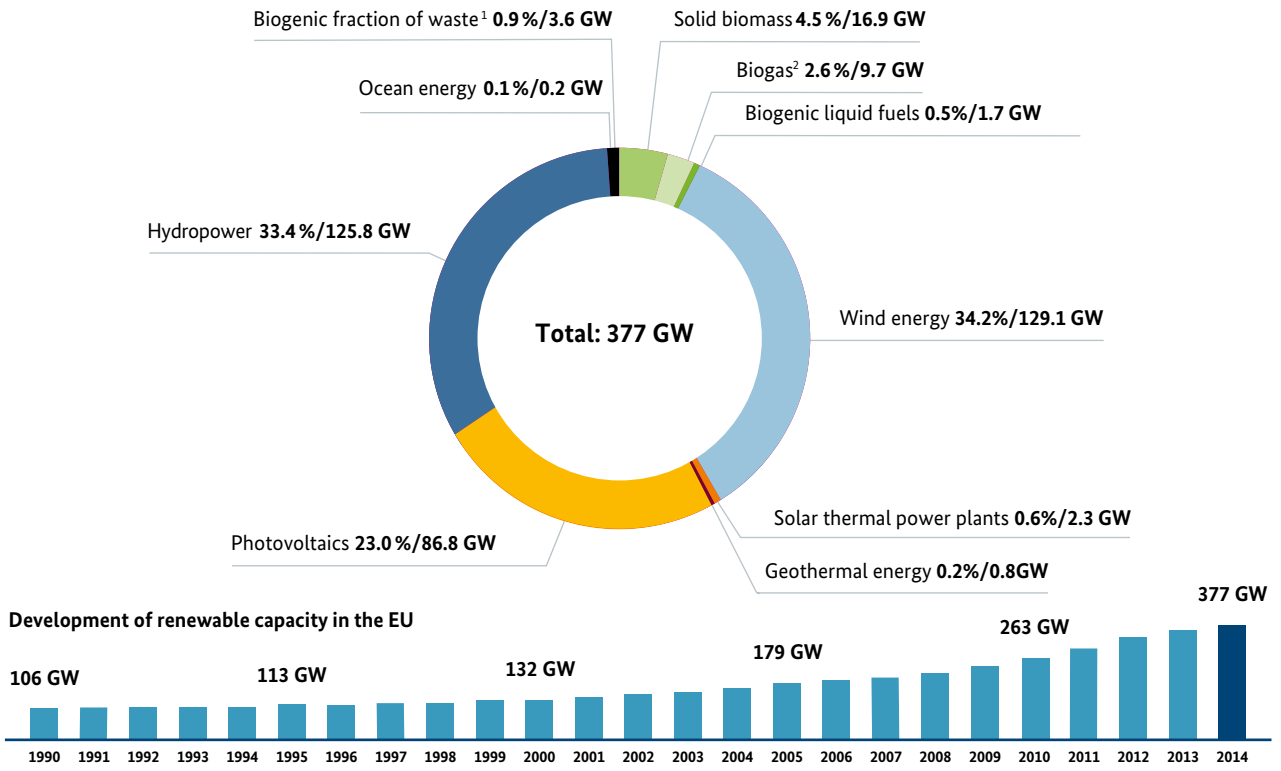
2 including sewage and landfill gas

3 gross electricity consumption = gross electricity generation plus imports minus exports; not calculated as set out in the EU directive

Sources: Eurostat [36]

In 2005, the share of renewables in total EU electricity consumption was only just under 14%, i.e. more than 86% of electricity consumption was covered by fossil fuels and nuclear energy. An analysis of the National Action Plans reveals that the target set in the Renewable Energy Directive 2009/28/EC of covering 20% of gross final energy consumption through the use of renewable energy by 2020 also includes an implicit target of achieving a clear increase in the share of gross electricity consumption covered by renewable energy. The overall set of Member State Action Plans creates a target exceeding 30%. In this way, the Directive – in tandem with the Electricity Directive (2001/77/EC), which entered into force in 2001 – has caused the share of the EU's gross electricity consumption covered by renewable energy to double to more than 28% within the space of 10 years (2004–2014).

Figure 48: Total installed capacity for renewables-based electricity generation in the EU, 2014

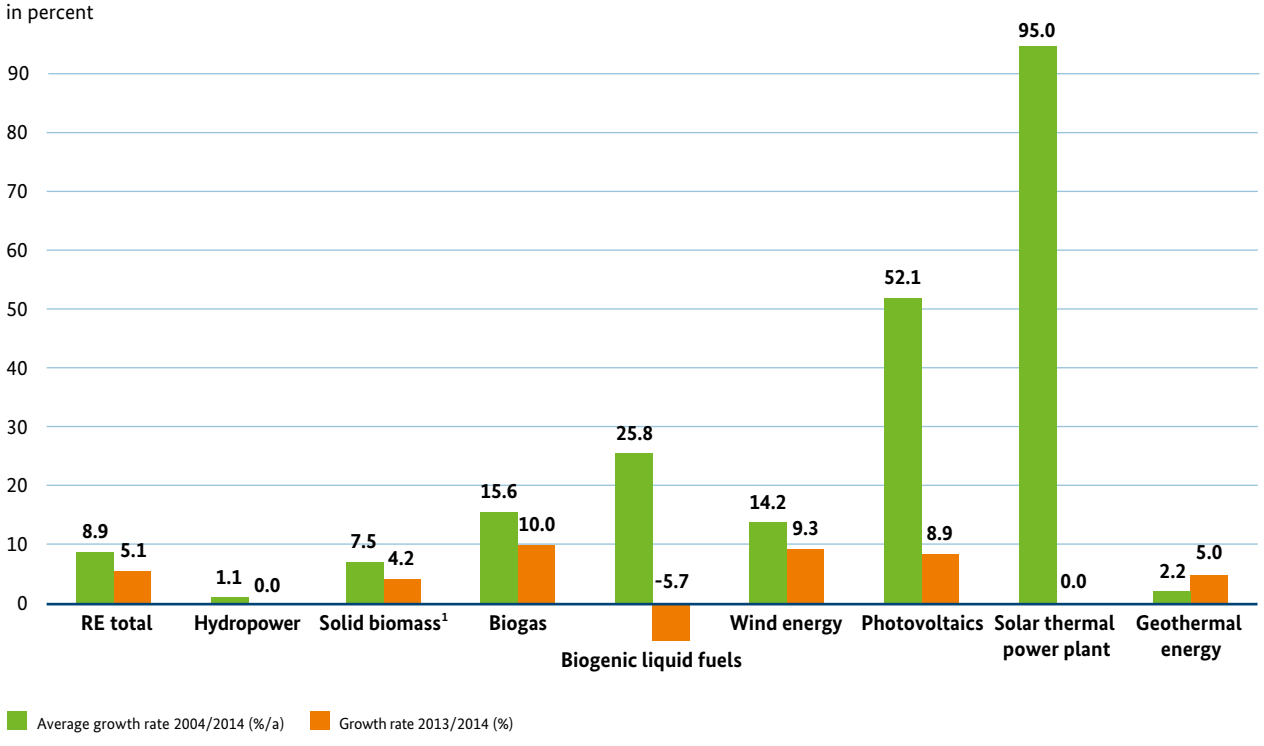


Provisional figures Marine. Energy is not shown due to the small quantities involved.
1 biogenic fraction of waste in waste incineration plants is estimated at 50 percent
2 including landfill gas and sewage gas

Source: Eurostat [38]

Figure 49: Growth rates of installed capacity for renewables-based electricity generation in the EU

in percent



1 including biogenic fraction of municipal waste
2 solar thermal power plant capacities available only since 2006, i.e. average growth rate was calculated for the period 2006/2013

Source: Eurostat [38]

Back in 2005, the bulk of green electricity came from hydropower. By 2014, the share of this technology had fallen to just less than 42%. In contrast, the shares of wind, biomass and solar energy have increased considerably, at 28%, 19% and 10% respectively.

At the end of 2014, total installed capacity in the EU for the generation of electricity from renewable energy amounted to nearly 380 gigawatts, or more than twice the level at the end of 2005. Wind energy accounted for approximately 129 gigawatts of this figure, ahead of hydropower (126 gigawatts) and photovoltaics (87 gigawatts).

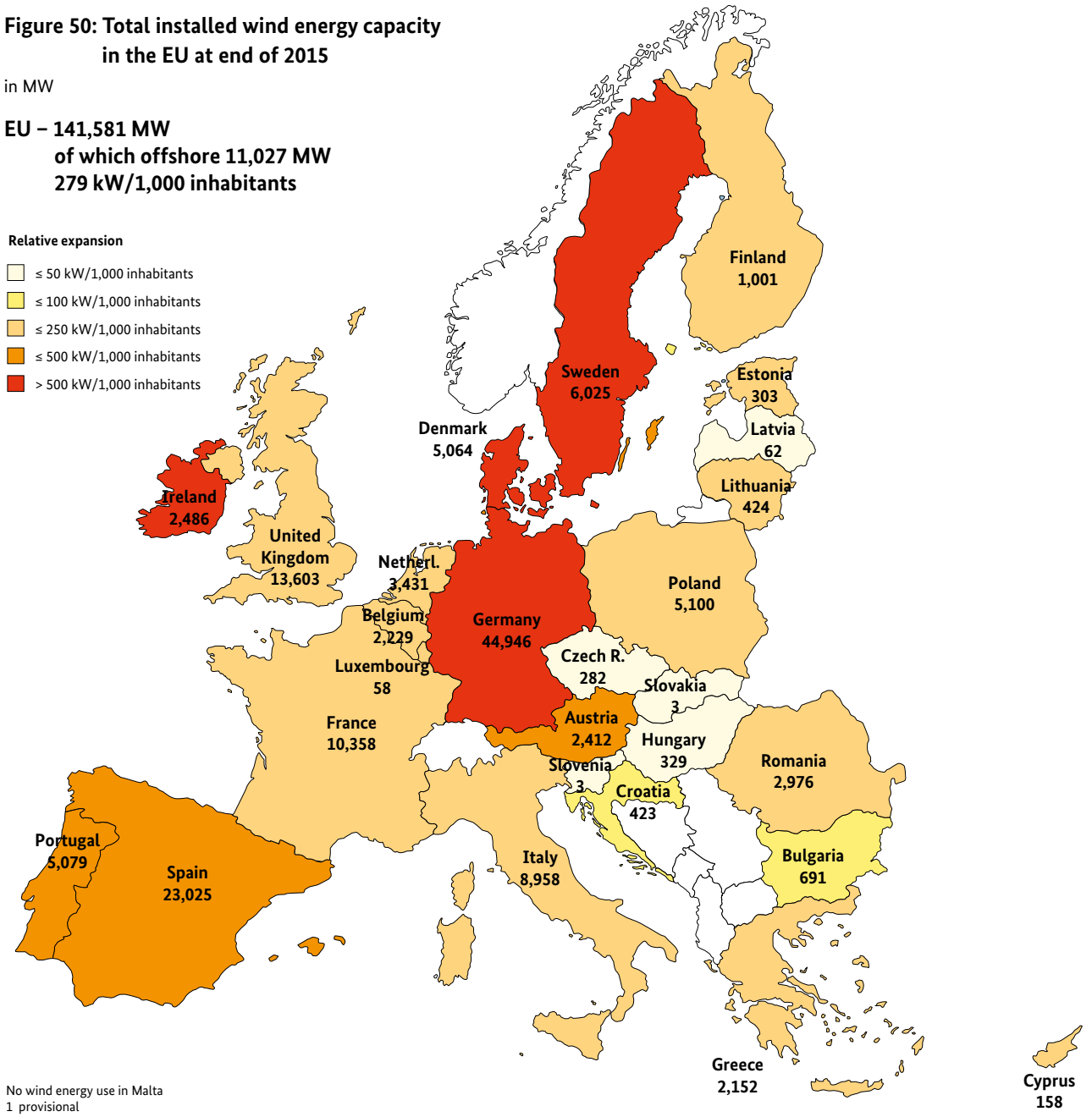
Wind energy use

At around 12.5 gigawatts (net), the highest level of new build of all the renewable technologies again fell to wind energy, which maintained the high rate of expansion seen in preceding years. In contrast, photovoltaics slightly exceeded the level of expansion seen in the preceding year (7.8 compared with 7.1 gigawatts), but for the second year in succession, fell below the strong new build levels seen in earlier years (11 gigawatts in 2013 and 17.5 gigawatts in 2012).

Figure 50: Total installed wind energy capacity in the EU at end of 2015

in MW

EU – 141,581 MW
of which offshore 11,027 MW
279 kW/1,000 inhabitants



No wind energy use in Malta
1 provisional

Source: EWEA [37]

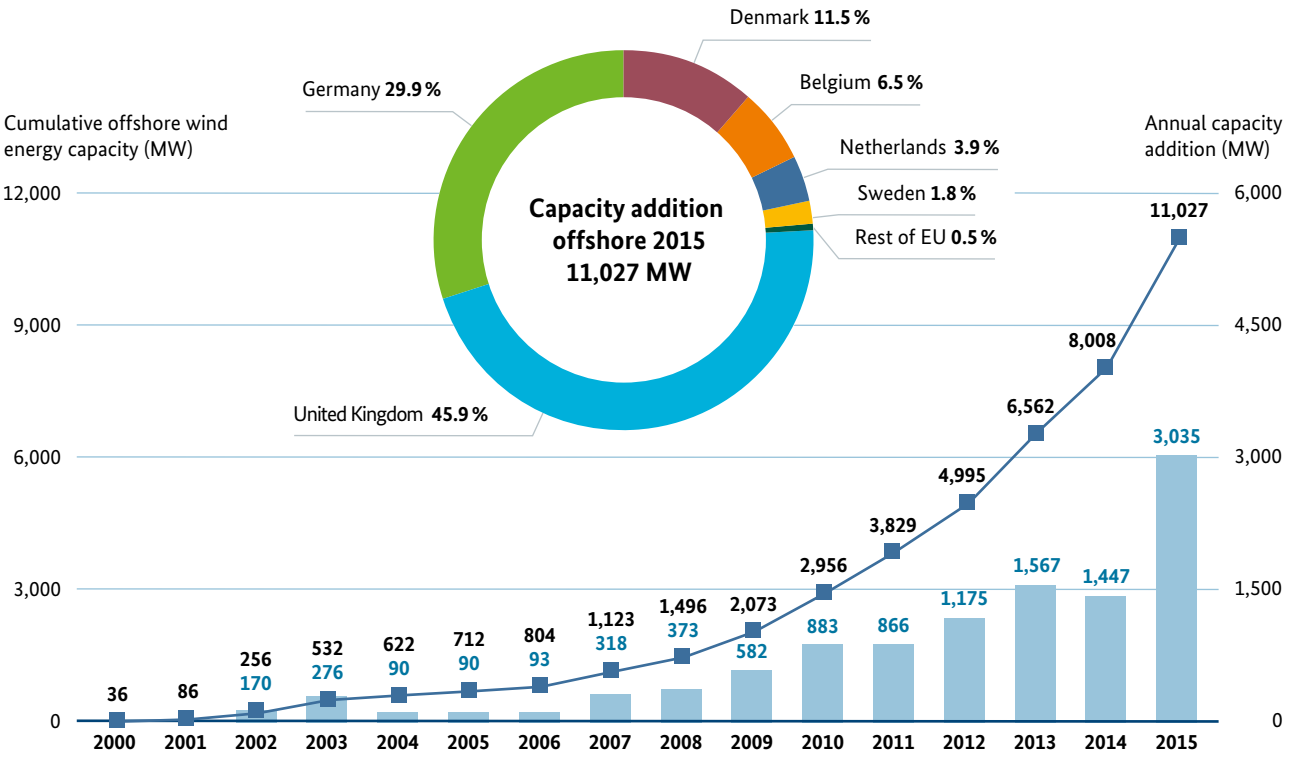
The rate of expansion in the use of wind energy across the EU remained at a high level in 2015. According to the European Wind Energy Association (EWEA) [37], net expansion of capacity hit a new record of approximately 12.5 gigawatts. The bulk of this was installed in Germany (46%). Poland (10%), France (almost 9%) and the United Kingdom (almost 8%) followed, trailing by quite some distance. According to the EWEA, this meant that by the end of 2015, wind energy installations across the EU had a combined total capacity of 141,581 megawatts. Here, Germany is again clearly leading the field, accounting for approximately 32%. Despite the fact that expansion in Spain has come to a halt, the country ranks second at 16%. After this come the United Kingdom (nearly 10%), France (7%) and Italy (6%).

However, the picture is different if the total installed capacity of the various Member States is considered in per-capita terms. On 31 December 2015, the EU average stood at just under 279 kilowatts per 1,000 inhabitants. This time, the country rankings were headed by Denmark with 895 kilowatts per 1,000 inhabitants, well ahead of Sweden (618 kW), Germany (553 kW) and Ireland (535 kW).

Considering installed offshore wind energy capacity on its own, the newbuild of over 3,000 megawatts resulted in total installed capacity of more than 11,000 megawatts at the end of 2015. Here, the United Kingdom (46%) is ahead of Germany (30%), Denmark (12%) and Belgium (7%).

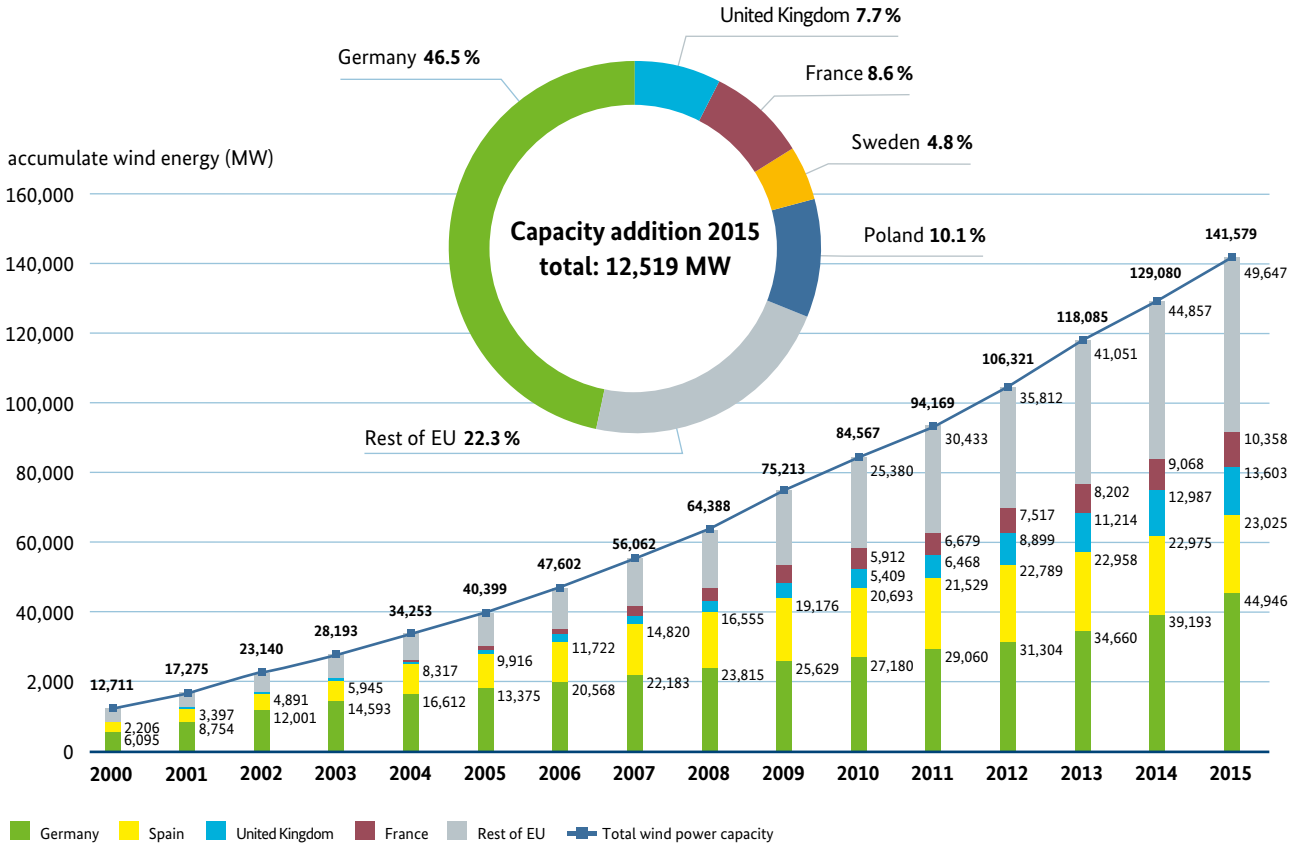
All the EU's wind energy installations together generated more than 300 terawatt-hours of electricity in 2015, covering approximately 11% of total electricity consumption [37].

Figure 51: Installed offshore wind energy capacity, additional and cumulative



Source: EWEA [40]

Figure 52: Development of cumulative wind energy capacity in the EU Member States



Total wind energy capacity in 2014 does not correspond exactly to the sum of installed capacity at the end of 2013 plus additions in 2014; this is due to repowering and closures of existing wind turbines and to data rounding

Sources: Eurostat [38]; EWEA [39]

Solar energy use – electricity generation

Following three successive years of declining newbuild on the European photovoltaics market, 2015 saw a higher level of newbuild than the preceding year, which climbed to around 7.5 gigawatts. The most important factor driving this development was higher demand in the United Kingdom, whilst most of the other markets stagnated or, as in the case of Germany, actually shrank further. But the European market is nowhere close to repeating the record years of 2011 and 2012, which saw 22.4 and 17.6 gigawatts of new capacity installed respectively [41].

The highest level of newbuild in 2015 was achieved by the United Kingdom (3.7 gigawatts), followed by Germany (1.5 gigawatts) and France (0.9 gigawatts).

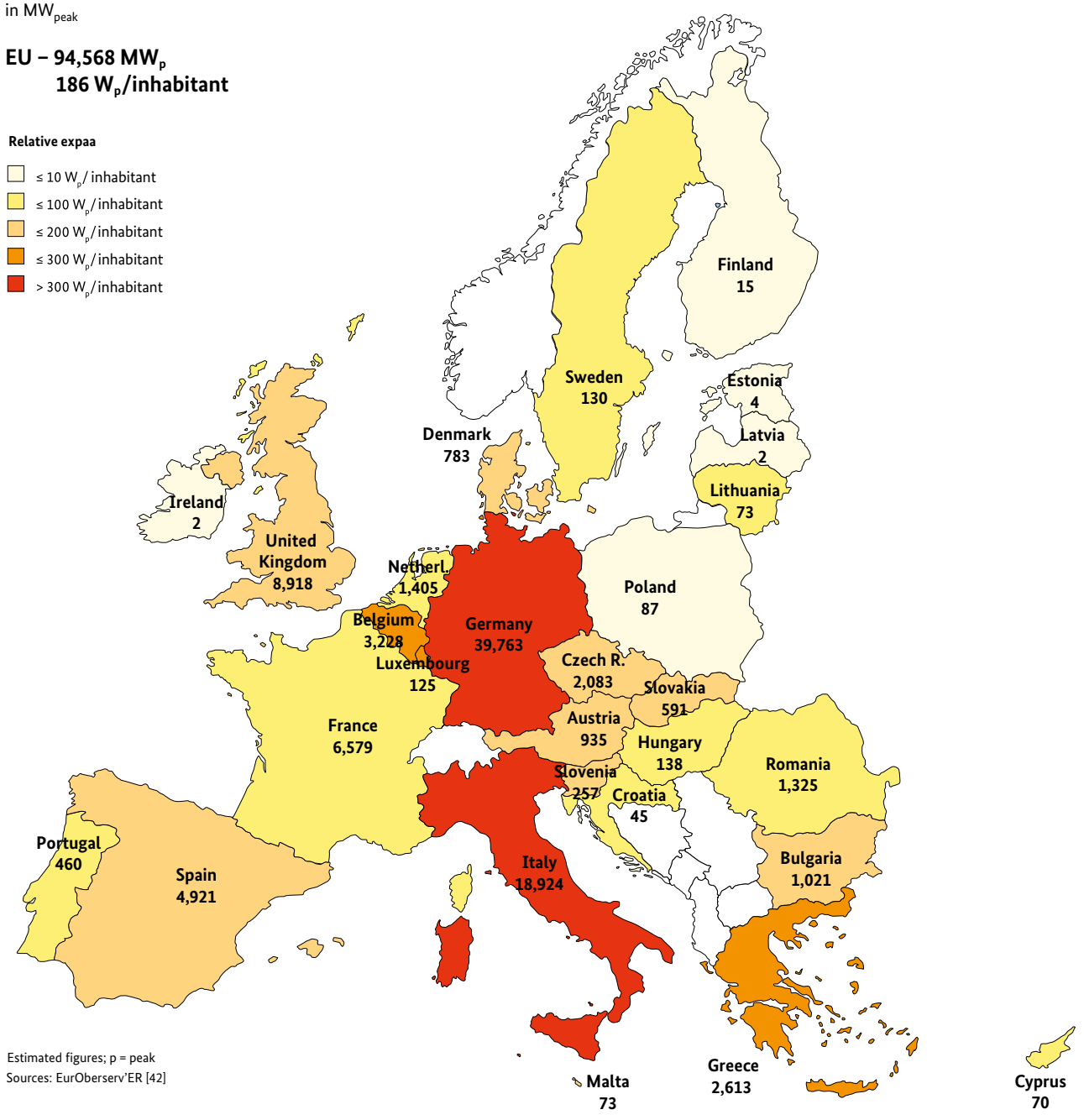
Looking at the total photovoltaics capacity installed in the EU, which amounted to 94,568 megawatts at the end of 2015, Germany is still well in front, with 42%, followed by Italy with 20%, the United Kingdom with 9% and France with 7%. Germany was also ahead in per-capita terms, at 490 kilowatts per 1,000 inhabitants. The next highest figures were registered by Italy with 311 kilowatts and Belgium with 287 kilowatts per 1,000 inhabitants.

Generating over 100 billion kilowatt-hours of electricity, photovoltaics covered just under 4% of total electricity consumption in the EU.

Solar thermal power plants are also used in the EU to generate electricity using solar energy. However, use of this technology is only commercially viable in the southern European countries. An attractive feed-in tariff made Spain the leader in commercialising this technology in both the EU and worldwide for many years. As a result, almost all of the more than 2,300 megawatts of installed capacity of solar thermal power plants in the EU is sited in Spain. At roughly 5 billion kilowatt-hours of electricity, the installations cover around 2% of Spanish electricity consumption each year [42].

Figure 53: Total installed photovoltaic capacity in the EU at the end of 2015

in MW_{peak}



Solar energy – heat supply

According to the EurObserv'ER solar thermal barometer [44], 2.7 million square metres of solar collector surface area was newly installed in the EU in 2015, corresponding to thermal output of 1.86 gigawatts; this marked a further 8.6% fall against the preceding year. As a consequence, the European solar thermal market shrank for the seventh successive year since its high-point in 2008, with the volume generated in 2015 falling below that of 2006. The current decline was largely due to the low level of oil and gas prices.

The market only managed to go against the EU-wide trend in Greece, Denmark and Poland, where the newly installed surface area was higher than the preceding year's level. In Greece, this was particularly driven by investment in the tourism industry, and a major factor in Denmark was the fact that most solar thermal installations are connected to heating grids, and are thus less dependent on the investment trends of private households. The highest sales in 2015 were again recorded in Germany, with a total of 831,000 square meters of newly installed collector surface area. Poland (277,000 square meters), Greece (271,600 square meters), Spain (241,165 square meters) and Italy (230,588 square meters) followed quite some distance behind.

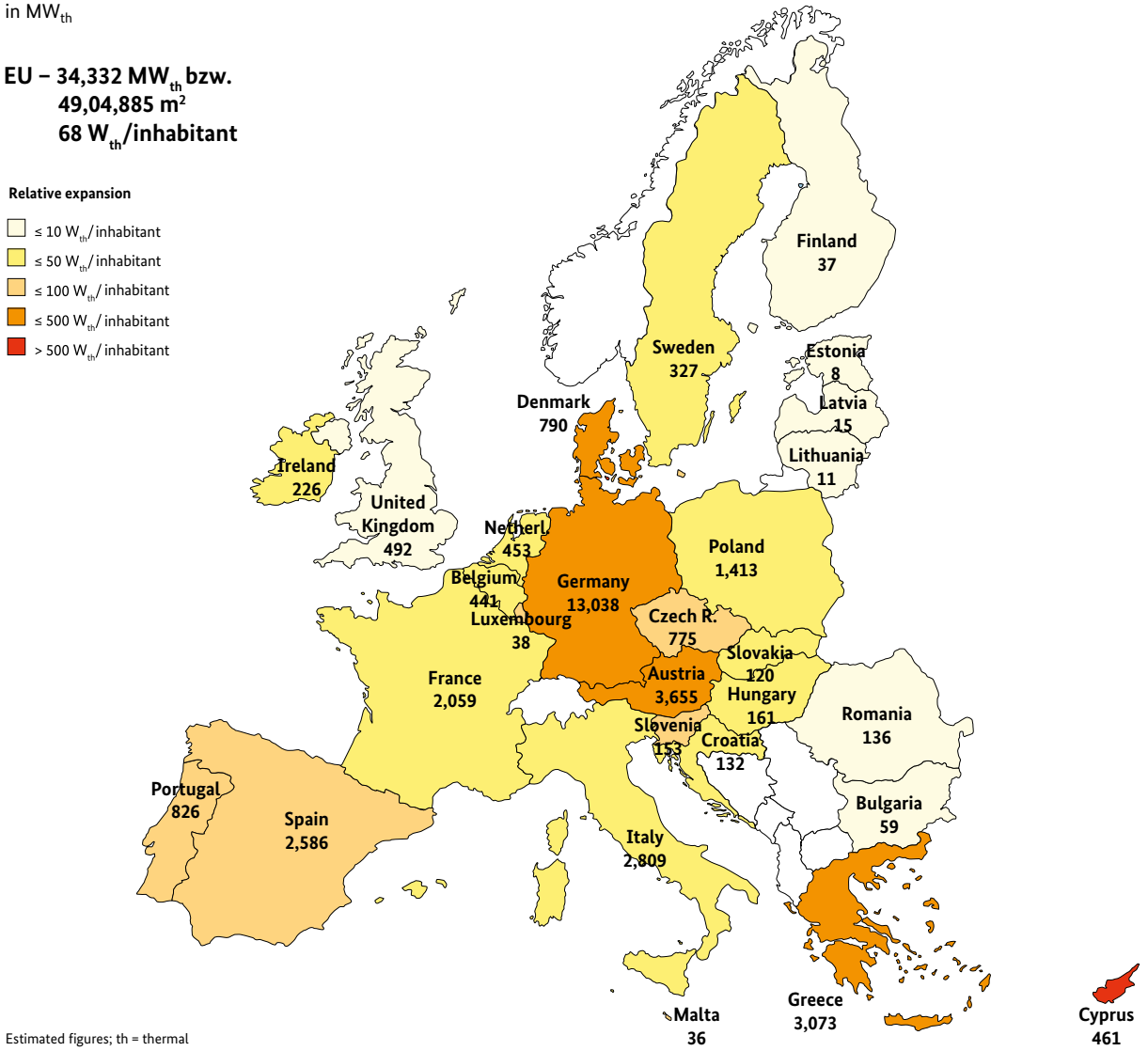
At the end of 2015, the EU had a total installed collector surface area of over 49 million square meters, corresponding to a thermal output of 34.3 gigawatts. At 18,625 million square meters, Germany had by far the largest collector surface area, followed by Austria (5,221 million) and Greece (4,390 million). In per-capital terms, Cyprus tops the rankings, with 0.778 square metres, ahead of Austria (0.608 square metres), Greece (0.406 square metres) and Germany (0.229 square metres).

Renewable energy sources in the transport sector

By 2020, renewable energy is to account for at least 10% of final energy consumption in transport in the individual EU Member States. This target was the only binding sector-specific one stipulated in EU Directive 2009/28/EC. According to an evaluation of the National Action Plans from 2011 [36], demand for biodiesel in the EU could rise to 252 billion kilowatt-hours, and demand for bioethanol to 85 billion kilowatt-hours. In 2015, sales of biodiesel reached around 130 billion kilowatt hours, while over 32 billion

Figure 54: Total installed solar thermal capacity in the EU, 2015

in MW_{th}



Estimated figures; th = thermal

Source: EurObserverER [44]

kilowatt-hours of bioethanol was sold. Following a strong year-on-year decline in consumption in 2014 (increase 6.1%), demand then rose again in 2015. According to estimates by EurObserv'ER [45], consumption levels in 2015 were, however, actually still lower than in 2014 (163 billion kilowatt-hours compared with 166 billion kilowatt-hours). Some 92% of all biofuel that was consumed across the EU in 2014 succeeded in meeting the sustainability criteria set out in EU Directive 2009/28/EC [45].

When it comes to the production of biofuel within the EU, the generation of biodiesel rose in 2015 by 5% over the preceding year, climbing to 11.5 billion litres. The biggest producer countries were Germany and France, which generated 2.8 billion litres and 2.4 billion litres respectively. In contrast, ethanol production in the EU fell by 7% year-on-year, dropping to 4.1 billion litres, which was particularly due to lower levels of production in the United Kingdom. The key producer countries for ethanol were France, Germany, Spain, Belgium, and the United Kingdom [41].

Figure 55: Biofuel consumption in the EU member states

	2014				2015			
	Bioethanol	Biodiesel[1]	Others[2]	Total	Bioethanol	Biodiesel[1]	Others[2]	Total
	(billion kWh)				(billion kWh)			
Austria	0.66	6.08	–	6.7	0.7	5.2	–	5.8
Belgium	0.4	4.3	–	4.8	0.4	2.7	–	3.1
Bulgaria	0.17	1.09	–	1.3	0.2	1.1	–	1.3
Croatia	–	0.34	–	0.3	–	0.3	–	0.3
Cyprus	–	0.16	–	0.2	–	0.1	–	0.1
Czech Republic	0.91	3.09	–	4.0	0.9	3.1	–	4.0
Denmark	–	2.66	–	2.7	–	2.4	–	2.4
Estonia	0.07	–	–	0.1	0.1	–	–	0.1
Finland	0.81	4.24	0.02	5.1	0.8	4.2	0.02	5.1
France	4.82	29.55	–	34.4	5.0	29.8	–	34.8
Germany	9.22	22.25	0.59	32.0	8.8	20.7	0.49	30.0
Greece	–	1.55	–	1.5	–	1.7	–	1.7
Hungary	0.98	1.28	0.20	2.3	1.0	1.4	–	2.4
Ireland	0.32	1.03	–	1.3	0.4	1.1	–	1.5
Italy	0.10	12.27	–	12.4	0.3	13.2	–	13.4
Latvia	0.07	0.18	–	0.3	0.1	0.2	–	0.3
Lithuania	0.06	0.67	–	0.7	0.1	0.7	–	0.8
Luxembourg	0.04	0.76	0.001	0.8	0.1	0.9	–	0.9
Malta	–	0.05	–	0.1	–	0.1	–	0.1
Netherlands	1.49	2.87	–	4.4	1.6	2.1	–	3.7
Poland	1.55	6.48	–	8.0	1.9	6.8	–	8.7
Portugal	0.06	3.23	–	3.3	0.3	3.8	–	4.1
Romania	0.49	1.46	0.12	1.9	0.5	1.5	–	1.9
Slovakia	0.36	1.22	–	1.6	0.4	1.2	–	1.6
Slovenia	0.07	0.42	–	0.5	0.1	0.4	–	0.5
Spain	2.20	9.00	–	11.2	2.1	9.2	–	11.3
Sweden	1.92	7.82	1.09	10.8	1.6	9.9	1.2	12.7
United Kingdom	4.83	8.73	–	13.6	4.7	6.0	–	10.8
EU 28	**31.6**	**132.8**	**2.0**	**166.1**	**31.9**	**129.7**	**1.7**	**163.3**

1 figure for biodiesel contains a share of bioethanol and HVO; no data for single biofuels available

2 biogas in Germany, Sweden and Finland; vegetable oil consumption and not exactly specified biofuels particularly in Germany, Romania, Hungary and Luxembourg

Source: EurObserv'ER [45]

Turnover from renewable energy

More than €143.6 billion in revenue was generated by renewable energy in the EU in 2014, approximately EUR 5.4 billion/4% more than in in the preceding year [46]. The rise was based on the record level of level of wind power capacity that was added, resulting in an increase in turnover of €8.5 billion, while turnover from photovoltaics fell by €5.7 billion. With turnover of €33.3 billion, Germany has thereby retained its lead position in the country rankings, followed by France (€18.9 billion), the United Kingdom (€18.1 billion), Italy (€16.1 billion), and Denmark (€12.6 billion).

When turnover is broken down into the various different technologies, we see that the largest share is generated by biomass use (including biofuels) (€55.5 billion), followed by wind power (€48.2 billion). The third technology, which comes in at a distance, is solar energy (photovoltaics and solar thermal energy), worth €19.9 billion, followed by geothermal energy (including heat pumps) (€15.1 billion), and hydropower (€4.9 billion) [46].

Figure 56: Revenue from renewable energy, 2014

	Wind energy	Photo-voltaics	Solid biomass	Biofuels	Biogas	Solar thermal energy	Heat pumps[1]	Geoth. energy	Hydro-power <10 MW	Total
					million Euro					
Germany[2, 3]	13,900	3,700	8,060	2,700	1,640	1,000	1,710	190	400	**33,300**
Italy	1,000	2,340	1,900	1,000	2,700	300	5,300	650	880	**16,070**
France	2,620	3,920	5,000	3,500	400	410	2,500	90	430	**18,870**
United Kindom[3]	7,475	2,845	4,150	645	485	300	1,350	15	850	**18,115**
Denmark	11,330	250	380	250	30	150	160	<5	<5	**12,560**
Spain	3,800	300	1,350	930	90	250	330	15	385	**7,450**
Sweden	1,700	80	2,600	900	40	<10	630	0	310	**6,270**
Austria[3]	1,035	905	2,425	305	110	365	370	15	770	**6,300**
Poland	1,000	30	1,800	700	50	220	110	30	100	**4,040**
Netherlands	800	600	350	330	150	50	320	100	0	**2,700**
Belgium	1,025	150	320	350	55	45	70	<5	10	**2,030**
Finland	300	<5	2,400	200	20	<5	400	0	40	**3,370**
Portugal	430	200	750	280	<5	45	50	10	180	**1,950**
Romania	750	500	990	200	10	15	0	25	110	**2,600**
Czech Republic	35	50	670	320	150	60	75	<5	90	**1,455**
Greece[3]	310	250	250	130	25	225	0	<5	70	**1,265**
Rest of EU	720	235	2,660	665	120	115	380	140	245	**5,280**
EU 28	**48,230**	**16,360**	**36,055**	**13,405**	**6,080**	**3,565**	**13,755**	**1,300**	**4,875**	**143,625**

The figures take account of production, distribution and installation of the plants, plus operation and maintenance.

1 geothermal heat pumps

2 for consistency reasons, the figures for Germany are taken from the stated source; since the figures on pages 26–28 were calculated on the basis of a different system, comparisons are not possible

3 including also Hydropower >10 MW

Source: EurObserv'ER [46]

Part III: Global use of renewable energy sources

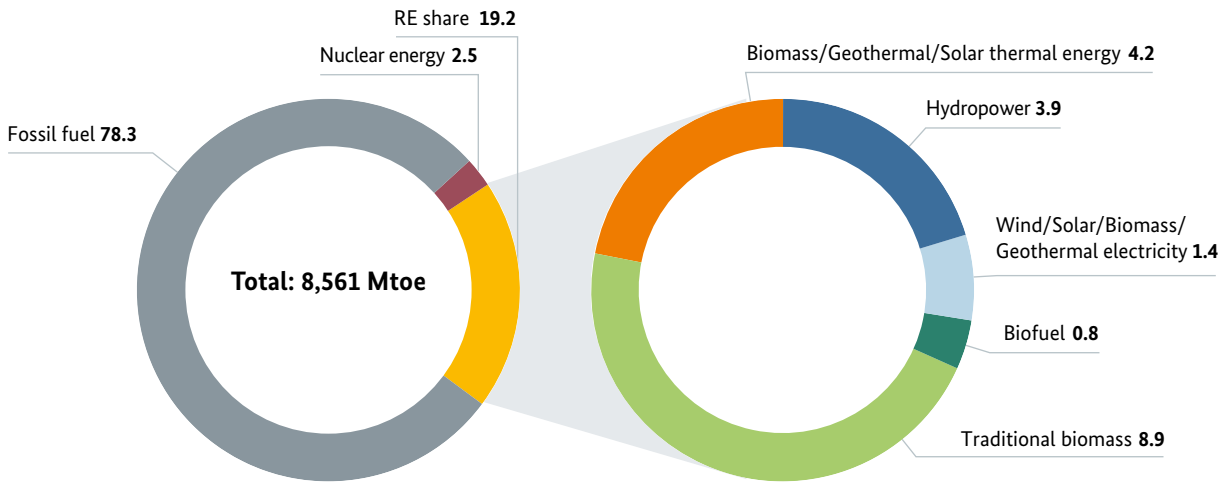
Renewable energy has been playing an ever greater role in worldwide electricity generation for some years now. However, the global population is growing at rapid speed, and if the increase in demand is to be met in a sustainable manner, the pace at which renewable energy is being developed must be stepped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

Wind and solar energy are considered to have the greatest potential for meeting the world's growing demand for energy. They are also the technologies that are posting the largest growth rates. According to REN 21 [41], the market for wind power has grown over the past 5 years by an average of 17% per year, with the market for photovoltaics having grown by an impressive 42%. Geothermal energy, marine energy, and modern biomass technologies are also of importance. Modern renewable energy technologies are a key factor in combating poverty. This is especially true in developing countries. In 2013, almost 1.2 billion people had no access to electricity. In future, renewable energy technologies, being decentralised by nature, could provide a basic electricity supply; the options range from off-grid photovoltaic systems for individual households, to renewable energy installations that supply entire villages with electric power. Indeed more than 44 million stand-alone photovoltaics solutions of this kind have already been sold around the world, and the market for this technology is estimated to be worth around $300 million per year. Renewables can give more people access to modern forms of energy, particularly electricity, improve people's living conditions and open up opportunities for economic development.

According to estimates by REN 21 [41], renewables accounted for 19.2% of final energy consumption in 2014. Some 78.3% derived from fossil fuels and 2.5% from nuclear energy. However, traditional biomass use accounted for 8.9%, or just under half the share of renewables.

Traditional biomass use refers primarily to the generation of heat from firewood and charcoal, without the use of technical aids. The potential offered by these forms of renewable energy is largely exhausted, and they are generally not used in a sustainable fashion. According to estimates by the IEA, as many as around 2.7 billion people rely on traditional biomass use for cooking. Simple cooking and heating methods based on the use of biomass and open fires carry health risks and often lead to an overexploitation of natural resources and irreversible deforestation [47]. According to estimates by the World Health Organisation (WHO), the use of traditional biomass for

Figure 57: Structure of global final energy consumption in 2014
in percent



Source: REN21: Renewables 2016 Global Status Report, REN21 Secretariat, Paris, 2016 [41]

heating and cooking causes the premature death of 4.3 million people, most of whom are women and children (http://www.who.int/mediacentre/factsheets/fs292/en/#). The disadvantages of traditional biomass use could be reduced simply by promoting more widespread use of simple ovens. Such ovens could reduce biomass consumption by up to 60% and lower smoke emissions through more efficient combustion [48]. In 2015, the corresponding market saw considerable growth, with REN 21 [41] reporting that around 28 million households were already using stoves of this kind by the end of the year.

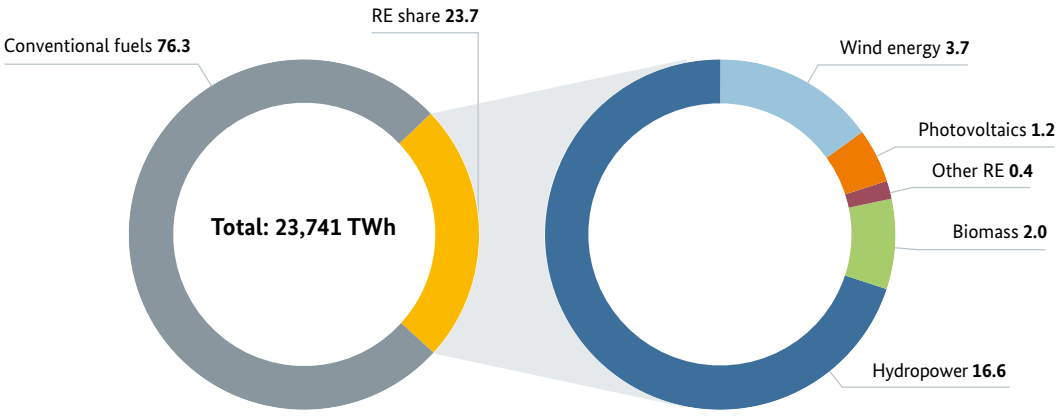
After biomass, hydropower used to provide the greatest share of electricity generated from renewables. Over the past few years, however, wind power, photovoltaics, and modern forms of utilising heat from biomass, geothermal energy, and solar energy have been able to catch up considerably.

Electricity generation from renewable energy sources

According to REN 21 [41], in 2015, 76.3% of global electricity consumption was covered by coal, oil, gas and nuclear energy, with a solid 23.7% already being generated from renewable energy sources. At 16.6%, hydropower still accounted for the largest share of generation from renewable energy. However, this share has been steadily declining in recent years, because the amount of electricity generated especially from wind and solar energy, but also from geothermal energy and biomass, has been growing at a much greater pace. Consequently, 3.7% of global electricity generation was already accounted for by wind energy in 2015, with 2.0% covered by biomass and 1.2% by solar power. Wind energy installations located in China alone generated 186.3 billion kilowatt-hours of electricity in 2015, or 3.3% of China's total electricity consumption.

Figure 58: Structure of global electricity production, 2015

in percent



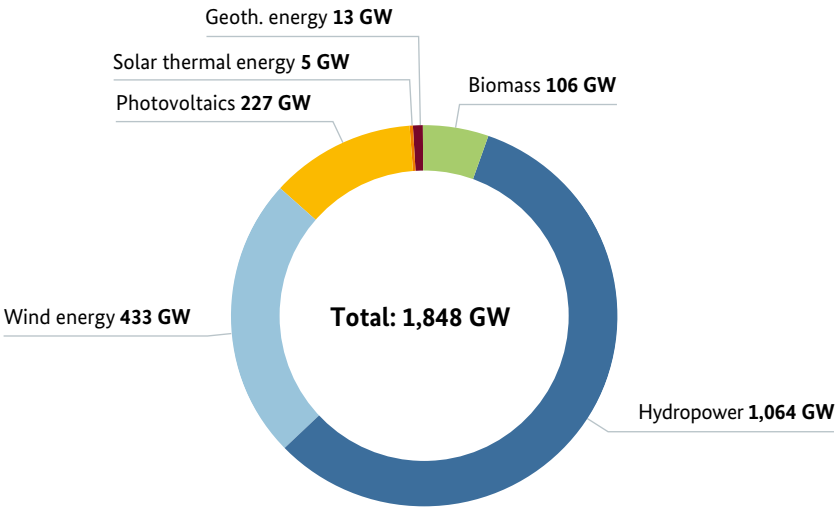
Source: REN21: Renewables 2016 Global Status Report, REN21 Secretariat, Paris, 2016 [41]

During the course of 2015, a total of 147 gigawatts of renewables-based power generation capacity was installed around the world. This represented 60% of the all global power generation capacity added throughout the year – a larger share than all of the conventional forms of energy combined. This meant that at the end of 2015, 1,848 gigawatts, or approximately 29% of global installed electricity generation capacity was based on renewables. At 1,064 gigawatts, hydroelectricity still accounted for the largest share of this, even if this share has now been declining for years. It was followed by wind energy (433 gigawatts), photovoltaics (227 gigawatts) and biomass (106 gigawatts).

Excluding hydropower, installed renewables-based power generation capacity already totalled 785 gigawatts at the end of 2015. At 199 gigawatts, China headed the rankings here, followed by the United States (122 gigawatts), Germany (92 gigawatts) and Japan (43 gigawatts).

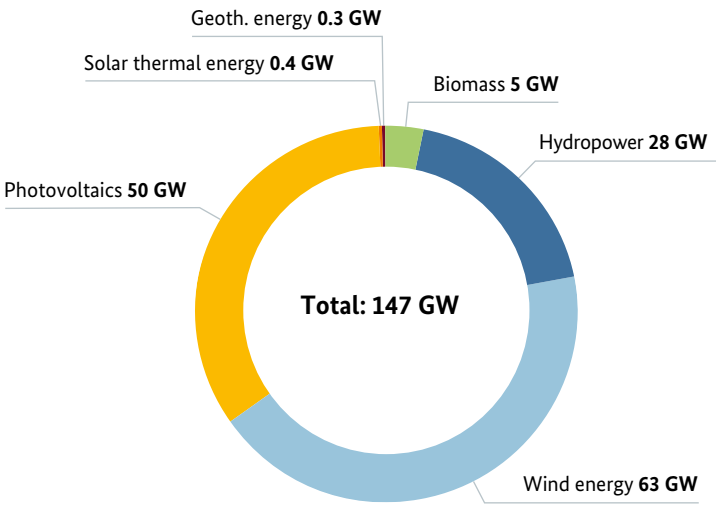
Breaking down the global market for the expansion of renewables-based electricity generation by technology, hydropower registered a global increase in capacity of 28 gigawatts in 2015. The largest share of this (16 gigawatts) was accounted for by China, which also ranked first in terms of total installed capacity, with a share of nearly

Figure 59: Global renewables-based installed capacity in the electricity sector, 2015



Source: REN21: Renewables 2016 Global Status Report, REN21 Secretariat, Paris, 2016 [41]

Figure 60: Global renewables-based installed capacity in the electricity sector, 2015



Source: REN21: Renewables 2016 Global Status Report, REN21 Secretariat, Paris, 2016 [41]

28% at the end of 2015. It was followed by Brazil (8.6%), the United States (7.5%) and Canada (7.4%).

In 2015, wind power capacity was expanded by 63 gigawatts in 2015, making this another record year. At 30.8 gigawatts, by far the largest amount of newbuild took place in China, followed by the United States (8.6 gigawatts) and Germany (6 gigawatts). Overall, too, the largest volume of installed wind energy capacity was located in China (145 gigawatts), followed by the United States and Germany. However, in per-capita terms, Denmark still has the highest installed capacity, followed by Sweden and Germany. Some 3.4 gigawatts of offshore capacity was newly installed around the world, roughly twice the preceding year's amount. This means that, at the end of 2015, more than 12 gigawatts of offshore wind capacity was installed, with 11 gigawatts of this being sited off the coastline of Europe.

Photovoltaics also set a new record in terms of newbuild in 2015. This totalled 50 gigawatts, marking a 25% increase over the preceding year. This means that 227 gigawatts of photovoltaics capacity was installed around the world by the end of 2015. In terms of new capacity, China headed the field (12.5 gigawatts), ahead of Japan (11 gigawatts) and the United States (7.3 gigawatts). With regard to total installed capacity at the end of 2015, China (44 gigawatts) pushed Germany down into second place, with Japan coming in third. The highest proportion of photovoltaic-based electricity in total electricity consumption was registered in 2015 by Italy (7.8%), ahead of Greece (6.5%) and Germany (6.4%).

Global power generation capacities based on biomass expanded by around 5% in 2015, rising to 106.4 gigawatts. Power generation from biomass rose by around 8% to 464 billion kilowatt-hours. Some 71% of this was based on solid biomass, and 20% on biogas.

A total of 315 megawatts of new geothermal-based power generation capacity was installed in 2015. Total capacity for this technology amounted to 13.2 gigawatts at the end of the year. The largest shares were to be found in the United States, followed by the Philippines and Indonesia. In terms of newbuild, Turkey took first place by a wide margin, followed by the United States and Mexico. In total, 75 billion kilowatt-hours were generated from geothermal energy sources worldwide in 2015.

Renewable energy sources in the other sectors

In 2015, around 25% of global final energy consumption for heating was covered by renewable energy. However, more than two-thirds of this was based on traditional biomass use, and must therefore be termed non-sustainable. Some 8% of the heat consumed around the world was provided by modern technologies. Roughly 90% of this was based on biomass, 8% on the use of solar thermal technology, and 2% on geothermal energy [39].

Worldwide, 26 gigawatts of solar thermal capacity was newly installed in 2015. However, as a result of the low price of oil, the growth rate halved when compared to the average rate recorded across the preceding five years, falling to 6%. The solar thermal capacity of 435 gigawatts installed worldwide at the end of 2015 suffices to provide an annual 357 billion kilowatt-hours of solar-based heat. At 71%, the bulk of the collector surface area was installed in China; the United States followed a long way behind at 4%, after which came Germany and Turkey with 3% each.

Following newbuild totalling 1.2 gigawatts in 2015, global installed thermal capacity for the direct use of geothermal heat amounted to 21.7 gigawatts at the end of that year. This capacity provided 75 billion kilowatt-hours of geothermal heat. China, Turkey, Japan and Iceland are the leading users of this technology.

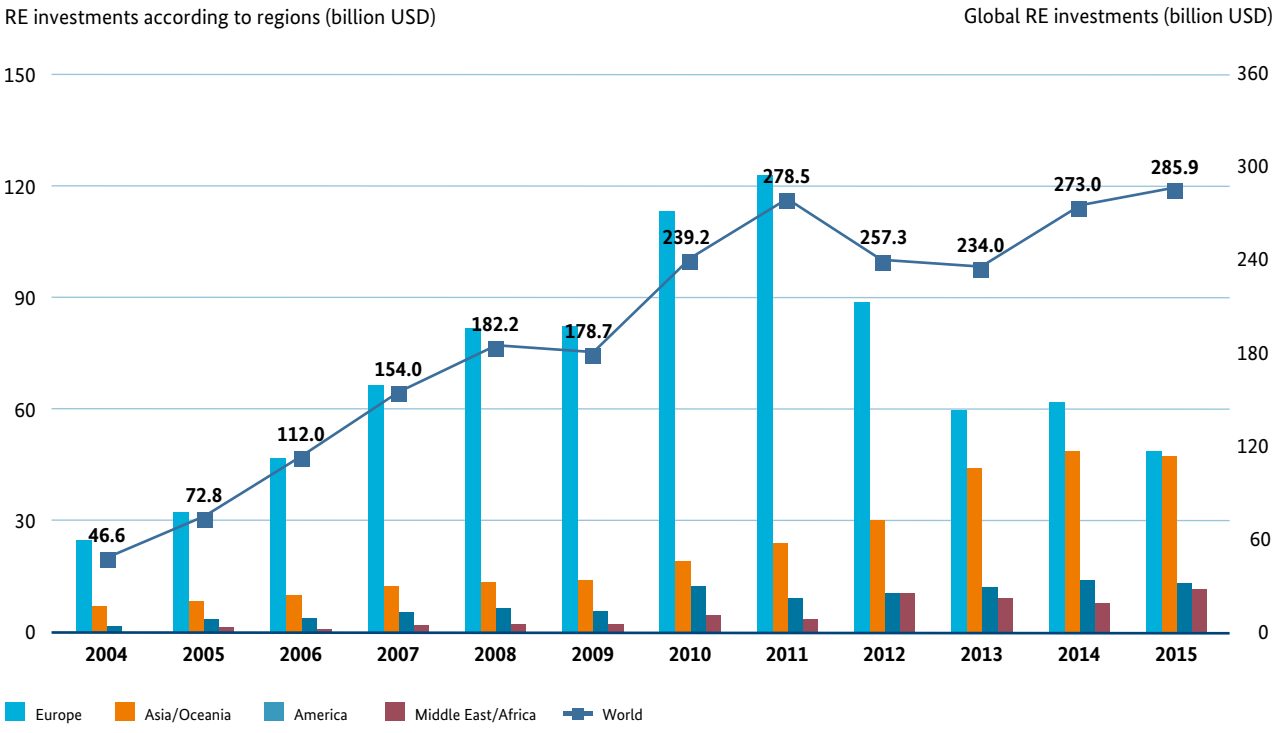
Final energy consumption in the transport sector has risen by around 2% a year since 2000 and now accounts for 28% of total final energy consumption. Two-thirds of this was consumed on the roads, with renewable energy covering 4% of fuel consumption in road transport in 2015. At 74%, the bulk of this was provided by bioethanol; biodiesel accounted for 22%. Global production of bioethanol rose by 3.8 billion litres to 98.3 billion litres; in contrast, the generation of biodiesel fell slightly, dropping by 0.3 billion litres to 30.1 billion litres. The largest producers of biofuels were the United States (46%) and Brazil (24%) [41].

Investment in renewable energy sources and employment

In 2015, global investment in renewable energy (excluding large hydroelectric installations) reached a new all-time high, at approximately $285.9 billion. This was 5% higher than the preceding year. The positive trend in overall investment in renewable energy seen in 2014 has thus continued. The temporary fall-off in investment in 2012 and 2013 has ended [49].

In 2015, developing and emerging economies invested more in renewable energy than the industrialised countries ($155.9 billion compared with $130.1 billion) for the first time. More than one-third of global investment took place in China ($102.9 billion), 17% more than in 2014. The USA ranked second with $44.1 billion, followed by Japan with a total of $36.2 billion [49].

Figure 61: Investment in the renewable energy sector by regions



Source: Frankfurt School-UNEP Centre/BNEF [49]

Figure 62:
Investment by renewable energy sector

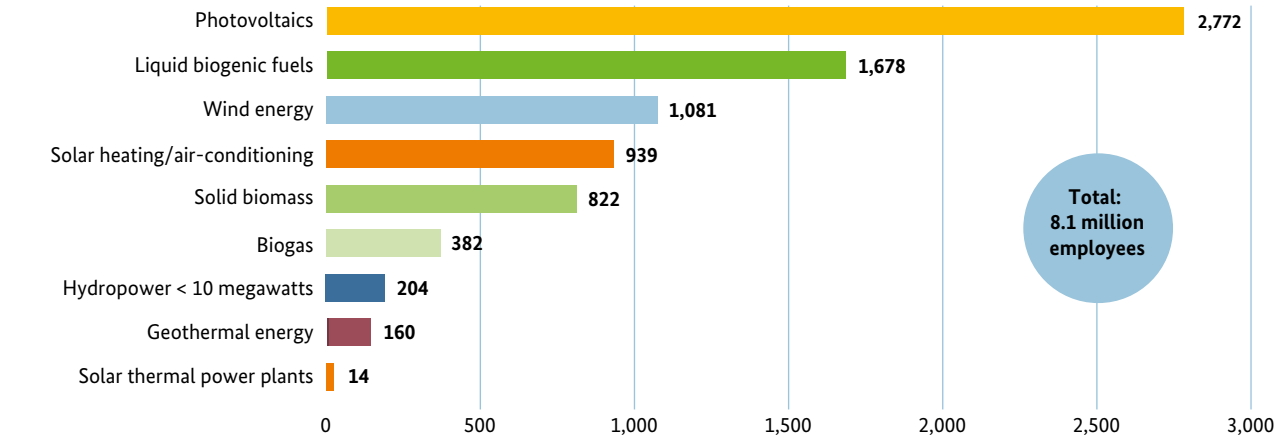
Sector	2014 RE-Investment	2015 RE-Investment	Growth rate 2014/2015
		(billion USD)	(%)
Wind energy	105.7	109.6	4
Solar energy	143.8	161.0	12
Biofuels	4.7	3.1	-34
Biomass[1]	10.4	6.0	-42
Hydropower[2]	5.5	3.9	-29
Geothermal power	2.6	2.0	-23
Ocean energy	0.4	0.2	-50
Total	**273.0**	**285.9**	**5**

1 including waste
2 hydropower < 10 megawatts only

Source: Frankfurt School-UNEP Centre/BNEF [49]

In global terms, the number of employees in the renewables sector continued to grow strongly in 2015. According to an estimate by IRENA [50], around 8.1 million people worked in the sector in 2015, an increase of roughly 5% over the preceding year. The largest number of jobs in the renewables sector are to be found in China (approx. 3.5 million), followed by Brazil (918,000) and the United States (approx. 769,000).

Figure 63: Employment in the renewable energy sectors, 2015
in 1,000 employees



Source: IRENA [50]

Annex

International networks for renewable energy sources

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

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

International Renewable Energy Agency (IRENA)

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation dedicated to worldwide promotion of the growth and sustainable use of renewable energy. IRENA now has 149 members, with another 27 states currently in the accession process. Adnan Z. Amin from Kenya has been Director-General of IRENA since 2011. IRENA is headquartered in Abu Dhabi, United Arab Emirates. The IRENA Innovation and Technology Centre, one of its three core divisions, is located in Bonn. IRENA currently works with over 100 international experts.

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

Cooperation with other players

Being an international organisation with a global reach, IENA aims to support all stakeholders' efforts to achieve the global, widespread adoption of renewable energy technologies. Its partners include governments, national and international institutions, non-governmental organisations and the private sector. They are indispensable to its work.

Work programme and budget

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

1. Planning for the Renewable energy Transition
2. Enabling Investment and Growth
3. Renewable Energy Access for Sustainable Livelihoods
4. Regional Action Agenda
5. Islands: Lighthouses for Renewable Energy Development
6. Gateway to Knowledge on Renewable Energy

Principal organs and structure

IRENA has three principal organs. The Assembly, which meets every year and consists of all the countries that have ratified the Statute, is IRENA's highest decision-making body.

The Council, which is composed of 21 members, reviews reports and documents, particularly the IRENA work programme and budget, and submits them to the Assembly for a decision.

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

The Knowledge, Policy and Finance Centre (KPFC) is the global repository of knowledge on renewable energy. It is also a centre of excellence for policies and financial issues relating to renewable energy. The KPFC is a one-stop shop for statistics on costs, employment, resource potential, investment frameworks and the socio-economic and environmental impact of renewable energy technologies. One of the KPFC's key projects is the Global Renewable Energy Atlas, an internet-based platform for investors and policymakers that measures and maps the worldwide potential for renewable energy growth.

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

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

The IITC provides governments with custom solutions for an accelerated transition to renewable energy technologies that take account of their national needs, economic conditions and available resources. This work includes analysing current technology costs and standards. To support governments in developing effective technology and innovation policies, the IITC develops scenarios, strategies and technology development guidelines. It also works up roadmaps for harnessing renewable energy in cities and industrial processes and attaining the goal of the UN's Sustainable Energy for All initiative: namely, to double the global share of renewable energy to 30 percent by 2030. IRENA serves as the renewable energy hub in this initiative and outlines how to achieve this goal in the REmap 2030 study that was issued by the IITC.

The IRENA Statute contains more information on its organs.

History of the creation of IRENA

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

More information is available at: www.irena.org

International Renewable Energy Conferences (IRECs)

The great success of renewables2004 continued with International Renewable Energy Conferences (IRECs) in other countries. The individual conferences have generated strong political impetus for the accelerated expansion of renewable energies worldwide. In addition, the IRECs have often had a strong impact in the respective host country.

The conference in Beijing (BIREC 2005) not only evaluated the follow-up process to the Bonn conference, but also discussed the use of renewable energy sources in developing countries. The subsequent Washington International Renewable Energy Conference (WIREC 2008) focused on, among other things, the progress made in expanding renewable energy capacity in industrialised countries. Like renewables2004, WIREC gave rise to a large number of voluntary commitments, thereby perpetuating the spirit of the Bonn conference. The next conference in the series was the Delhi International Renewable Energy Conference (DIREC 2010) in October 2010. DIREC led to the signing of a joint political declaration reaffirming the intention of all the conference participants to promote the accelerated worldwide expansion of renewable energy, and supported the initiative for the UN's International Year of Sustainable Energy For All. The latest International Renewable Energy Conference took place in Abu Dhabi in January 2013 (ADIREC) as part of the Sustainable Energy Week held there. The Sustainable Energy Week hosted not only the ADIREC, but also the third session of the IRENA Assembly and the annual World Future Energy Summit.

The next – and sixth – International Renewable Energy Conference in early October 2015 will be held for the first time on the African continent – in Cape Town, South Africa (SAIREC). There, participating countries will confer on the development of renewable energy in Africa, particularly in Sub-Saharan Africa, the contribution renewable energy sources make to economic growth and prosperity, and the contribution they make to climate protection.

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

The Renewable Energy Policy Network for the 21st Century (REN21) was co-founded and extensively funded by Germany after the renewables2004 conference. It has developed into the most important global multi-stakeholder network dedicated to promoting political measures to accelerate the expansion of renewable energy. It plays a key role in the provision of conceptual and organisational support to the countries hosting International Renewable Energy Conferences (IRECs). Governments, international organisations, civil society, the research community and the private sector involved in the energy, environmental and development fields are represented in REN21.

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

In addition to the Global Status Report, REN21 also publishes Regional Status Reports that examine the development of renewables in the individual global regions in greater depth. For example, it published a status report on the ECOWAS (Economic Community of West African States) region in 2014. Plans foresee the publication of a status report on the SADC (Southern African Development Community) region in 2015.

In 2013, REN21 launched a companion to the Global Status Report – the Global Futures Report. This publication, which has only been published once, presents a mosaic of possible directions and expectations for the future growth of renewable energy. Based on scenarios and interviews with experts, it describes and compares the expectations of various players for the future of renewables, key issues and important policy options. The report was published for the Abu Dhabi International Renewable Energy Conference in 2013 (ADIREC 2013) and has attracted international attention. Building on this, REN 21 plans to publish a further issue of the Global Futures Report in which it examines the macroeconomic effects of the envisioned energy supply that is completely based on renewable energy sources.

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

The Secretariat of REN21 is located in Paris.

For more information, see: www.ren21.net

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 industrialised nations, which all consume high levels of energy, and currently consists of 29 OECD member countries. Given the strong growth in energy demand outside the OECD, the IEA is also expanding its cooperation with countries that are not members of the OECD and therefore cannot become members of the IEA. Its efforts here focus particularly on establishing Association with major emerging countries. This began in November 2015, with China, Indonesia and Thailand being granted Association status.

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

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

The IEA issues numerous publications on renewable energy, most recently the Medium-Term Renewable Energy Market Report in 2015, with forecast extending up to 2020, and a study on the relationship between electricity market regulation and decarbonisation of the energy supply, released in early 2016. The IEA also publishes technology roadmaps on renewable energy. The IEA and the International Renewable Energy Agency (IRENA) cooperate closely upon the basis of a partnership agreement signed by the two organisations in January 2012.

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

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

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

Clean Energy Ministerial (CEM)

The Clean Energy Ministerial (CEM) is a multilateral forum that was set up to promote sustainable energy generation right around the world. It was established at the initiative of the USA. Prior to the COP-15 climate conference in Copenhagen in 2009, the major economies – which are all substantial emitters of greenhouse gases – drew up ten technology action plans for a number of low-carbon technologies, which were intended as a constructive contribution to the negotiations. The technology action plans have been translated into 12 initiatives within the CEM, all of which focus on specific issues and technologies. The Federal Ministry for Economic Affairs and Energy heads the Multilateral Solar and Wind Working Group along with Denmark and Spain, and is also involved in initiatives on energy-efficient electrical appliances, energy management systems in industry, electric mobility and smart grids.

Other implementing initiatives within the CEM are dedicated to bioenergy, hydropower, sustainable cities, improved access to energy in developing countries and to strengthening the role of women in the energy sector. The various ministers involved meet on an annual basis to decide on what the key areas of focus should be when it comes to the work carried out as part of the initiatives. The sixth such meeting was held in Mérida, Mexico, on 27 and 28 May 2015. The latest, seventh Clean Energy Ministerial Meeting took place in San Francisco from 1-2 June 2016, hosted by the United States. The eighth Clean Energy Ministerial will be held in China in 2017.

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

SE4ALL – The Sustainable Energy for All initiative

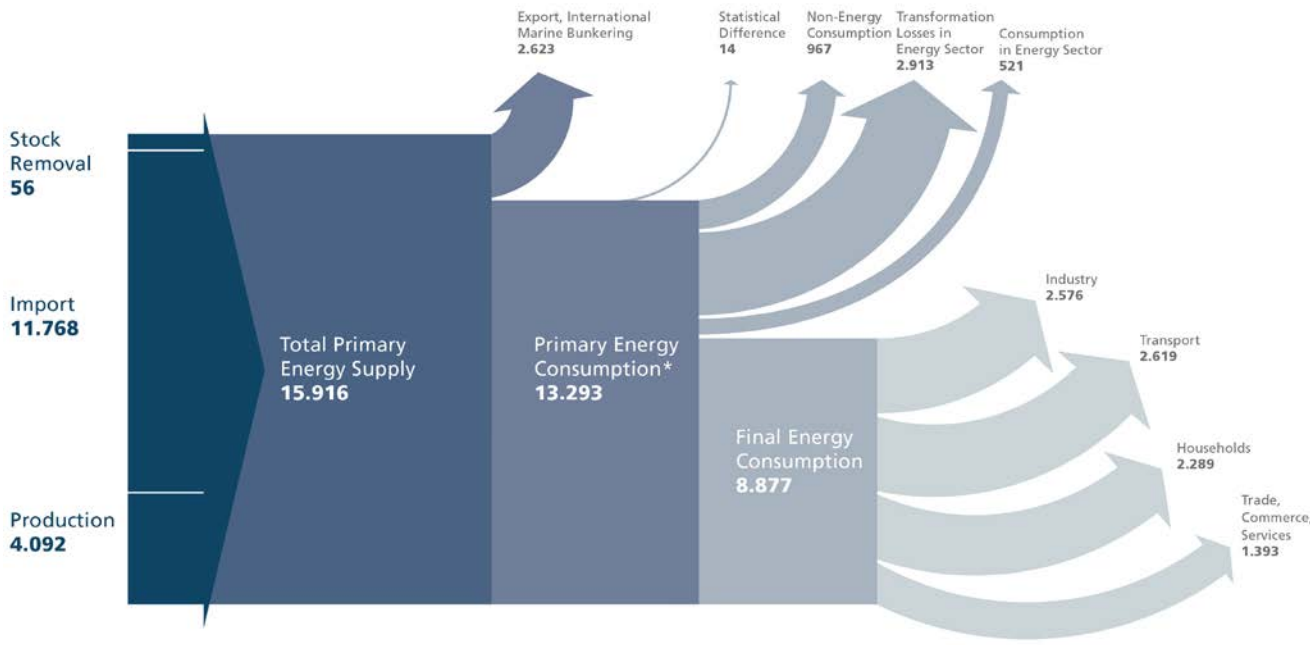
Launched by UN Secretary General Ban Ki-moon in 2011, the Sustainable Energy for All initiative aims to ensure that all people around the world can access sustainable energy by the year 2030. Besides ensuring universal access to modern energy services, the initiative seeks to raise the annual improvement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

Today, 1.3 billion people worldwide have no access to electricity. This figure is forecast to remain essentially unchanged until 2030 if no additional efforts are undertaken. Two times this number of people are reliant on the use of traditional biomass.

A high-ranking group of 46 advisors from industry, government and civil society has drawn up an agenda for action in order to implement the three subordinate targets. As the relevant steps are then taken, it will be necessary to combine the efforts made by both the public and private sectors and civil society in order to increase the overall impact. At the United Nations Conference on Sustainable Development in Rio (Rio+20), 50 countries from Africa, Asia, Latin America and the group of the Small Island Developing States, plus a large number of companies, local governments and various groups from civil society presented their own commitments towards implementing the Action Agenda. The initiative thus harnessed the political momentum from the Rio+20 negotiations to mobilise support.

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

Figure 64: Schematic diagram of energy flows in Germany in 2015
in Petajoule (PJ)



Source: Arbeitsgemeinschaft Energiebilanzen 07/2016

Methodological notes

Some of the figures published here are provisional results. When the final data are published, they may differ from earlier publications. Discrepancies between the figures in the tables and the respective column or row totals are due to rounding differences.

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, so some of the energy's technical work capacity is lost.

The amounts of energy (gross electricity consumption, final energy consumption for heating and transport from renewable energy) listed in this brochure cannot be added appropriately to produce an aggregate value because each summation follows specific conventions. Consequently it is not possible to calculate shares of total energy consumption on this basis.

1. Methodological changes

Methodological changes relating to the installed capacity of wind energy converters

In the light in particular of the register of installations which has been maintained by the Federal Network Agency since 1 August 2014 and of the core market data register, which will be available from 1 January 2017, AGEE-Stat held a meeting on 31 May 2016 to look into the need to alter the data base used by AGEE-Stat to measure the installed capacity of wind energy converters. In the course of this meeting, the available data sources – the statistics of Deutsches Windenergieinstitut (DEWI, UL International GmbH) and Deutsche WindGuard GmbH, the Federal Statistical Office's survey of grid operators regarding the electricity feed-in and the data from the Federal Network Agency on the annual accounting by the transmission system operators under the Renewable Energy Sources Act – were compared, and the disparities discussed. The data from the various sources differ as a result of different methods being deployed, e.g. in terms of the periods covered. The statistics from DEWI and WindGuard contain data for the construction of the installation; in contrast, the data from the annual accounting under the Renewable Energy Sources Act, from the register of installations and the feed-in survey refer to the date of the commissioning of the installation.

In order to ensure that the statistics are in line with the Federal Network Agency's register of installations and are consistent with AGEE-Stat's time series on gross electricity generation from wind power, which is based on the annual accounting of the transmission system operators under the Renewable Energy Sources Act, AGEE-Stat has decided to make the following changes to the data base: For the accounting years from 1990 to 2002, the AGEE-Stat time series for the installed capacity of wind energy converters shall continue to be based on the statistics published by DEWI. For the accounting years between 2003 and 2014, the data from the annual accounts under the Renewable Energy Sources Act shall be used; and for the years from 2015, these data shall be combined with the data about new installations, changes in capacity and dismantling from the Federal Network Agency's register of installations/core market data register.

Methodological change in the field of power generation and installed capacity based on solid biomass

The generation of electricity from solid biomass funded under the Renewable Energy Sources Act shall continue to be measured based on the data from the annual accounts under the Renewable Energy Sources Act from the transmission system operators, as processed by the Centre for Solar Energy and Hydrogen Research Baden-Wuerttemberg (ZSW). The time series for the gross electricity generation from solid biomass has however been retrospectively revised from 2010 following new findings by AGEE-Stat. The basis is a procedure developed together with the BDEW to determine the quantities of electricity not entitled to remuneration under the Renewable Energy Sources Act, using data from the Federal Statistical Office:

Starting from an analysis of the relationship between net and gross volumes of electricity fed into the grid and entitled to remuneration under the Renewable Energy Sources Act (approx. 75%), the first step is to ascertain the amount consumed within the generating installations receiving such remuneration and feeding electricity into the grid, on the basis of the official surveys by the Federal Statistical Office. This takes account of the fact that the official figures also include small amounts of electricity generation from burning of solid biomass in coal-fired power plants; in line with the principle that electricity entitled to remuneration under the Renewable Energy Sources Act must be generated by installations purely based on renewables, these amounts are not entitled to funding under the Act. To cover this aspect, data from a survey by the BDEW of its member companies are used. Finally, the amount of electricity generated by manufacturing companies from solid biomass and used in their own operations is added, by adjusting the data from the Federal Statistical Office to include corresponding amounts of electricity awarded funding under the Renewable Energy Sources Act.

With regard to the installed capacity to generate electricity from solid biomass, AGEE-Stat has decided to list only those power plants which use solid biomass as their main source of energy. The previous approach, i.e. including those power plants which use biomass in addition to another energy source on a pro-rata basis, is being abandoned. This avoids the danger of double counting; in future, the output of power stations mainly based on a conventional or renewable source of energy can be added up.

2. Share of renewable energy in gross final energy consumption

Calculation of share based on EU Directive 2009/28/EC:

EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources contains detailed requirements with regard to calculating the achievement of targets. In addition to the overall share of renewable energy in gross final energy consumption, it also defines specific shares for electricity, heating and transport.

Calculations of the contributions of wind energy and hydropower take account of the effects of climate fluctuations on electricity yield. As a result of this "normalisation" to an average year, the figure for wind and hydropower no longer corresponds to the actual yield for the year in question, but does provide a better picture of the segment's growth.

In order to include bioliquids and biofuels in the calculation of progress made in achieving the overall target or sub-target in transport, they must fulfil specific sustainability criteria.

The share for the transport sector also includes electricity generated from renewable energy sources and consumed in all types of electric vehicles. It is considered with a factor of 2.5. In addition, biofuels from waste, lignocellulose, biomass-to-liquids (BtL) and biogas from waste are included with a factor of 2.

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

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

Thus, data determined in accordance with the requirements of the EU Directive can be compared with statistics from other sources, such as national statistics or data under the Renewable Energy Sources Act, only to a limited extent.

Calculation of shares without applying the calculation method of EU directive:

The German government's Energy Concept also calls for renewable energy sources to account for 18 percent of gross final energy consumption by the year 2020. To track current progress exactly, the calculation deviates from the calculation method applied in the EU Directive; it is based on the real generation of electricity from wind and hydropower and the actual consumption of biofuels in transport.

3. Calculation of the share of renewable energy in final energy consumption for heating/cooling

The share of renewable energy in final energy consumption for heating/cooling is calculated on the basis of the quotient of the final energy consumption for heating/cooling from renewable energy sources and total final energy consumption for heating/cooling. From the year 2014, heating/cooling generated with electricity is not taken into account. For the purpose of comparability, the time series has been accordingly adjusted for previous years as well. This method is based on international reporting requirements which consider the electricity and heating segments separately when calculating the shares held by renewable energy sources. This avoids double-counting the electricity used for heating/cooling.

4. Economic stimulus from the use of renewable energy The rapid expansion of renewables seen in Germany

In recent years has resulted in a massive increase in the importance of the renewable energy sector for the economy as a whole. This is particularly due to investment in plant construction. As the number of plants grows, the operation of these plants is becoming an increasingly important economic factor as well. Investment in renewable energy plants is calculated on the basis of newly installed capacity or the number of additional plants. This number is then combined with the specific investment costs (EUR/kW) or average cost per plant (EUR/plant) to determine the total investment per segment in the year under review.

The economic stimuli arising from plant operation include not only the costs for operation and maintenance, especially in the form of personnel costs and ancillary energy costs, but also the provision of renewable fuels. What constitutes costs for plant operators represents, from the vantage point of supplier companies, demand for goods and services and in turn stimulates the economy.

The costs for operating and maintaining plants are determined on the basis of technology-specific valuations. Cost calculations from various scientific studies are used for this purpose. These studies include in particular the research projects relating to the Renewable Energy Sources Act (including, for example, the research reports for the Renewable Energy Sources Act Progress Report [51] and the final report on the monitoring of power generation from biomass [52]), the evaluations of the Market Incentive Programme [53], and the evaluations of KfW assistance for renewable energy sources [54].

The calculation of the costs arising from supplying fuel for heat and power generation takes account of the costs of solid and liquid heating fuels and of the substrates used to produce biogas. Relevant solid biomass heating fuels include waste wood, residual wood from forestry and industry, wood pellets, wood chips, wood briquettes, and commercially traded firewood. The main components of substrates for biogas production are maize silage, grass silage, whole-crop grain silage and inferior grain. All in all, the economic stimulus arising from supplying biogenic fuels for heat and power is assessed at EUR 4.5 billion.

Conversion factors

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

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

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

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

The figures refer to the net calorific value.

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

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

List of abbreviations

Technical terms

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

Glossary

Acidification potential

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

Air pollutant

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

Assessable final consumption

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

Avoidance factor

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

Biodiesel

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

Bioethanol

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

Biofuel

Liquid or gaseous motor fuels made from biomass.

Biogas

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

Biogenic (municipal) waste

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

Biomass

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

Biomethane

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

Carbon dioxide (CO_2)

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

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

CO_2 equivalent

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

Coal equivalent

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

Combined solar thermal plants

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

District heating

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

EEG surcharge

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

Efficiency

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

Electric mobility

Use of electric vehicles on road and rail.

Electric power

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

Emission balance

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

Emission factor

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

Emissions

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

Energy

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

Energy crops

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

Energy sources

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

Feed-in tariff

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

Final energy

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

Final energy consumption (FEC)

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

Fossil fuels

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

Geothermal energy

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

Global warming potential (GWP)

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

of different gases and express their contribution to global warming. CO_2, being a reference gas, has a global warming potential of 1. According to the Fourth IPPC Assessment Report: Climate Change 2007, the relative global warming potential of methane (CH_4) over a 100-year period is 25. The GWP of nitrous oxide (N_2O) is 298. Global warming potential is expressed in CO_2 equivalents.

Greenhouse effect

Various greenhouse gases contribute to global warming by absorbing and re-emitting solar radiation. This is known as the greenhouse effect. A distinction is made between a natural and an anthropogenic (man-made) greenhouse effect.

Greenhouse gases

Atmospheric trace gases which contribute to the greenhouse effect and which can be of natural or anthropogenic origin. Examples are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs).

Gross electricity consumption

Gross electricity consumption corresponds to the sum of total electricity generated in Germany (wind, water, sun, coal, oil, gas, etc.), plus electricity imports and minus electricity exports. Net electricity consumption is gross electricity consumption minus grid and transmission losses.

Gross electricity generation

Gross electricity generation comprises the total amount of electricity generated in a country. Net electricity generation is determined by subtracting the captive consumption of the generating plants.

Gross final energy consumption (GFEC)

Gross final energy consumption refers to the final energy consumption of the final consumer, plus the losses incurred in the generating units and during transport. The gross final energy consumption for renewable energy is the final energy consumption for households, transport, industry, skilled trades, commerce and services, plus on-site consumption in the conversion sector as well as line and flare losses.

Section 1 of the Annex to this report shows the shares of renewable energy in gross final energy consumption, calculated pursuant to Directive 2009/28/EC (utilising special calculation rules such as “normalised” electricity supply from wind and hydropower).

This report implicitly classifies renewable energy used in electric vehicle and railway applications as electricity. There are still no methods for allocating the shares of renewable electricity in the transport sector that do not involve double-counting. However, these contributions are described in detail in the report submitted to the European Commission regarding the fulfilment of the 2020 minimum target of 10% renewable energy in transport.

Heat pump

Technical installation which can be used to raise the temperature of available heat energy by inputting mechanical energy, in order to permit technical use. The principle of the heat pump is also used in refrigerators, but there it is used for cooling purposes.

Kreditanstalt für Wiederaufbau (KfW)

Bank of Germany’s federal and Land authorities. Assists various projects by providing low-interest loans.

Landfill gas

Energy-rich gas formed by rotting waste. May contain up to 55% methane (CH_4) and 45% carbon dioxide (CO_2).

Local heating

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

Marine energy

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

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

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

Methane (CH_4)

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

Near-surface geothermal energy and ambient heat

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

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

Net calorific value

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

Nitrous oxide (N_2O)

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

Nuclear fuel

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

Offshore wind turbine

A wind turbine for generating electricity in marine waters.

Photovoltaics (PV)

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

Physical energy content method

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

Precursors of ground-level ozone

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

Primary energy

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

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

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

Primary energy consumption (PEC)

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

Process heat

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

Regrowable raw materials

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

Renewable Energy Heat Act (EEWärmeG)

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

Renewable energy sources (RES)

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

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

Renewable Energy Sources Act (EEG)

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

Repowering

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

Secondary energy

Energy obtained from primary energy as a result of a conversion process. The quantity of useful energy is reduced by the conversion stages. Secondary energy sources are "line bound", such as electricity, district heating and town gas. Also, the refinement of fuels such as coal and coke in briquette plants, oil in refineries or natural gas in CO_2 and H_2S removal units makes for better availability and thus counts as conversion to secondary energy.

Secondary energy source

Unlike primary energy sources, secondary energy sources are obtained from the conversion of primary energy sources. This includes all hard coal and lignite products, petroleum products, blast furnace gas, converter gas, coke oven gas, electricity and district heating. Secondary energy sources can also be obtained by converting other secondary energy sources.

Sewage gas

Energy-rich gas formed in the digestion towers of sewage works. It is one of the biogases. Its main component is methane.

SO_2 equivalent

Unit used to state the acidification potential of an air pollutant.

Solar cell

Converts light directly into electricity. The photons in solar radiation temporarily release electrons in semiconductors (mainly silicon, obtained from quartz sand) from their atomic bonds, thereby generating an electric current. This functional principle is known as the photovoltaic effect.

Solar thermal power stations

Power stations where direct solar radiation is converted into heat, transferred to a heat-transfer medium (e.g. heat-transfer oil, water, air) and transformed into electrical energy in a prime mover (e.g. steam turbine, gas turbine).

Substitution factor

Describes the extent to which individual energy sources are replaced by another energy source. In the context of emission accounting, substitution factors are used in particular to describe the replacement of primary and secondary fossil fuels with renewable energy sources.

Transmission losses

These losses occur during the transmission and conversion of electrical energy. Transmission losses increase as the square of the current transmitted. That is the reason why electricity is stepped up to higher voltages in transformers prior to transmission over long distances.

Upstream chains

Processes that occur before plant operation and involve the production, provision and processing of fuels and materials needed to build and operate energy generation plants.

Useful energy

The energy available to the final user for meeting his needs. It is obtained directly from final energy. Useful energy may come in the form of light, mechanical work, heat for space heating or cooling for space cooling.

Wind turbine

In the strict sense, plants for converting wind energy into electrical energy. There is no clear-cut definition of the borderline to "small wind turbines".

Wood pellets

Standardised cylindrical pellets of dried untreated waste wood (sawdust, wood shavings, waste wood from forestry) with a diameter of 6 mm and a length of 10 to 30 mm. They are produced under high pressure without the addition of any chemical bonding agents and have a net calorific value of approximately 5 kWh/kg.

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For more information about renewable energy sources, visit the BMWi´s websites at
www.bmwi.de, and www.erneuerbare-energien.de

www.bmwi.de