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Renewable Energy Sources in Figures

National and International Development

IMPRINT

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FOREWORD

DEAR READER,

For the tenth year, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety has brought out „Renewable Energy Sources in Figures – National and International Development“. The publication documents the impressive growth of renewable energies over the past two decades. In 1990, the renewable share of electricity consumption was just 3.1 percent, by 2011 this figure was as much as around 20 percent. Renewable energies gained considerable ground in the heat sector too, particularly biomass, which played an important role in the expansion of renewables. Starting at 2.1 percent in 1990, the biomass share rose to 11 percent in 2011. Biofuels, which were only used to any significant degree from 2000, had a 5.5 percent share of the mobility sector in 2011.

With its Energy Concept of 2010 and the decisions on the transformation of the energy system taken in June 2011, the German government launched the first comprehensive strategy for renewables‘ expansion over the coming decades. The aim is to raise their share in electricity supply to at least 35 percent by 2020, and by 2050 renewables are to be the main pillar of our energy supply, supported by major improvements in energy efficiency. The strategy will focus on ensuring supply security, sustainability and affordability. This can succeed if the Federation, the Länder and the local authorities are united in a single national consensus on energy.

The German government is now working hard to lay the foundations for successfully transforming the energy system. The main task is to better synchronise the development of renewables with the expansion of the power grids. The German government has also revised the Renewable Energy Sources Act (EEG), ensuring more market options, more competition and greater cost efficiency. This will keep our transformation of the energy system affordable.

This transformation is the most important post-war project for innovation. The future success of Germany as an industrial location will depend on the success of this project. Moreover, it is a project of and for the citizens – and that is why it will succeed.

Peter Altmaier
Federal Minister for the Environment, Nature Conservation and Nuclear Safety

Working Group on Renewable Energy – Statistics (AGEE-Stat)

Arbeitsgruppe Erneuerbare Energien - Statistik

In collaboration with the Federal Ministry of Economics and Technology and the Federal Ministry of Food, Agriculture and Consumer Protection, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety established the Working Group on Renewable Energy – Statistics (AGEE-Stat) to ensure that all statistics and data relating to renewable energies are part of a comprehensive, up-to-date and coordinated system. The results of AGEE-Stat's work form part of this publication.
AGEE-Stat is an independent expert body and has been working since February 2004. Its members include experts from

- the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU),
- the Federal Ministry of Economics and Technology (BMWi),
- the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV),
- the Federal Environment Agency (UBA),
- the Federal Statistical Office (StBA),
- the Agency for Renewable Resources (Fachagentur Nachwachsende Rohstoffe e.V. – FNR),
- the Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen e.V. – AGEB), and
- the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg – ZSW).

The "Data Service" section of the BMU renewable energies website, at www.erneuerbare-energien.de, category "Data Service", contains regularly updated data on the situation with regard to the development of renewable energies in Germany, including their environmental impacts. It includes complete time series, some of which are presented in abridged form in this brochure.

The figures published in this brochure for 2011, and to some extent for preceding years as well, are provisional and reflect the situation at the time of going to press in July 2012.

The BMU renewable energies website also includes diagrams and tables with up-to-date data, and further information about renewable energy in general.

Since the beginning of 2010, the Working Group on Renewable Energy – Statistics has been headed by Dr. Frank Musiol (Centre for Solar Energy and Hydrogen Research Baden-Württemberg).

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-wide and international reporting obligations in the field of renewable energies, and
- providing technical information on renewable energy data and development.

A variety of research work is carried out within AGEE-Stat and published to improve the data basis and the scientific calculation methods. The work of the group is also supported by workshops and expert consultations on selected technical topics.

Further information on AGEE-Stat and on renewable energies can be found on the BMU website: www.erneuerbare-energien.de

PART I: GERMANY ADVANCING INTO THE AGE OF RENEWABLE ENERGY

In its cabinet decisions of 6 June 2011 on the transformation of Germany's energy system, the German government confirmed an extensive reorientation of its energy policy on the basis of its Energy Concept of September 2010: It is to undertake a speedy phase-out of nuclear energy and at the same time move into the age of renewable energy. The German government also regards its decisions as a milestone in Germany's economic and social development. The cornerstones are:

- Use of nuclear power to cease not later than at the end of 2022,
- Dynamic expansion of renewable energies in all sectors,
- Rapid expansion and modernisation of electricity grids,
- Improvements in energy efficiency with the aid of modern technologies, especially in the fields of buildings, mobility and electricity consumption.

The German government will thus ensure that energy supply remains reliable, Germany's position as an industrial location is strengthened, and the sustainability and climate objectives are rigorously implemented.

Phasing out nuclear energy

Following the Fukushima nuclear power plant disaster, the German government has re-evaluated the residual risks of nuclear power and decided to proceed with its rapid phase-out. This phase-out has been regulated in clear and legally binding form in a step-by-step plan set out in an amendment to the Atomic Energy Act. The last nuclear power plant will be disconnected from the grid by the end of 2022.

Expansion of renewable energies

Renewable energy is to become one of the pillars of our future energy system. By 2020 at the latest, the share of electricity supply contributed by renewable energy sources is to be at least 35 percent. The main basis for this is the revised version of the Renewable Energy Sources Act (EEG), which came into force on 1.1.2012. The adjustments of the Renewable Energy Sources Act (EEG), amongst others in the scope of solar radiation energy (so called PV-amendment), become effective retroactively from 1 April 2012. These updated provisions are designed to ensure a continuing steady rise in the generation of electricity from renewable energy sources and at the same time bring improvements in market and system integration. The principles – priority purchase of renewable electricity and fixed feed-in payments as an important prerequisite for good investment conditions – have remained unchanged. Furthermore, the system of payment has been simplified and made more transparent, especially in the field of biomass. A flexibility premium and an optional market premium have been introduced as an incentive to promote demand market oriented operation of installations for the use of renewable energy sources. The EEG is a central building block in the implementation of EU Directive 2009/28/EC on the promotion of energy from renewable sources. Moreover, the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG) and the market introduction programme (MAP) will promote faster expansion of renewable energy in the heating and buildings sector. Innovative solutions will be fostered by stepping up assistance for research and development (R&D).

Expansion of power grids

In future our electricity grid system must be developed and improved to ensure that it is better equipped for transporting electricity from renewable energies. For this reason the Energy Industry Act has been amended so that, for the first time, it facilitates coordinated nationwide planning of grid expansion. Through strong public involvement, the amended rules will also ensure a large measure of transparency, making it possible to generate great acceptance for grid expansion. In addition, the "Act concerning measures to speed up the expansion of power grids" (NABEG), which entered into force in July 2011, is intended to ensure faster construction of new transmission lines. There are also plans to modernise electricity grids, partly by the creation of "smart grids", in order to achieve better coordination of power generation and power consumption. This will become increasingly important as the share of fluctuating electricity generation from wind and sun rises.

Energy and Climate Fund

To finance the accelerated energy turnaround, the German government has established a special "Energy and Climate Fund". This resource will be used to fund, among other things, CO_2 building refurbishment and research and development on energies and storage technologies. The fund will derive its revenue from the auctioning of emission allowances.

Monitoring the transformation of the energy supply system

In October 2011 the German government approved the monitoring process "Energy for the Future". Its purpose is to review the implementation of the agreed programmes of measures on the transformation of Germany's energy system and the Energy Concept, including the relevant targets, with a view to taking corrective measures if required. In this process, the German government will present a monitoring report once a year and a progress report every three years. The reports will be appraised by a committee of four experts.
The figures in this brochure on the development of renewable energies provide an important foundation for the monitoring and progress reports.

Prospects for the future

The transformation of the energy system will be a great challenge – but also a great opportunity: Germany has the prospect of becoming a pioneer among industrialised countries, with a highly efficient energy system based on renewable energies. Thus we can pave the way by setting an example for an economically successful and sustainable transformation. Advancing into a future with no additional ecological burdens and no dependence on expensive energy imports opens up outstanding new opportunities for our country in the fields of exports, jobs and growth. At the same time this process has to comply with all sustainability criteria – environmental, economic and social.

Renewable energy: Goals of the German government

	Renewables-based share of electricity consumption
At the latest	[%]
2020	at least 35
2030	at least 50
2040	at least 65
2050	at least 80

	Renewables-based share of gross final energy consumption
	[%]
2020	18
2030	30
2040	45
2050	60

By 2020 the renewables share of total heat supply is to be raised to 14 percent and the renewables share of final energy consumption in the transport sector to 10 percent.

These targets will also help to achieve a 40-percent reduction in greenhouse gas emissions in Germany by 2020 (compared to 1990) and a reduction of between 80 and 95 percent by 2050. At the same time, electricity consumption is to be reduced by 10 percent by 2020 and 25 percent by 2050, and primary energy consumption will be cut by 20 percent by 2020 and 50 percent by 2050.

Renewable energies in Germany: The most important facts in 2011 at a glance

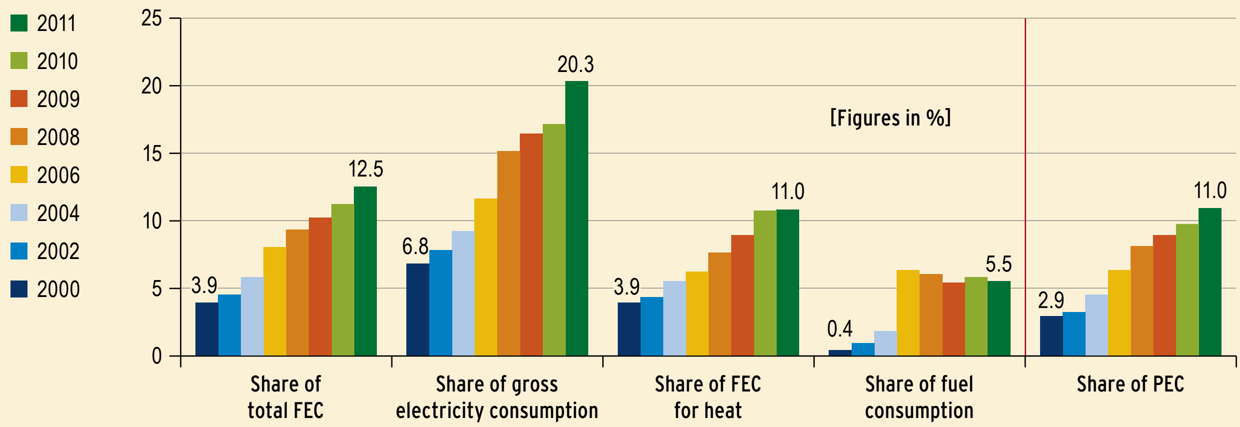
This is what renewable energy sources achieved in 2011:

- 12.5 percent of total final energy consumption – electricity, heat and motor fuels (2010: 11.2 percent)
- 20.3 percent of gross electricity consumption (2010: 17.1 percent)
- 11.0 percent of final heat energy consumption (2010: 10.7 percent)
- 5.5 percent of motor fuel consumption (2010: 5.8 percent)
- Greenhouse gas emissions avoided came to 130 million tonnes CO_2 equivalent (2010: 120 million tonnes), including 70 million tonnes saved by EEG electricity
- Investments triggered totalled 22.9 billion Euro (2010: 27.9 billion Euro)
- 381,600 people employed in the renewable energies sector (2010: 367,400)

Falling energy consumption and rising renewable energy shares

After a rise in Germany's energy consumption in 2010 due to the favourable economic situation, the warm weather in 2011 once again brought a decline in final energy consumption. The simultaneous growth in the supply of electricity from renewable energy sources resulted in the renewable share of final energy consumption increasing from 11.2 percent to 12.5 percent.

Renewable energies and their share of the energy supply in Germany



Sources: BMU on the basis of AGEE-Stat and other sources; see following tables

Wind situation back to normal – electricity production at record level

After two low-wind years, with a negative record in 2010, winds were back to normal again last year. This resulted in a record wind power yield of 48.9 terawatt hours (TWh). This also helped to produce a marked rise in net expansion of wind power output to 1,880 megawatts (MW) from the previous year's level of 1,488 MW.

Ongoing upward trend in use of biogas

In the field of biomass, the trend towards power generation from biogas continued. A total of 30.2 TWh of electricity was generated in 2011 from solid, liquid and gaseous biomass (including electricity generation from landfill gas, sewage gas and biogenic waste the figure came to 36.9 TWh). Over 132 TWh of heat was generated from total biomass, and sales of biofuels came to nearly 3.7 million tonnes.

Photovoltaic equals previous year's record

With the construction of around 7,500 MW of new capacity, the photovoltaic sector equalled its previous year's growth record (7,000 MW) in 2011. By the end of the year, installed photovoltaic capacity in Germany reached 25,000 MW. At around 19.3 TWh its share of gross electricity consumption rose to 3.2 percent, the same level as hydro power. The increase in collector area for solar thermal energy remained at around 1.2 million square meter, roughly the same level as the year before.

Contribution of renewable energies to the energy supply and greenhouse gas emission reductions in Germany in 2011

		Final energy 2011	Share of final energy consumption		Avoided GHG emissions	Final energy 2010
		[GWh]	[%]		[1,000 t]	[GWh]
Electricity generation	Hydropower [1]	18,074	Share of electricity consumption [9]	3.0	14,072	20,956
	Wind energy	48,883		8.1	35,239	37,793
	on land	48,315		8.0	34,830	37,619
	at sea (offshore)	568		0.09	409	174
	Photovoltaics	19,340		3.2	12,848	11,729
	Biogenic solid fuels	11,300		1.9	8,648	11,204
	Biogenic liquid fuels	1,400		0.2	821	1,676
	Biogas	17,500		2.9	9,613	14,454
	Sewage gas	1,100		0.2	805	1,101
	Landfill gas	620		0.1	454	650
	Biogenic fraction of waste [2]	4,950		0.8	3,760	4,781
	Geothermal energy	18.8		0.003	9	28
	Total	**123,186**		**20.3**	**86,270**	**104,372**
Heat generation	Biogenic solid fuels (households) [3]	67,500	Share of FEC for heat [10]	5.2	20,165	79,435
	Biogenic solid fuels (industry) [4]	23,600		1.8	7,506	23,339
	Biogenic solid fuels (HP/CHP) [5]	6,800		0.5	1,976	6,744
	Biogenic liquid fuels [6]	7,700		0.6	2,139	7,974
	Biogas	17,000		1.3	2,900	13,971
	Sewage gas [7]	1,090		0.08	305	1,086
	Landfill gas	280		0.02	78	294
	Biogenic fraction of waste [2]	7,600		0.6	2,252	7,566
	Solar thermal energy	5,600		0.4	1,240	5,200
	Deep geothermal energy	307		0.02	21	285
	Near-surface geothermal energy, ambient heat [8]	5,990		0.5	487	5,300
	Total	**143,467**		**11.0**	**39,070**	**151,194**
Fuel	Biodiesel	24,920	Share of fuel consumption [11]	4.0	3,541	26,095
	Vegetable oil	205		0.03	36	636
	Bioethanol	9,091		1.5	1,191	8,714
	Total	**34,216**		**5.5**	**4,767**	**35,444**
	Total	**300,869**	**FEC [12]**	**12.5**	**130,108**	**291,010**

For information on photovoltaic electricity production and heat production from solar thermal energy, see Annex, Section 1.

1) In the case of pumped storage power plants: only electricity generation from natural inflow
2) Biogenic component of waste in waste incineration plants is taken as 50 percent
3) Largely wood, including wood pellets
4) Operations in the mining and quarrying sectors and in the manufacturing industry, pursuant to Section 8 of the Energy Statistics Act (EnStatG)
5) Pursuant to Sections 3 and 5, Energy Statistics Act (EnStatG)
6) Including vegetable oil
7) Includes figure for use of heat in sewage plants
8) Renewable heat from heat pumps (air/water, water/water and brine/water heat pumps)
9) Based on gross electricity consumption of 605.8 TWh in 2011, according to AGEB [4]
10) Final energy consumption of 1,307 TWh (4,705 PJ) in 2011 for space heating, hot water and other process heat according to ZSW [1]
11) Based on motor fuel consumption of 621.5 TWh in 2011 (excluding jet fuel, military and inland waterway shipping), ZSW [1] according to BAFA [16]
12) Based on final energy consumption 2011 of 2,415 TWh (8,692 PJ) according to AGEB [4]

Sources: BMU on the basis of AGEE-Stat and other sources; see following tables; provisional figures

Renewable energy shares of energy supply in Germany, 1990 and 2000 to 2011

	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Final energy consumption (FEC)	**[%]**	**[%]**											
Electricity generation (based on total gross electricity consumption)	3.1	6.8	6.7	7.8	7.5	9.2	10.1	11.6	14.3	15.1	16.4	17.1	20.3
Heat generation (based on total heat generation)	2.1	3.9	4.2	4.3	5.0	5.5	6.0	6.2	7.4	7.6	8.9	10.7	11.0
Fuel consumption 1) (based on total fuel consumption)	0.0	0.4	0.6	0.9	1.4	1.8	3.7	6.3	7.4	6.0	5.4	5.8	5.5
Renewable energies' share of total FEC	**1.9**	**3.9**	**4.1**	**4.5**	**5.0**	**5.8**	**6.8**	**8.0**	**9.5**	**9.3**	**10.2**	**11.2**	**12.5**
Primary energy consumption (PEC)	**[%]**	**[%]**											
Renewable energies' share of total PEC 2)	**1.3**	**2.9**	**2.9**	**3.2**	**3.8**	**4.5**	**5.3**	**6.3**	**7.9**	**8.1**	**8.9**	**9.9**	**11.0**

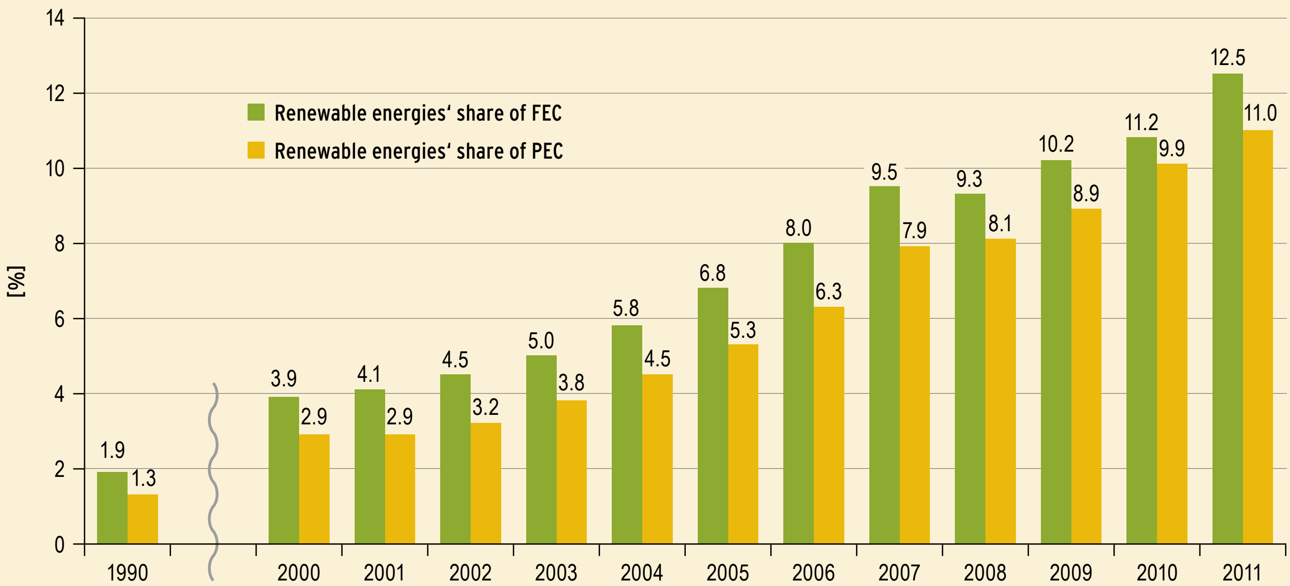
The complete time series on the development of renewable energy sources can be found on the BMU website "Renewable Energies" at www.erneuerbare-energien.de.

1) Basis until 2002: motor fuel consumption by road traffic; from 2003: total consumption of motor fuel, excluding jet fuel, military and inland waterway shipping

2) Calculated by the physical energy content method, after AGEB [4]

Sources: BMU on basis of AGEE-Stat after VDEW [8], [9], [10]; DIW [13]; EEFA [67] and BDEW [11] and other sources, see pages 20, 24 and 26

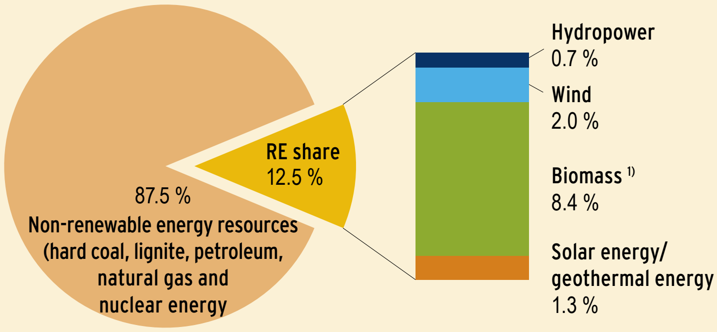
Development of renewable energy shares of final and primary energy consumption in Germany in 1990 and since 2000



Sources: see table above

Final energy consumption in Germany, 2011 - Shares met by renewable energies

Renewable energy shares of total final energy consumption in Germany 2011

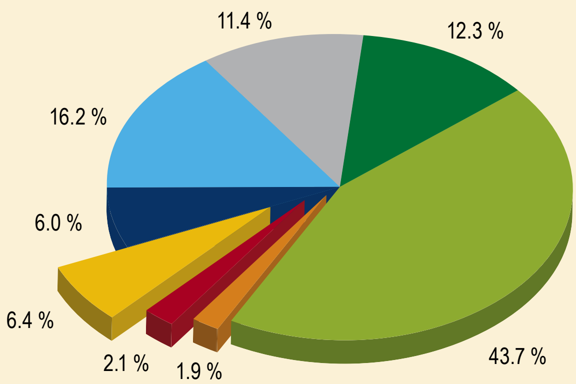


Final energy supply from renewable energies: around 300.9 TWh
(12.5 % of total final energy consumption)

1) Solid, liquid, gaseous biomass (biogas, sewage gas and landfill gas), biogenic fraction of waste and biogenic motor fuels

Sources: BMU on basis of AGEE-Stat and other sources, see table on pages 20, 24 and 26

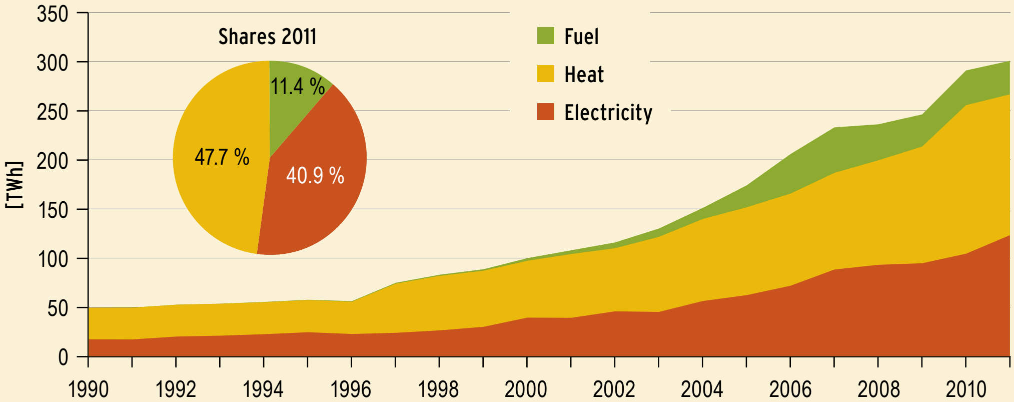
Structure of renewables-based final energy supply in Germany, 2011



1) Biogenic solid fuels, liquid and gaseous biomass (biogas, sewage gas and landfill gas), biogenic fraction of waste

Sources: BMU on basis of AGEE-Stat and other sources, see pages 20, 24 and 26

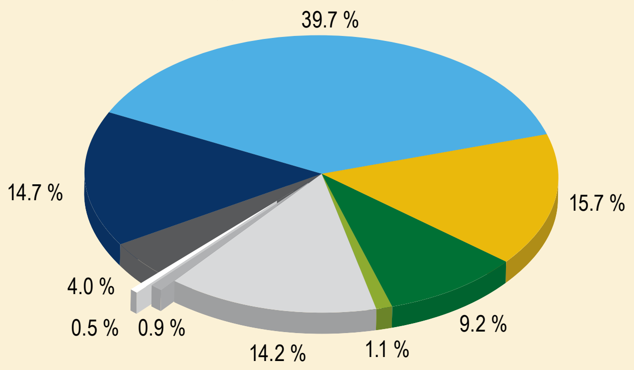
Development of renewables-based final energy supply in Germany, by sectors



Sources: BMU on basis of AGEE-Stat and other sources, see pages 20, 24 and 26

Structure of renewables-based energy supply in Germany, 2011

Structure of renewables-based electricity supply in Germany, 2011



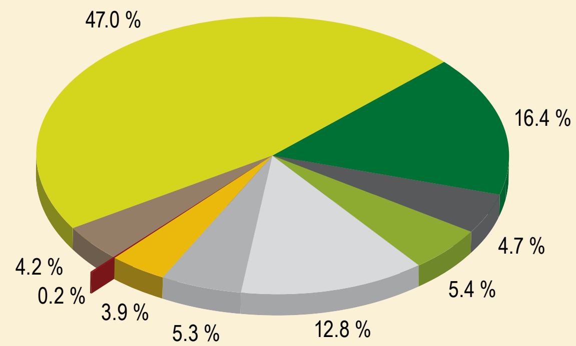
Electricity supply from renewable energies: 123.2 TWh
(share of total electricity consumption: 20.3 %)

- Hydropower
- Wind energy
- Photovoltaics
- Biogenic solid fuels
- Biogenic liquid fuels
- Biogas
- Sewage gas
- Landfill gas
- Biogenic fraction of waste

Geothermal electricity generation is not shown due to the small quantities involved

Sources: BMU on basis of AGEE-Stat and other sources, see table on page 20

Structure of renewables-based heat supply in Germany, 2011

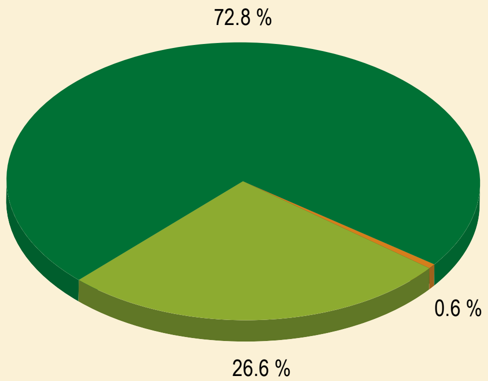


Heat production from renewable energies: 143.5 TWh
(Share of total heat consumption: 11.0 %)

- Biogenic solid fuels (households)
- Biogenic solid fuels (industry)
- Biogenic solid fuels (CHP/HP)
- Biogenic liquid fuels
- Biogenic gaseous fuels
- Biogenic fraction of waste
- Solar thermal systems
- Deep geothermal energy
- Near-surface geothermal energy and ambient heat

Sources: BMU on basis of AGEE-Stat and other sources, see table on page 24

Structure of renewables-based motor fuel supply in Germany, 2011



Biogenic fuels: 34.2 TWh
(Share of total motor fuel consumption: 5.5 %)

- Biodiesel
- Vegetable oil
- Bioethanol

Biogenic fuels 2011:
Biodiesel: 2,426,000 tonnes, 2,748 million litres;
Vegetable oils: 20,000 tonnes, 21 million litres;
Bioethanol: 1,233,000 tonnes, 1,554 million litres.

Sources: BMU on basis of AGEE-Stat and other sources, see table on page 26

Biomass use in the electricity, heat and motor fuel sectors in Germany, 2011

In 2011 bioenergy supplied a total of 202.7 terawatt hours (TWh) in the electricity, heat and motor fuel sectors, thereby meeting 8.4 percent of Germany's total final energy consumption of 2,415 TWh. Bioenergy thus accounted for about 67 percent of the total final energy produced from renewable sources (300.9 TWh).

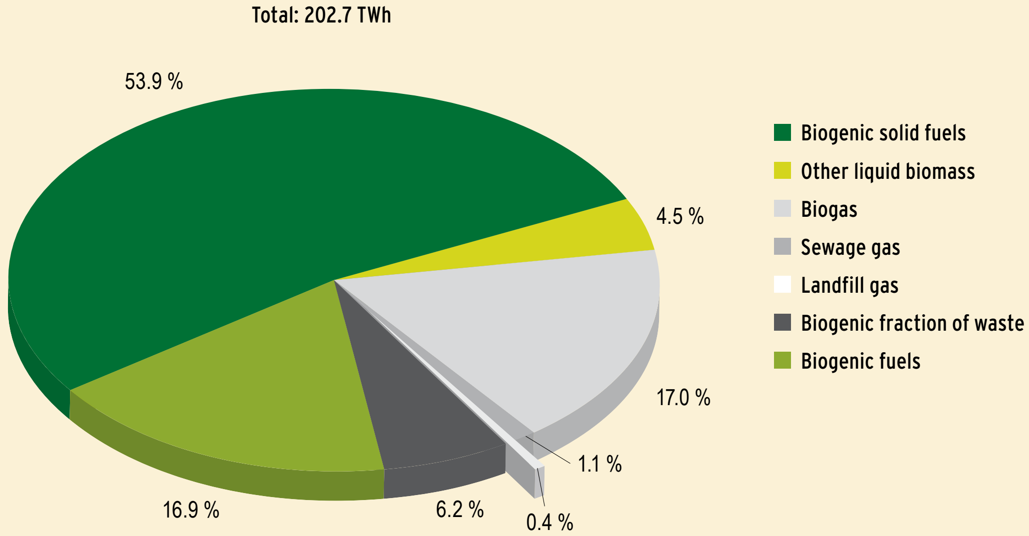
By far the largest share of the total of 202.7 TWh bioenergy supplied was due to biogenic solid fuels (largely wood products) with a figure of 109.2 TWh (corresponding to 53.9 percent of bioenergy supplied). Some 90 percent of final energy from solid fuels was used in the heat sector, and the remaining 10 percent in the electricity sector.

Biofuels, at 34.2 TWh, accounted for 16.9 percent of total bioenergy. Of this, 73 percent was due to biodiesel, the rest to bioethanol. Vegetable oil is only of minor importance.

At 34.5 TWh, the biogas share of final energy supply came to 17.0 percent. Of this, 50.7 percent was due to electricity and 49.3 percent to the heat sector. Heat from biogas is produced mainly in combined heat-and-power generation processes.

Other bioenergy sources that are used for both heat and power generation include the biogenic fraction of waste, landfill gas, sewage gas and liquid biomass (including vegetable oil).

Structure of final energy produced from total biomass in the electricity, heat and motor fuel sectors in Germany in 2011



Sources: BMU on basis of AGEE-Stat and other sources, see table on pages 20, 24 and 26

Development of renewables-based energy production in Germany, 1990 to 2011

Electricity generation (final energy) from renewable energies in Germany since 1990

	Hydro-power 1)	Wind energy	Biomass 2)	Biogenic fraction of waste 3)	Photo-voltaics	Geothermal energy	Total electricity generation	Share of gross electricity consumption
	[GWh]						[GWh]	[%]
1990	15,580	71	221	1,213	1	0	**17,086**	**3.1**
1991	15,402	100	260	1,211	2	0	**16,974**	**3.1**
1992	18,091	275	296	1,262	3	0	**19,927**	**3.7**
1993	18,526	600	433	1,203	6	0	**20,768**	**3.9**
1994	19,501	909	569	1,306	8	0	**22,293**	**4.2**
1995	20,747	1,500	665	1,348	11	0	**24,271**	**4.5**
1996	18,340	2,032	759	1,343	16	0	**22,490**	**4.1**
1997	18,453	2,966	880	1,397	26	0	**23,722**	**4.3**
1998	18,452	4,489	1,642	1,618	32	0	**26,233**	**4.7**
1999	20,686	5,528	1,849	1,740	42	0	**29,845**	**5.4**
2000	24,867	9,513	2,893	1,844	64	0	**39,181**	**6.8**
2001	23,241	10,509	3,348	1,859	76	0	**39,033**	**6.7**
2002	23,662	15,786	4,089	1,949	162	0	**45,648**	**7.8**
2003	17,722	18,713	6,086	2,161	313	0	**44,995**	**7.5**
2004	19,910	25,509	7,960	2,117	556	0.2	**56,052**	**9.2**
2005	19,576	27,229	10,978	3,047	1,282	0.2	**62,112**	**10.1**
2006	20,042	30,710	14,841	3,844	2,220	0.4	**71,657**	**11.6**
2007	21,169	39,713	19,760	4,521	3,075	0.4	**88,238**	**14.3**
2008	20,446	40,574	22,872	4,659	4,420	17.6	**92,989**	**15.1**
2009	19,036	38,639	25,989	4,352	6,583	18.8	**94,618**	**16.4**
2010	20,956	37,793	29,085	4,781	11,729	27.7	**104,372**	**17.1**
2011	18,074	48,883	31,920	4,950	19,340	18.8	**123,186**	**20.3**

The complete time series on the development of renewable energy sources can be found on the BMU website "Renewable Energies" category "Data Service" at www.erneuerbare-energien.de.

For electricity generation from photovoltaic energy, see Annex, Section 1.

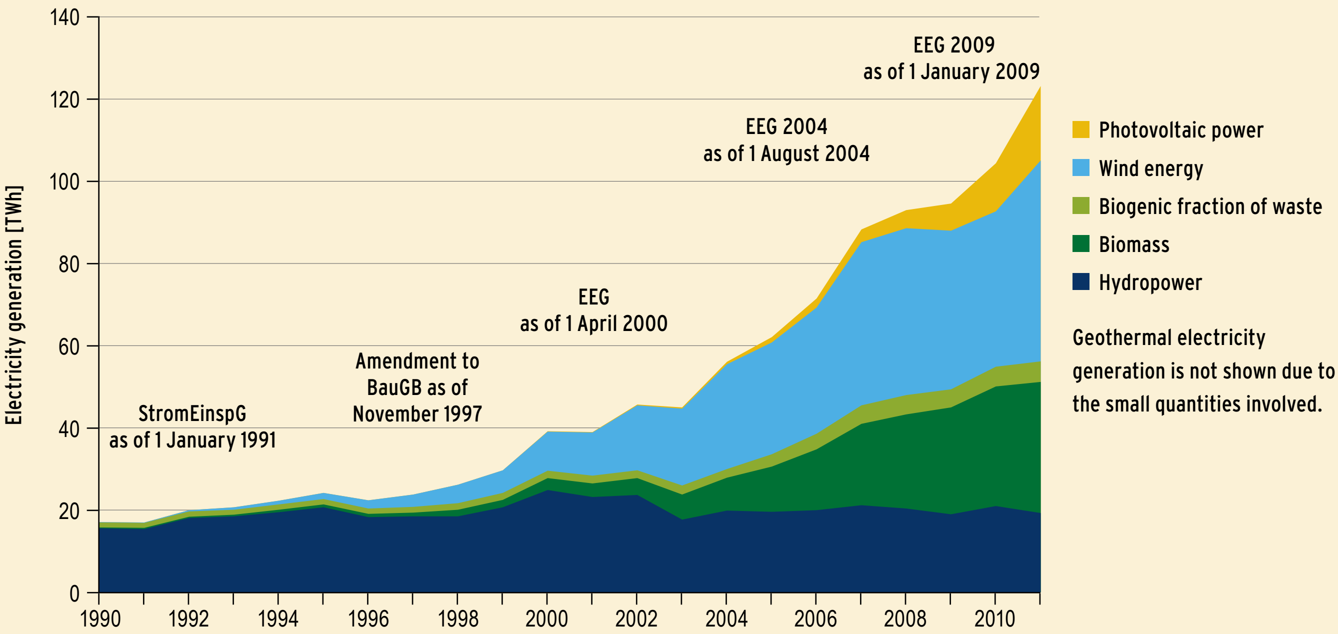
1) In the case of pumped storage power plants: only electricity generation from natural inflow

2) Until 1998: only feed-in to the general supply grid; figures from 2003 also include industrial electricity production from liquid biomass including vegetable oil

3) Biogenic component of waste in waste incineration plants is taken as 50 percent

Sources: BMU based on AGEE-Stat; ZSW [1]; VDEW [17], [18], [22] [27], [28], [29]; AGEB [2], [4]; BDEW [6]; ÜNB [68]; StBA [21]; SFV [26]; Erdwärme-Kraft GbR [41]; geo x [42]; Geothermie Unterhaching [43]; Pfalzwerke geofuture [44]; ewb Bruchsal [45]; Energie AG Oberösterreich [46]; DBFZ [57]

Development of electricity generation from renewable energies in Germany since 1990



Sources: BMU on basis of AGEE-Stat and other sources, see table on pages 20

Installed capacity for renewables-based electricity generation in Germany since 1990

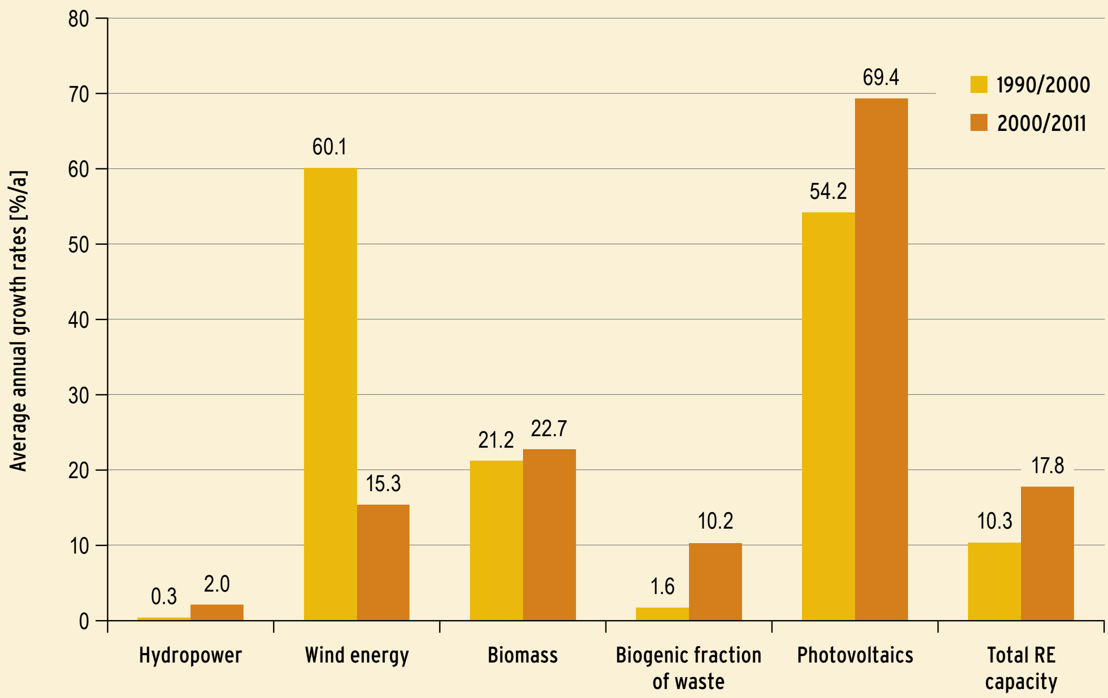
	Hydro-power	Wind energy	Biomass	Biogenic fraction of waste	Photo-voltaics	Geo-thermal energy	Total capacity
	[MW]	[MW]	[MW]	[MW]	[MW_p]	[MW]	[MW]
1990	3,429	55	85	499	1	0	**4,069**
1991	3,394	106	96	499	2	0	**4,097**
1992	3,550	174	105	499	3	0	**4,331**
1993	3,509	326	144	499	5	0	**4,483**
1994	3,563	618	178	499	6	0	**4,865**
1995	3,595	1,121	215	525	8	0	**5,464**
1996	3,510	1,549	253	551	11	0	**5,874**
1997	3,525	2,089	318	527	18	0	**6,476**
1998	3,601	2,877	432	540	23	0	**7,473**
1999	3,523	4,435	467	555	32	0	**9,012**
2000	3,538	6,097	579	585	76	0	**10,875**
2001	3,538	8,750	696	585	186	0	**13,755**
2002	3,785	11,989	843	585	296	0	**17,498**
2003	3,934	14,604	1,091	847	435	0	**20,911**
2004	3,819	16,623	1,444	1,016	1,105	0.2	**24,007**
2005	4,115	18,390	1,964	1,210	2,056	0.2	**27,735**
2006	4,083	20,579	2,620	1,250	2,899	0.2	**31,431**
2007	4,169	22,194	3,434	1,330	4,170	3.2	**35,300**
2008	4,138	23,826	3,969	1,440	6,120	3.2	**39,497**
2009	4,151	25,703	4,519	1,550	10,566	7.5	**46,497**
2010	4,395	27,191	5,014	1,650	17,554	7.5	**55,812**
2011	4,401	29,071	5,479	1,700	25,039	7.5	**65,698**

Notes: Until the end of 1999, the figures for the installed electrical capacity of biomass installations include only "power plants for the general public supply" and "other parties feeding in renewables-based electricity".
In each case the information on installed capacity relates to the figure at the end of the year.

The complete time series on the development of renewable energy sources can be found on the BMU website "Renewable Energies" at www.erneuerbare-energien.de.

Sources: BMU based on AGEE-Stat and VDEW [17], [18], [22], [27], [28], [29]; BDEW [30]; EnBW [39]; Fichtner [40]; BWE [47]; DEWI et al.[33]; DEWI [48]; BSW [51]; IE [58]; DBFZ [57]; ITAD [66]; Erdwärme-Kraft GbR [41]; geo x GmbH [42]; Geothermie Unterhaching [43]; Pfalzwerke geofuture [44]; ewb Bruchsal [45]; Energie AG Oberösterreich [46]; BNetzA [52], [74]; ZSW [1]

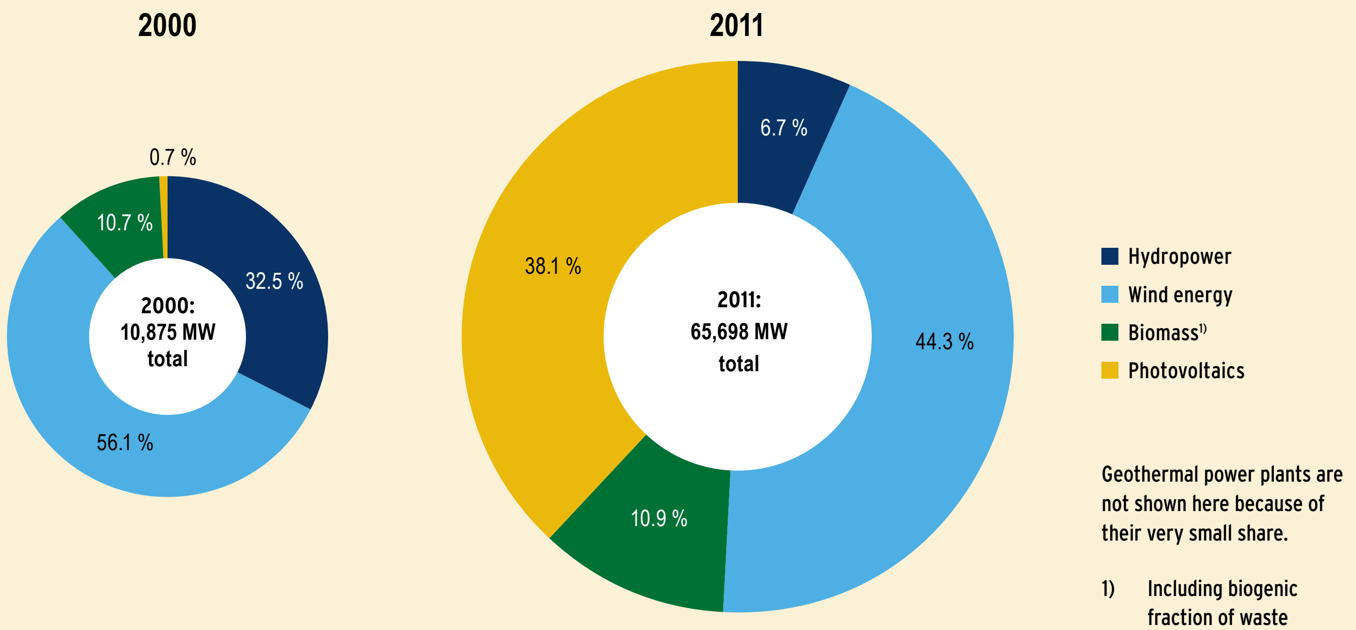
Average growth rate of installed electricity generation capacity in Germany



Note: Geothermal power generation capacity only started operating in Germany in 2004 (0.2 megawatts). Installed capacity at the end of 2011 was 7.5 megawatts, which is equivalent to an average annual growth of 67.8 percent.

Sources: BMU on basis of AGEE-Stat and other sources, see table on page 21

Shares of total renewables-based installed capacity in the electricity sector in Germany, 2000 and 2011



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

1) Including biogenic fraction of waste

Since the entry into force of the Renewable Energy Sources Act (EEG) in 2000, installed capacity for renewables-based electricity generation has increased about sixfold. The importance of hydropower has declined steadily in the same period, while the photovoltaic sector has shown a strong rise.

Sources: BMU on basis of AGEE-Stat and other sources, see table on page 21

Heat supply from renewable energies in Germany since 1990

	Biomass 1)	Biogenic fraction of waste 2)	Solar thermal energy 3)	Geoth. energy, ambient heat 4)	Total heat generation	Share of heat consumption
	[GWh]				[GWh]	[%]
1990	28,265	2,308	131	1,515	**32,195**	**2.1**
1991	28,360	2,308	169	1,517	**32,354**	**2.1**
1992	28,362	2,308	221	1,522	**32,413**	**2.1**
1993	28,368	2,308	280	1,530	**32,486**	**2.1**
1994	28,375	2,308	355	1,537	**32,575**	**2.2**
1995	28,387	2,308	440	1,540	**32,675**	**2.1**
1996	28,277	2,538	549	1,551	**32,915**	**2.0**
1997	45,591	2,290	690	1,569	**50,140**	**3.2**
1998	49,740	3,405	848	1,604	**55,597**	**3.6**
1999	50,858	3,674	1,026	1,645	**57,203**	**3.8**
2000	51,419	3,548	1,261	1,694	**57,922**	**3.9**
2001	58,220	3,421	1,587	1,765	**64,993**	**4.2**
2002	57,242	3,295	1,884	1,855	**64,276**	**4.3**
2003	69,182	3,169	2,144	1,956	**76,451**	**5.0**
2004	75,376	3,690	2,443	2,086	**83,595**	**5.5**
2005	79,746	4,692	2,778	2,294	**89,510**	**6.0**
2006	83,023	4,911	3,218	2,762	**93,914**	**6.2**
2007	86,670	4,783	3,638	3,415	**98,506**	**7.4**
2008	93,133	5,020	4,134	4,168	**106,455**	**7.6**
2009	102,403	6,832	4,733	4,931	**118,899**	**8.9**
2010	132,843	7,566	5,200	5,585	**151,194**	**10.7**
2011	123,970	7,600	5,600	6,297	**143,467**	**11.0**

The complete time series on the development of renewable energy sources can be found on the BMU website "Renewable Energies" at www.erneuerbare-energien.de, category "Data Service".

1) Survey method modified in 1996/1997; from 2003 onwards, unlike previous years, the figures are based on Sections 3 and 5 (combined heat-and-power generation plants and heating plants) and Section 8 (industry) of the Energy Statistics Act of 2003, and heat utilisation in sewage gas plants

2) Figures for 1990 to 1994 equated with 1995, figures for 2000 to 2002 estimated in the light of figures for 1999 and 2003. Biogenic fraction of waste in waste incineration plants is taken as 50 percent. The increase in the heat sector in 2009 compared with the year before is due to first-time inclusion of newly available data. This is a statistical adjustment which does not permit any conclusions about the actual expansion of use.

3) Useful energy; takes decommissioning of old plants into account

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

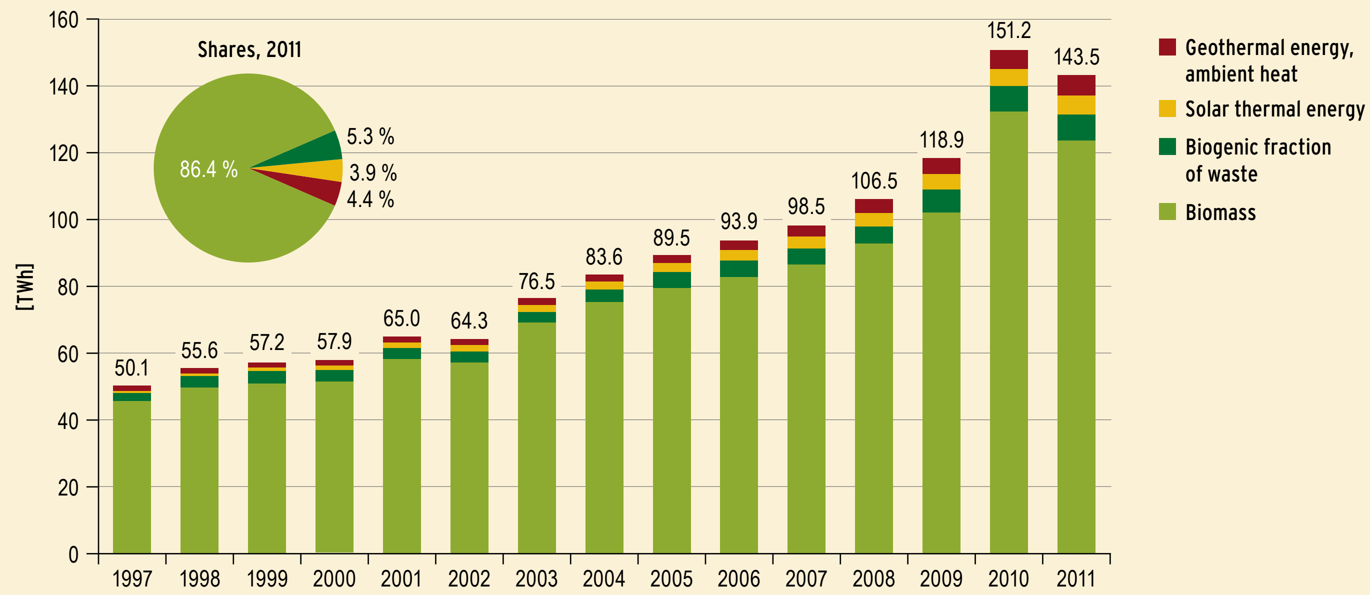
Sources: BMU based on AGEE-Stat and ZSW [1]; StBA [21]; IEA [65]; AGEB [4], [69], [70]; BSW [51]; ZfS [54]; IE et al. [58]; ITW [72]; GZB [59]; LIAG [61]; BWP [3]; DBFZ [57]

Solar heat: development of area and capacity of solar collectors in Germany since 1990

		1990	2000	2002	2004	2006	2008	2010	2011
Cumulative area	[1,000 m^2]	348	3,251	4,679	6,151	8,501	11,330	14,044	15,234
Cumulative output	[MW]	243	2,276	3,275	4,306	5,951	7,931	9,831	10,664

Sources: BMU based on AGEE-Stat and ZSW [1]; ZfS [54]; BSW [51]

Development of heat supply from renewable energies in Germany since 1997



Sources: BMU based on AGEE-Stat and other sources, see page 24

Additions to solar collector (solar heat) capacity in Germany since 1990

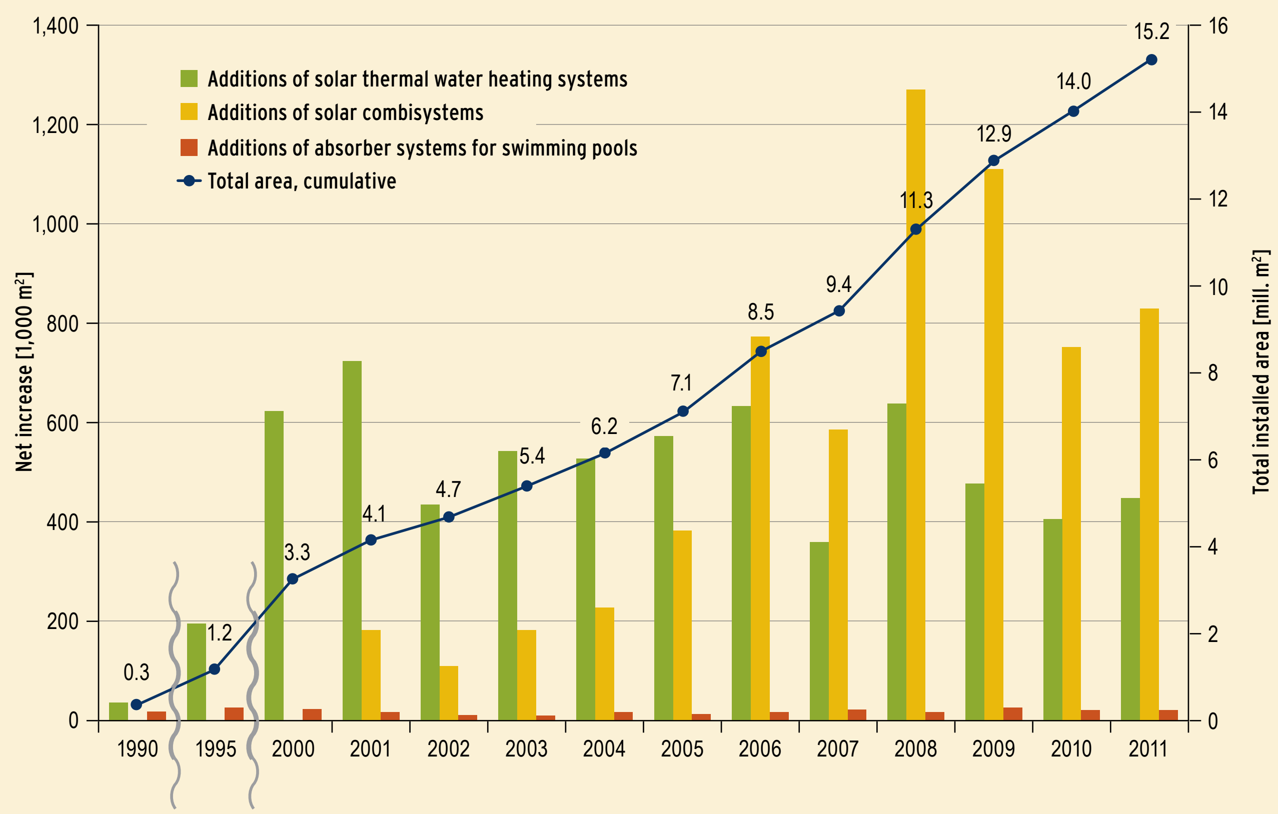


Diagram takes account of decommissioning of old installations; combined solar thermal installations: hot water heating and central heating support

Sources: BMU based on AGEE-Stat and ZSW [1]; ZfS [54]; BSW [51]

Motor fuel supply from renewable energies in Germany in 1998 and since 2000

	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	[1,000 tonnes]												
Biodiesel	100	250	350	550	800	1,017	1,800	2,817	3,318	2,695	2,431	2,529	2,426
Vegetable oil	11	16	20	24	28	33	196	711	838	401	100	61	20
Bioethanol	0	0	0	0	0	65	238	512	460	625	892	1,165	1,233
Total	**111**	**266**	**370**	**574**	**828**	**1,115**	**2,234**	**4,040**	**4,616**	**3,721**	**3,423**	**3,755**	**3,679**

Source: BMU on the basis of AGEE-Stat and other sources, see following table

Motor fuel supply from renewable energies in Germany since 1990

	Biodiesel	Vegetable oil	Bioethanol	Total biofuels	Share of fuel consumption [1]
	[GWh]			[GWh]	[%]
1990	0	N/A	0	**0**	**0**
1991	2	N/A	0	**2**	**0**
1992	52	21	0	**73**	**0.012**
1993	52	31	0	**83**	**0.013**
1994	258	31	0	**289**	**0.05**
1995	310	53	0	**363**	**0.06**
1996	516	53	0	**569**	**0.09**
1997	825	104	0	**929**	**0.1**
1998	1,032	115	0	**1,147**	**0.2**
1999	1,341	146	0	**1,487**	**0.2**
2000	2,579	167	0	**2,746**	**0.4**
2001	3,611	209	0	**3,820**	**0.6**
2002	5,674	251	0	**5,925**	**0.9**
2003	8,253	292	0	**8,545**	**1.4**
2004	10,493	345	481	**11,319**	**1.8**
2005	18,570	2,047	1,763	**22,380**	**3.7**
2006 [2]	29,062	7,426	3,792	**40,280**	**6.3**
2007	34,239	8,748	3,437	**46,424**	**7.4**
2008	27,810	4,192	4,673	**36,675**	**6.0**
2009	25,086	1,044	6,673	**32,803**	**5.4**
2010	26,095	636	8,713	**35,444**	**5.8**
2011	24,920	205	9,091	**34,216**	**5.5**

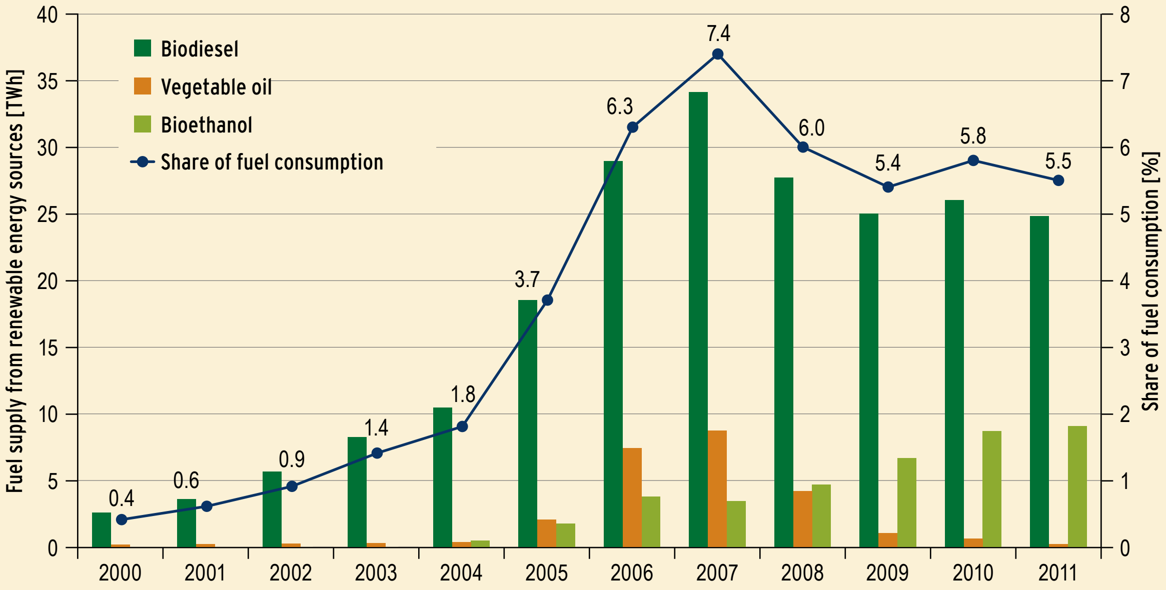
The complete time series on the development of renewable energy sources can be found on the BMU website "Renewable Energies" at www.erneuerbare-energien.de, category "Data Service".

1) Basis until 2002: motor fuel consumption by road traffic; from 2003: total consumption of motor fuel, excluding jet fuel, military and inland waterway shipping

2) The biodiesel figure for 2006 also includes vegetable oil. AGQM [31] and UFOP [32] show a biodiesel consumption of 25,800 gigawatt hours for 2006.

Sources: BMU based on AGEE-Stat and BMU/BMELV [14]; BMELV [15]; BAFA [16]; FNR [60]; UFOP [32]; AGQM [31]

Development of renewables-based fuel supply in Germany since 2000



Source: BMU on the basis of AGEE-Stat and other sources, see table on page 26

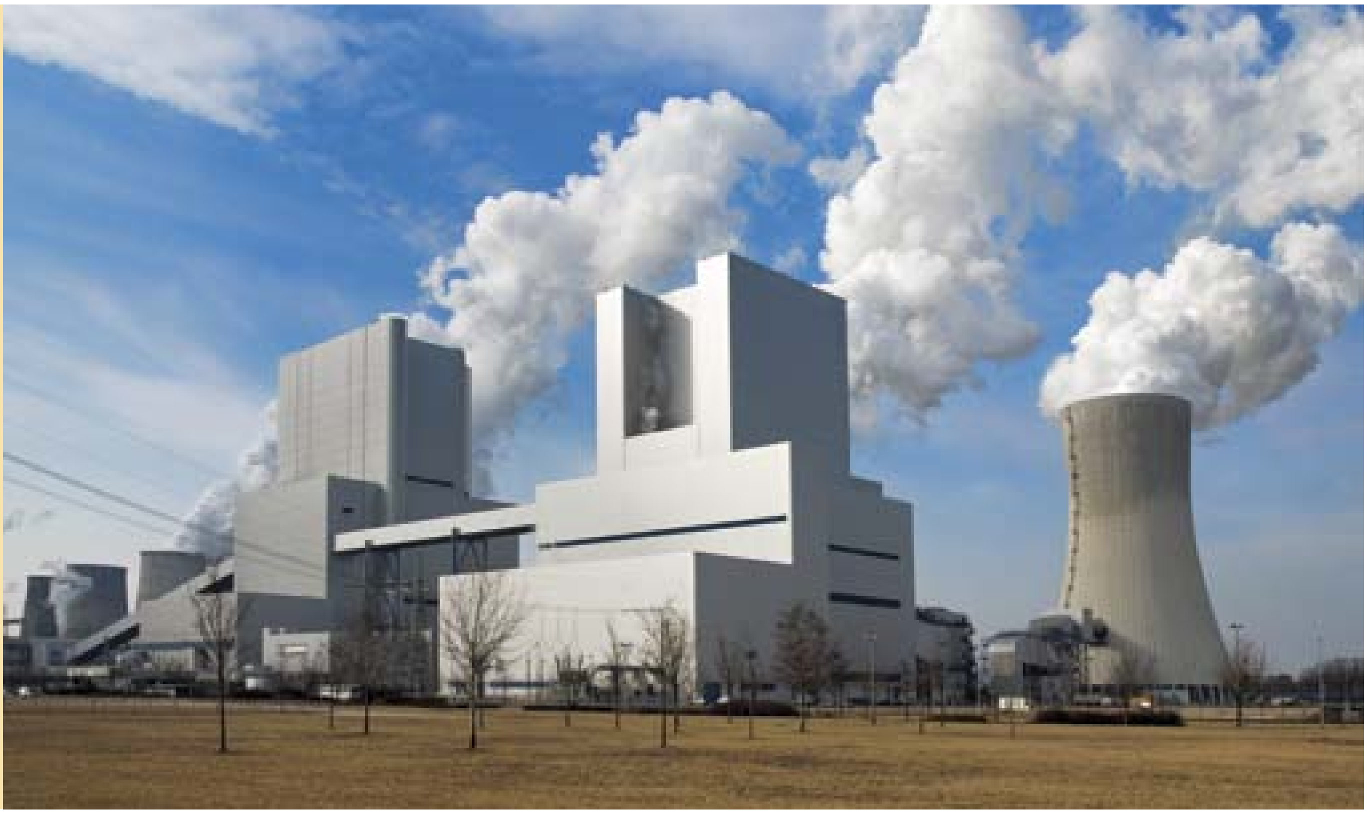
Emissions avoided through use of renewable energies in Germany, 2011

The expansion of renewable energy makes a major contribution to meeting the climate objectives. Fossil fuels are being replaced by renewable energy in all consumption sectors (power, heat, transport). There is a corresponding reduction in energy-induced greenhouse gas emissions.

In 2011 the resulting quantity of greenhouse gas avoided came to 130 million tonnes CO_2 equivalent. Of this, 86.3 million tonnes were due to the electricity sector, including 70 million tonnes attributable to renewable energy electricity subject to remuneration under the Renewable Energy Sources Act (EEG). Avoided emissions amounted to 39.1 million tonnes in the heat sector and 4.8 million tonnes CO_2 equivalent in the motor fuel sector.

If one considers the greenhouse gas carbon dioxide (CO_2) only, without taking into account methane emissions the picture looks slightly different. On this basis, renewable energy sources saved a total of 128 million tonnes CO_2 emissions in 2011. Of this, 81.4 million tonnes were due to power generation from renewable sources (including 66 million tonnes due to renewable energy electricity with EEG remuneration), 39.3 million tonnes to heat production from renewables, and 7.0 million tonnes to the use of biofuels.

The net balance of emissions avoided as a result of renewables basically takes account of all upstream process chains for electricity production, fuel supply and plant construction.

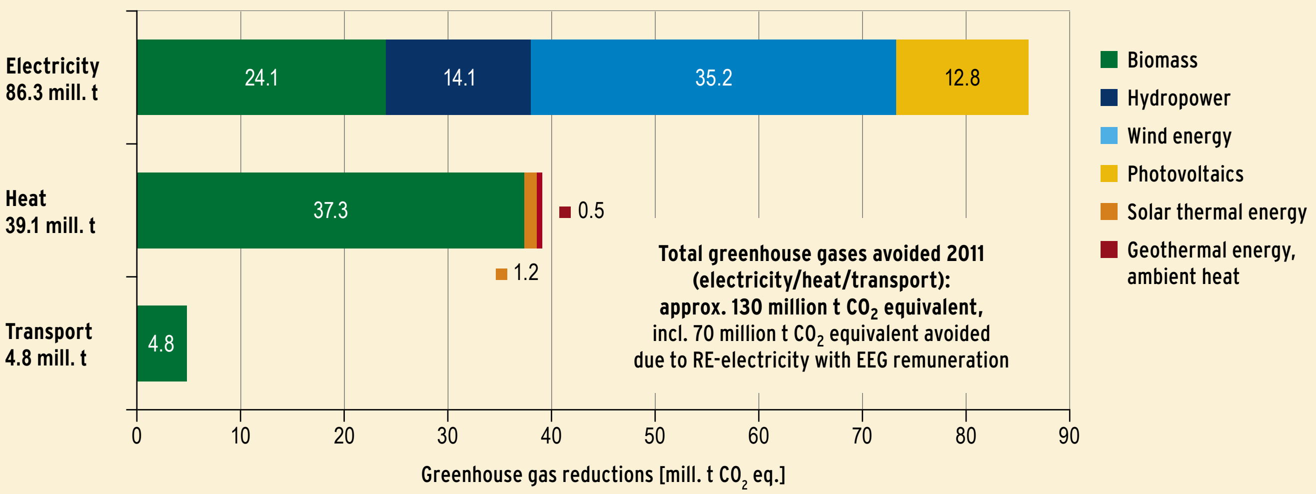


Here the emissions of the conventional fuels replaced by renewable energy sources are compared with the emissions resulting from the upstream chains and the operation of the renewable energy generation installations (see also methodological notes in the Annex).

In the case of electricity and heat the result depends to a considerable extent on which fossil fuels are being replaced by renewables. In the case of biofuels, the nature and provenance of the raw materials used is critical. For further information see the Annex.

Greenhouse gas reductions due to biofuels are particularly dependent not only on the emission intensity of the fossil fuels replaced, but also on the nature and origin of the raw materials used. Except where these are biogenic residues (e.g. wood) and waste, it is necessary to take account of land use changes resulting from agricultural cultivation of energy crops. These can have a crucial influence on the results of the balance. The effects of indirect land use changes (e.g. those caused indirectly by displacement effects) are not yet taken into account in the calculation of greenhouse gas emissions. Methodological approaches for this purpose are currently being developed by the European Commission and others. Since January 2011, direct land use changes have largely been ruled out in the case of biofuels and heating bioliquids thanks to the provisions of the Biofuels Sustainability Ordinance and the Biomass Electricity Sustainability Ordinance; in the case of energy crop cultivation for biogas production, direct land use changes still have a certain relevance, e.g. as a result of ploughing up grassland.

Greenhouse gas emissions avoided via use of renewable energies in Germany, 2011



Discrepancies in the totals are due to rounding differences

Sources: UBA on basis of AGEE-Stat and other sources, see pages 31, 33 and 35

Emissions avoided in the electricity sector in 2011 by using renewables

Renewable energy generation from water, wind, solar energy, biomass and geothermal energy reduces the consumption of fossil fuels, which still largely form the basis for electricity supplies in Germany today. Thus electricity generation from renewables makes a major contribution to the reduction of energy-induced greenhouse gases and acidifying air pollutants in Germany.

The net balance of electricity generation from renewables takes into account not only the directly avoided emissions of greenhouse gases and air pollutants from fossil fuel power stations in Germany, but also the emissions avoided in the supply chains for the primary fossil fuels. The high emissions of methane (CH_4) in the production and transport of coal and natural gas have to be especially emphasized here. But the emissions of greenhouse gases and air pollutants which occur during the production of renewable power generation plants and the supply and use of biomass are also taken into account.

On balance, the specific greenhouse gas avoidance factors display slight differences. One particularly high climate protection effect can be seen in electricity generation from hydropower, solid biomass (wood) and solid or gaseous biogenic waste. In the case of electricity generation from biogas, by contrast, the emissions resulting from the cultivation of energy crops make themselves felt.

Greenhouse gas avoidance factors for renewables-based electricity generation, 2011

Electricity	Avoidance factor [g CO_2 eq./kWh]
Hydropower	779
Wind energy	721
Photovoltaics	664
Biogenic solid fuels	765
Biogenic liquid fuels	586
Biogas	549
Sewage gas	732
Landfill gas	732
Biogenic fraction of waste	760
Geothermal energy	472

The avoidance factor is the quotient of avoided emissions and electricity supply from renewables. It corresponds to the average avoidance of greenhouse gases and air pollutants (for further information, see Annex).

Sources: UBA on the basis of AGEE-Stat and other sources, see following table

Emission balance of renewables-based electricity generation, 2011

	Greenhouse gas/ air pollutant	Renewables-based electricity generation total: 123,186 GWh Avoidance factor [g/kWh]	Avoided emissions [1,000 t]
Greenhouseeffect 1)	CO_2	660	81,353
	CH_4	1.81	223
	N_2O	0.02	3.0
	CO_2 equivalent	**700**	**86,270**
Acidification 2)	SO_2	0.22	27.6
	NO_X	0.04	5.0
	SO_2 equivalent	**0.25**	**31.2**
Ozone 3) Particulates 4)	CO	-0.23	-28.3
	NMVOC	-0.0001	-0.014
	Particulates	-0.01	-1.1

1) No account is taken of other greenhouse gases (SF_6, PFC, HFC).
2) No account is taken of other air-pollutants with acidification potential (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.

The calculations are based on the "Report on CO_2 reduction in the electricity sector through the use of renewable energy sources in 2008 and 2009" (Gutachten zur CO_2-Minderung im Stromsektor durch den Einsatz erneuerbarer Energien im Jahr 2008 und 2009 (Klobasa et al. [88]).
For the calculation method, see Annex, Section 3.

Sources: UBA [75] on the basis of AGEE-Stat and Klobasa et al. [88]; UBA [92]; Öko-Institut [90]; Ecoinvent [84]; Vogt et al. [89]; Ciroth [83]; UBA [37]

Emissions avoided in the heat sector in 2011 by using renewables

Apart from the use of solar energy and ambient heat, renewable energy for space heating and hot water in households and for industrial process heat comes largely from CO_2-neutral combustion of biomass. Here the amount of CO_2 released is no more than the plant previously took up for its growth.

Thus heat supply from renewables makes an important contribution to avoiding greenhouse gas emissions. This climate protection effect is due partly to avoiding the release of the carbon bound in fossil fuels such as oil, natural gas, coal and lignite, and partly to avoiding environmental pollution (e.g. methane emissions) produced during the extraction, processing and transport of fossil fuels.

However, where biomass is burned in older heating installations such as stoves, greater quantities of air pollutants are released than in the case of fossil fuels (the emission balance becomes negative). This applies particularly to the volatile organic compounds which contribute to photochemical smog, and to carbon monoxide and particulate emissions of all sizes. Such environmental pollution can be reduced by using modern heating systems and stoves and by a responsible approach on the part of the user.

With regard to the greenhouse gas avoidance factors of the individual renewable energy sources, the picture is similar to the production of electricity from renewables. A particularly high climate protection effect results from the use of solid biomass (wood) and biogenic waste. In the case of heat generation from biogas, the emissions arising from cultivation of the energy crops are once again relevant.

It should be noted that the avoidance factor for geothermal energy is not based on fuel input, but directly on useful energy.

Greenhouse gas avoidance factors for renewables-based heat generation, 2011

Heat	Avoidance factor [g CO_2 eq./kWh]
Biogenic solid fuels (households)	299
Biogenic solid fuels (industry)	318
Biogenic solid fuels (HP/CHP)	291
Biogenic liquid fuels	278
Biogas	171
Sewage gas	280
Landfill gas	280
Biogenic fraction of waste	296
Solar thermal energy	221
Deep geothermal energy	68
Near-surface geothermal energy, ambient heat [1]	81

The avoidance factor is the quotient obtained by dividing avoided emissions by renewables-based heat generation. It corresponds to the average avoidance of greenhouse gases and air pollutants (for further information, see Annex).

1) Renewable heat from heat pumps (air/water-, water/water- and brine/water heat pumps)

Sources: UBA on the basis of AGEE-Stat and other sources, see following table

Emission balance for renewables-based heat generation, 2011

		Renewables-based heat supply total: 143,467 GWh	
Greenhouse gas/ air pollutant		Avoidance factor [g/kWh]	Avoided emissions [1,000 t]
Greenhouseeffect [1]	CO_2	274	39,304
	CH_4	0.17	24.1
	N_2O	-0.02	-2.4
	CO_2 equivalent	**272**	**39,070**
Acidification [2]	SO_2	0.19	27.8
	NO_X	-0.17	-24.8
	SO_2 equivalent	**0.07**	**10.6**
Ozone [3] Particulates [4]	CO	-4.34	-623.3
	NMVOC	-0.22	-31.4
	Particulates	-0.16	-23.3

1) No account is taken of other pollutants with global warming potential (SF_6, PFC, HFC).
2) No account is taken of other air-pollutants with acidification potential (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.

For the calculation method, see Annex, Section 4.

Sources: UBA [75] on the basis of AGEE-Stat and Frondel et al. [87]; UBA [92]; Öko-Institut [90]; Ecoinvent [84]; Vogt et al. [89]; Ciroth [83]; AGEB [2], [73]; UBA [37]

Emissions avoided in the transport sector in 2011 by using renewables

The supply and use of biofuels involves emissions. These arise from the cultivation and harvesting of the biomass, its processing, its combustion in the engine and – to a smaller extent – its transport. In the cultivation phase, use of fertiliser is a particularly important factor, being responsible, for example, for the emission of climate-relevant laughing gas (N_2O).

The emission balances depend on numerous parameters. In particular, the nature of the biomass used, the processing methods in motor fuel production, the reference systems on which the calculations are based and the allocation methods used all have an influence on the results. If one considers total greenhouse gases, the emission level is determined by the basic raw materials and hence also by the origin of the biofuels and the corresponding emission factors.

Greenhouse gas emissions due in particular to indirect land use changes arising from cultivation of energy crops are a relevant parameter (since January 2011, direct land use changes in the case of biofuels have been largely excluded by the provisions of the Biofuels Sustainability Ordinance). As already mentioned on page 29, methodological reasons have prevented their being taken into account to date.

Greenhouse gas avoidance factors for renewables-based fuel supply, 2011

Transport	Avoidance factor [g CO_2 eq./kWh]
Biodiesel	142
Vegetable oil	176
Bioethanol	131

The avoidance factor is the quotient obtained by dividing avoided emissions by renewables-based motor fuel production. It corresponds to the average saving in greenhouse gases and air pollutants.

Sources: UBA on the basis of AGEE-Stat and other sources, see following table

Emission balance for renewable-based fuel supply, 2011

		Biogenic fuels total: 34,216 GWh	
	Greenhouse gas/ air pollutant	Avoidance factor [g/kWh]	Avoided emissions [1,000 t]
Greenhouseeffect [1)]	CO_2	204	6,985
	CH_4	-0.27	-9.2
	N_2O	-0.19	-6.6
	CO_2 equivalent	**139**	**4,767**
Acidification [2)]	SO_2	-0.05	-1.5
	NO_x	-0.38	-13.0
	SO_2 equivalent	**-0.139**	**-4.7**
Ozone [3)] Particulates [4)]	CO	-0.07	-2.5
	NMVOC	0.14	4.9
	Particulates	-0.03	-1.0

1) No account is taken of other pollutants with global warming potential (SF_6, PFC, HFC).
2) No account is taken of other air-pollutants with acidification potential (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.

For the calculation method, see Annex, Section 5.

Sources: UBA [75] on the basis of AGEE-Stat and EP/ER [85]; BR [79]; BR [80]; BDBe [82]; VDB [81]; Greenpeace [78]; BLE [96] and IFEU [5]

Saving in fossil fuels and energy imports in Germany in 2011 due to the use of renewables

Primary energy savings due to the use of renewables

	Lignite	Hard coal	Natural gas	Petroleum/ heating oil	Diesel fuel	Petrol	Total
	Primary energy [TWh]						
Electricity	17.0	189.8	69.1	0.0	–	–	**275.9**
Heat	11.9	13.7	72.4	58.1	–	–	**156.0**
Transport	–	–	–	–	14.1	6.2	**20.4**
Total	**28.9**	**203.5**	**141.5**	**58.1**	**14.1**	**6.2**	**452.3**
	Primary energy [PJ]						
Total	**104.0**	**732.6**	**509.5**	**209.0**	**50.9**	**22.4**	**1,628.3**
Which corresponds to[1]:	**10.3 mill. t [2]**	**24.3 mill. t [3]**	**14.486 mill. m^3**	**5.848 mill. litres**	**1.420 mill. litres**	**691 mill. litres**	

The savings in fossil fuels are calculated on the same lines as the emission balances, see also Annex, Section 6.

1) The saving in primary energy was calculated using the following calorific values determined by the AGEB in 2008: lignite 2.501 kilowatt hours/kilogram (kWh/kg), brown coal briquettes 5.421 kWh/kg, pulverised coal 6.060 kWh/kg; hard coal 8.366 kWh/kg, coke from hard coal 7.958 kWh/kg, natural gas 9.769 kilowatt hours/cubic metre, light heating oil 9.928 kilowatt hours/litre (kWh/litre), diesel 9.964 kWh/litre, petrol 9.011 kWh/litre.

2) Including approx 9.3 million tonnes lignite, approx. 0.3 million tonnes lignite briquettes and approx. 0.7 million tonnes pulverised coal

3) Including approx. 24.1 million tonnes hard coal and approx. 0.2 million tonnes of coke from hard coal

Sources: UBA [75] on the basis of AGEE-Stat and Klobasa et al. [88]; Frondel et al. [87]; Öko-Institut [90]; Ecoinvent [84]; Vogt et al. [89]; Frick et al. [86] and other sources; see tables on pages 31, 33 and 35

The tables below show details of the savings in fossil fuels as result of the use of renewable energies in the fields of electricity, heat and transport in 2011. The total saving has risen steadily in recent years. Since Germany has to import a large proportion of its fossil, i.e. non-renewable fuels such as oil, gas and coal, these savings also result in a reduction in German energy imports. The amount is partly determined by movements in energy prices.

Trends in fossil fuel savings resulting from use of renewables

	Electricity	Heat	Transport	Total
	Primary energy [TWh]			
2009	217.5	129.4	20.2	367.0
2010	236.5	166.3	21.2	424.0
2011	275.9	156.0	20.4	452.3

Sources: UBA [75] on the basis of AGEE-Stat and Klobasa et al. [88]; Frondel et al. [87]; Öko-Institut [90]; Ecoinvent [84]; Vogt et al. [89]; Frick et al. [86] and other sources; see tables on pages 31, 33 and 35

Development of savings on fossil fuel import costs in Germany [1)]

	Electricity	Heat	Transport	Total
	[billion EUR]			
2009	2.1	3.1	0.9	6.1 [2)]
2010	2.5	3.3	0.8	6.6 [2)]
2011	2.9	3.4	0.7	7.1 [2)]

Provisional figures

1) Excluding imported lignite for heating purposes (briquettes). Import shares for oil and natural gas according to [BMWi]. Import share for boiler coal 100 percent , since fixed supply contracts for German coal do not permit any reductions. Savings in boiler coal therefore result in a reduction in hard coal imports. The total import share for hard coal is over 75 percent . Import prices according to [BAFA].
2) Gross figures. Taking account of imports of biogenic heating fuels reduces the import savings to 6.0 billion Euro (2011), 5.8 billion Euro (2010) and 5.7 billion Euro (2009). For calculation method, compare [133]

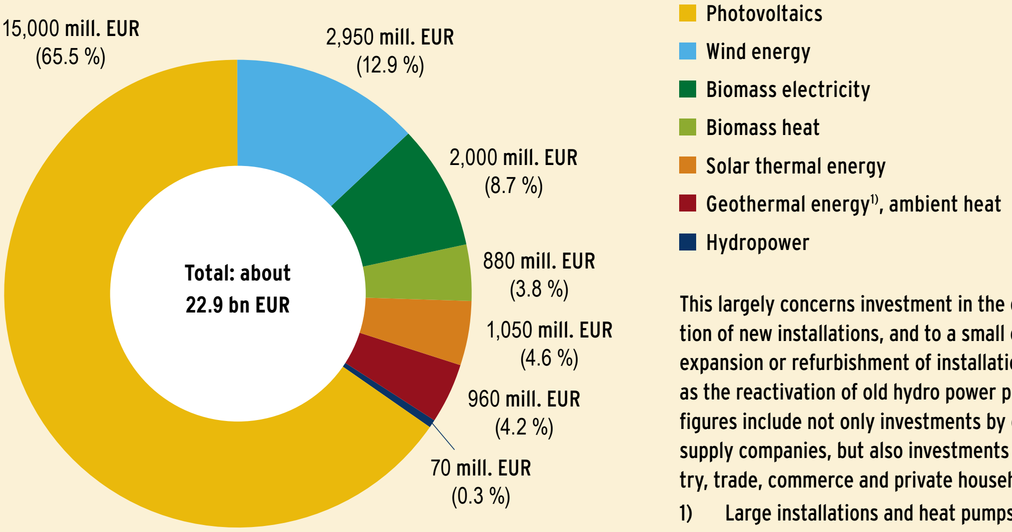
Sources: ISI et al. [50], [55]

Revenue resulting from the construction and operation of installations for exploiting renewable energies in Germany, 2011

Although the construction of new electricity generation capacity for exploiting renewable energy sources in 2011 once again slightly exceeded the previous year's figure, investment showed a drop on the previous year for the first time in years in Germany. This was largely due to the much reduced prices for photovoltaic installations, which dominated total investment as they had done the year before. Also, the slight drop in construction of new biomass and hydro power installations was not completely offset by the rise in the wind, solar thermal and geothermal sectors. On balance, the investment total of 22.9 billion Euro was 18 percent lower than the year before. As in the past, the greater part (87 percent) of the investment was due to installations eligible for assistance under the Renewable Energy Sources Act. However, revenue related to renewable energy technology of German companies in the year 2011 (24.9 billion Euro) were approximately on the same level as 2010 (25.3 billion Euro) [38].

Nevertheless, the decline in investment cannot obscure the fact that renewable energies are a major economic factor which is still tending to increase in importance. This is underlined by the growing economic importance of plant operation. In view of the rapid growth in the number of installations, revenue from the operation of renewables-based installations in 2011 showed a 12-percent rise on the year before to 13.8 billion Euro. These revenues provide a sustainable boost to the economy, because they accrue continuously over the entire life of the installations (usually 20 years) and are augmented by every newly installed installation.

Investments in construction of renewable energy installations in Germany, 2011

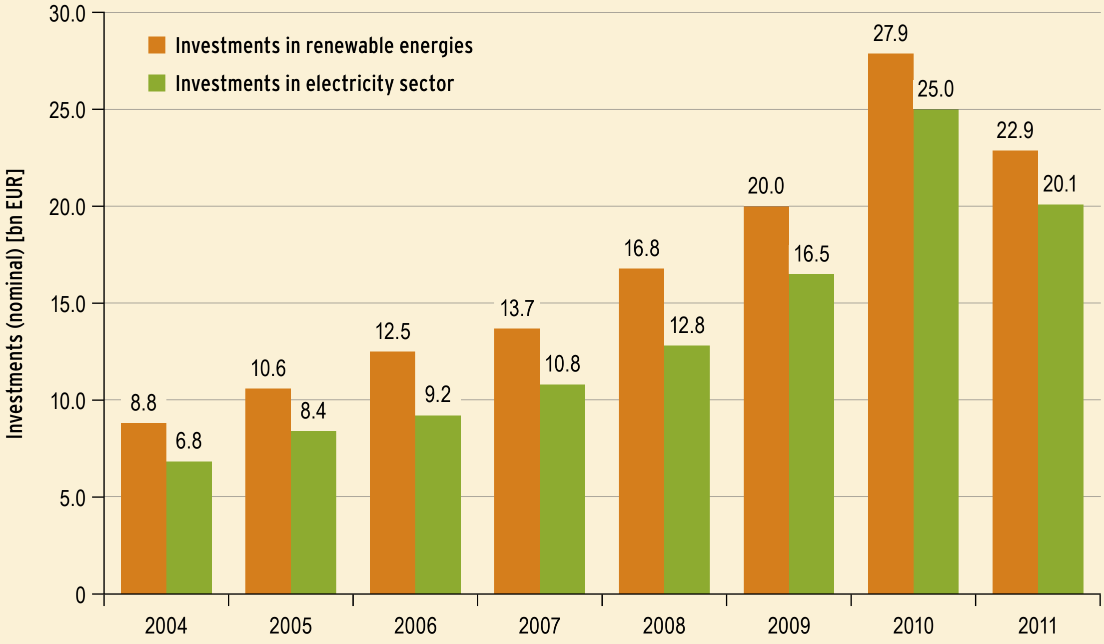


This largely concerns investment in the construction of new installations, and to a small extent the expansion or refurbishment of installations, such as the reactivation of old hydro power plants. The figures include not only investments by energy supply companies, but also investments by industry, trade, commerce and private households.

1) Large installations and heat pumps

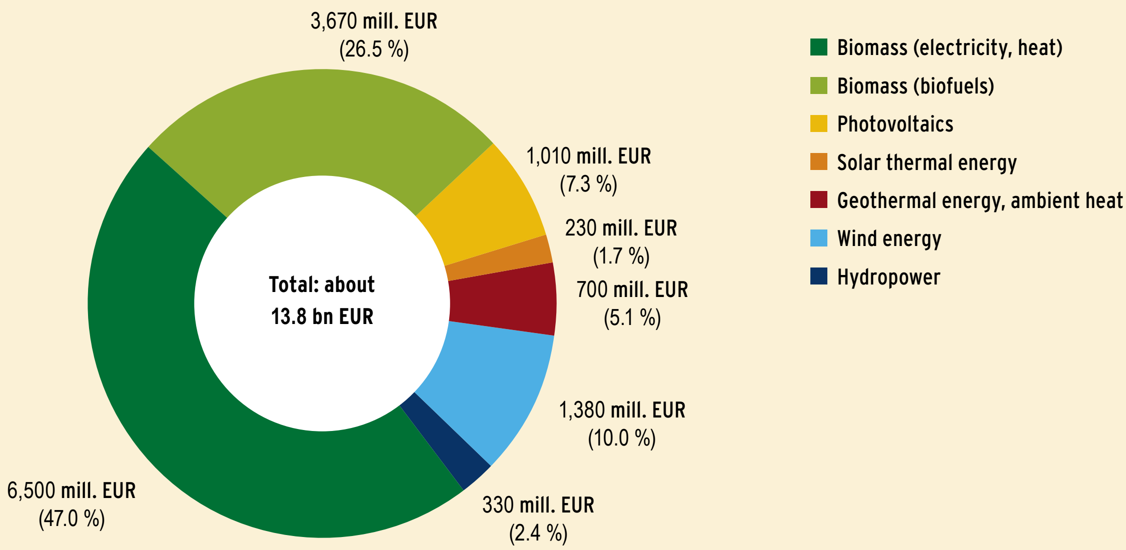
Source: BMU according to ZSW [1]

Trends in investments in renewable energies and their induced share in the electricity sector in Germany up to 2011



Source: BMU according to ZSW [1]

Revenues from the operation of renewable energy installations in Germany, 2011



Source: BMU according to ZSW [1]

The revenue from operation of installations results from the expenditure on operation and maintenance of the installations, especially in the form of personnel expenses and ancillary energy costs, plus the cost of any fuels required. A detailed description of the method used can be found in the Annex, Section 7.

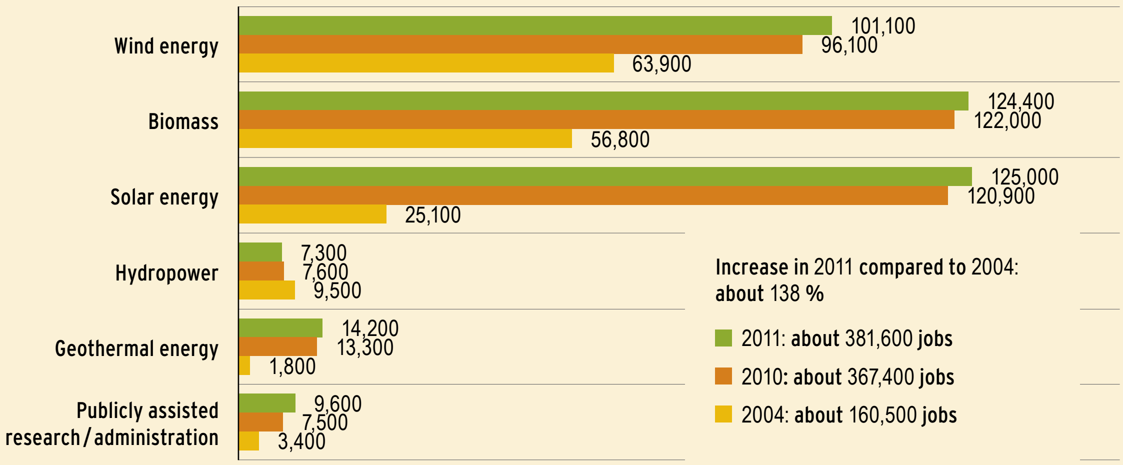
Employment in Germany's renewable energies sector

The importance of renewable energy sources as an economic factor in Germany is continuing to grow. This is reflected by high investment in installations, and also by an ongoing rise in employment in this sector. According to a current BMU research project [38], initial estimates indicate that a total of more than 382,000 jobs in Germany can be attributed to the renewable energy sector in 2011. This is more than double the figure for 2004 (approx. 160,000 employees). About 276,500 jobs, i.e. more than two thirds of the jobs counted in 2011, were due to the effects of the Renewable Energy Sources Act.

The number of employees is determined on the basis of data on investments in installations for the use of renewable energy, expenditure on their operation, estimates of foreign trade by the relevant industry and the relevant intermediate products, e.g. the necessary supplies of biomass, and also industrial intermediate products by other sectors. Employment resulting from public and non-profit funds in this sector must be added to this figure including employees in the public service.

Worldwide economic expectations for 2012 are subdued as a result of the unsolved problems of the Euro zone, fears of overheating in the newly industrialising countries and the uncertainties of the American debt crisis. This situation could affect the markets for renewable energy, but it could also result in a move into these very markets. Another critical factor is the performance of German renewable energy industry on the global markets. According to [38] it is still possible that the number of employees in the renewable energy sector will continue to rise to between 500,000 and 600,000 by 2030. In addition, macroeconomic model calculations (most recently [63]) have been used to set the present negative factors against the positive effects on employment and calculate the resulting net employment. This indicates that in virtually all scenarios analysed, an ambitious expansion of renewable energy sources in Germany leads on balance to more jobs than an energy supply system that largely dispenses with renewable energy. A separate study has ascertained the employment situation for 2011 in the individual Länder and the boost that the production facilities in individual Länder give to the regions. Its findings were published on the BMU's renewable energy website (see below) in June 2012 [115]. More information on this topic can be found on the BMU website www.erneuerbare-energien.de/40289.

Employment in Germany's renewable energies sector



Sources: BMU [62], [63], [38]

Initial and further training in the renewable energy sector in Germany

The expansion of renewable energy in Germany is to make dynamic progress in the years ahead, and to this end the German government has set ambitious targets. This expansion also has positive effects on the labour market. Today already around 382,000 people (see page 40) have jobs in this sector, and the number of employees can continue to rise in the years to come. To ensure that there are enough skilled employees available for this fast-growing market of the future, the topic of renewable energy needs to be addressed at every level in the field of initial education and further training. In recent years the Federal Environment Ministry has initiated discussion processes which in some cases have already led to activities on a basis that cuts across trades or educational paths. The educational sector is now called upon to take up "Renewables" as the topic of the future.

The project-oriented assistance for renewable energy sources by the Federal Environment Ministry (see www.erneuerbare-energien.de/42761) has helped to take a closer look at the field of education for renewable energy and to develop teaching material for various educational areas. For example, schools and initial and further vocational training establishments can obtain a wide variety of material, e.g. from the BMU Education Service (www.bmu.de/6807).

At university level a large number of courses geared to renewable energy have emerged, including some permitting a special focus on this field. As yet, however, there is no regularly updated overview of the opportunities for further education and the quality of the offerings.

An initial overview is provided by Internet portals on industry-specific opportunities for further education in the field of renewable energy. The following list is only a selection and makes no claim to completeness.

Information portal for Studies Renewable Energies	This information portal on studies in renewable energies provides extensive details of masters and bachelor programmes in Germany in the field of renewable energy, plus information on dual studies with integrated training, professional development courses in the different federal Länder, entrance requirements, duration of courses and career opportunities. www.studium-erneuerbare-energien.de/
Knowledge portal – Energieagentur NRW	This knowledge portal of the energy services provider for the state of North Rhine-Westphalia includes a database for training and professional development courses in the field of renewable energy. whoiswho.wissensportal-energie.de/
Wissenschaftsladen Bonn	Scientific portal on renewable energy, with training options, job offers and information on renewable energy trade fairs. www.jobmotor-erneuerbare.de/
Education portal Wind energy	An education portal focussing on wind energy, with information on qualifications in the field of wind energy, degrees in on- and offshore wind energy studies, and training, further training and professional development courses. www.bildungsportal-windenergie.de/bildungsportal/suche_index.html
SolarServer – Online portal to Solar Energy	This internet portal on solar energy contains comprehensive information on the solar sector, including training and professional development courses. www.solarserver.de/branchen/ausbildung-und-fortbildung.html
German Renewable Energies Agency	The information platform of the German Renewable Energies Agency brings users up-to-date on developments in renewable energy, with further details and links to sites for employment, training and professional development opportunities. www.unendlich-viel-energie.de/de/wirtschaft/arbeitsplaetze-erneuerbare-karriere.html
Career portal of the energy industry	This website on work prospects in the energy sector contains job offers, career advice and information on working in the energy industry as a whole. Includes a platform for those seeking or offering internships. www.energiejobs.de/

Support under the Renewable Energy Sources Act (EEG), and cost apportionment to electricity price

At present, electricity generated from renewable sources in Germany and paid for under the Renewable Energy Sources Act (EEG) is still, on average, more expensive than electricity from fossil or nuclear sources[1]. This gives rise to assistance costs which are passed onto electricity customers as part of the electricity price by means of an EEG apportionment. In 2011, approximately 600 particularly electricity-intensive companies in the manufacturing industry and railways profited from the special compensation provision in the EEG, being largely exempted from this apportionment [123]. As a result, the EEG costs paid by all other electricity customers are currently around 20 percent higher.

How is the EEG apportionment calculated?

Since 2010 the apportionment procedure for EEG costs has been set out in detail in the Renewable Energy Sources Act and related ordinances – especially the Equalisation Mechanism Ordinance (Ausgleichsmechanismus-Verordnung – AusglMechV). Under these provisions, the four transmission grid operators market the EEG electricity directly via the electricity exchange. The expected difference between the proceeds of sale on the electricity exchange and the costs of the payments to operators of EEG installations and the costs of marketing the EEG electricity is distributed pro rata over the entire final EEG power consumption by means of the EEG apportionment. This increases the suppliers' electricity procurement costs. Under the Compensating Mechanism Ordinance, the transmission grid operators have to submit an estimate of the expected EEG cost differential by 15 October for the coming year and publish the resulting nationwide EEG apportionment. The latter then applies to the entire following year. Any surplus or deficit on the EEG account as a result of market trends deviating from the forecast must then be adjusted in the year after that. Further information can be found in [132] and on the grid operators' EEG apportionment platform (www.eeg-kwk.net).

EEG apportionment in 2011

On 15 October 2010 the transmission grid operators had estimated total expenditure of around 17.1 billion Euro for 2011. The corresponding income was expected to be 4.7 billion Euro. Owing to the underestimated EEG apportionment for 2010, the EEG account also showed a deficit of around 1.1 billion Euro, and this backlog went into the calculations for 2011. Thus the difference of approx. 13.5 billion Euro between income and expenditure was to be met in 2011 via the EEG apportionment, resulting in an EEG apportionment of 3.53 cents per kilowatt-hours for 2011 [124].

Development of EEG cost differential for non-privileged electricity customers

Year	EEG cost differential [bn Euro]
2000	0.9
2001	1.1
2002	1.7
2003	1.8
2004	2.4
2005	2.8
2006	3.3
2007	4.3
2008	4.7
2009	5.3
2010	9.4
2011	12.1

Nominal data, after deduction of grid charges. In view of the change in the calculation method, the figures for since 2010 are not directly comparable to those for previous years.

Figures are calculated on the basis of the final EEG account and therefore differ from the grid operators forecasts.

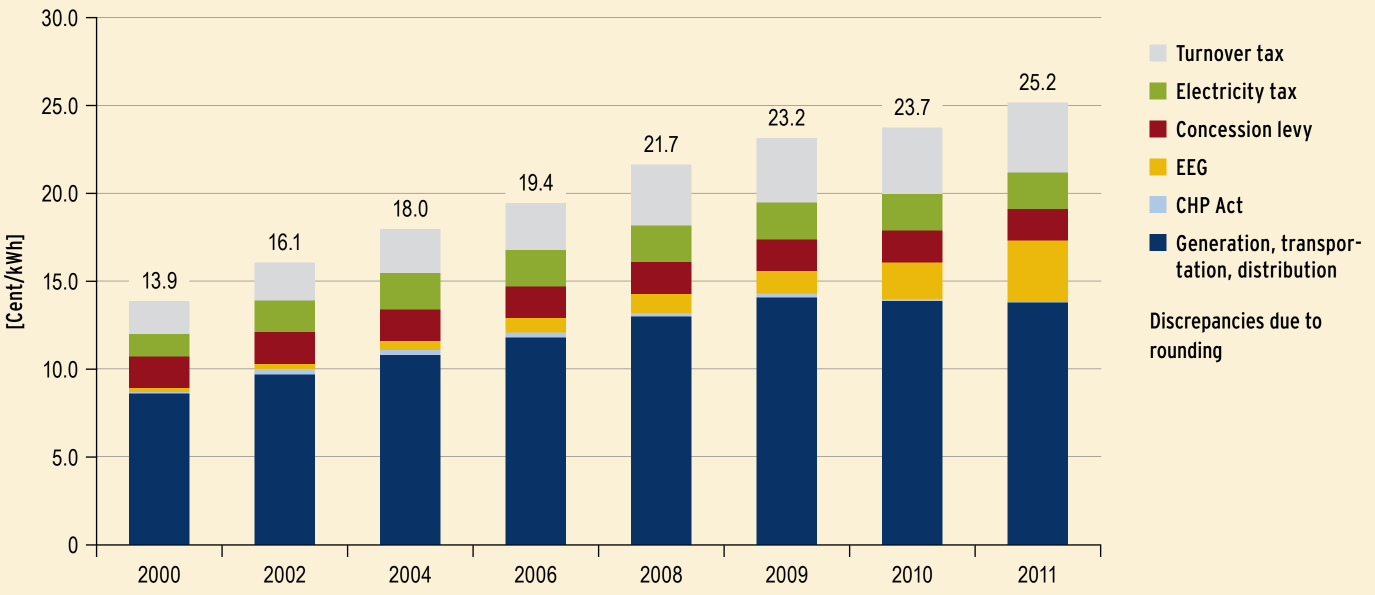
Source: IfnE [7]

1) One reason for this is the fact that this business calculation fails to take account of various items on the benefits side. A macroeconomic view could result in a different picture; for more details see pages 54, 56 and the sources cited there.

In retrospect, important assumptions made in this estimate for 2011 proved to be incorrect. On the one hand the net increase in the number of photovoltaic installations and the development of the payments for biomass were underestimated. This resulted in higher costs for the transmission grid operators in 2011. On the other hand, the proceeds of sale for EEG electricity fell short of expectations because of low price levels on the electricity exchange. In view of this situation, the transmission grid operators' EEG account showed a deficit of around 700 million Euro at the end of October 2011, which was taken into account when calculating the EEG apportionment for 2012.

The final EEG accounts for 2011 presented in July 2012 confirm the provisional estimates. They showed that the precisely calculated EEG cost differential for 2011 came to around 12.1 billion Euro. In purely mathematical terms this results in an EEG apportionment of about 3.2 cents per kilowatt-hour for 2011.

Cost components for one kilowatt-hour of electricity for household consumers



Sources: see table below

	2000	2002	2004	2006	2008	2009	2010	2011
	Cent/kWh							
Generation, transportation, distribution	8.6	9.7	10.8	11.8	13.0	14.1	13.9	13.8
CHP Act	0.1	0.3	0.3	0.3	0.2	0.2	0.1	0.03
EEG	0.2	0.3	0.5	0.8	1.1	1.3	2.1 [1)]	3.5 [1)]
Concession levy	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Electricity tax	1.3	1.8	2.1	2.1	2.1	2.1	2.1	2.1
Turnover tax	1.9	2.2	2.5	2.7	3.5	3.7	3.8	4.0
Total	**13.9**	**16.1**	**18.0**	**19.4**	**21.7**	**23.2**	**23.7**	**25.2**

1) The table includes the EEG apportionment levied each year on the basis of the operators' forecasts. The EEG annual statements give rise to calculated figures of around 2.3 Cent/ kilowatt hour (2010) and around 3.2 Cent/ kilowatt hour (2011).

Sources: IfnE [7]; BDEW [23]

Merit-order effect

When analysing the effects of renewable energy sources and specifically of the Renewable Energy Sources Act on electricity prices, it is also important to take account of the "merit-order effect". This describes the influence that preferential feed-in of electricity generated from renewables, especially wind power and increasingly from photovoltaic installations, has on wholesale electricity prices.

The merit-order system determines that as the demand for conventional electricity decreases, the most expensive power plants that would otherwise be used are no longer needed to meet the demand. Accordingly, the exchange price falls. Whereas this reduces the income of the electricity generators, the suppliers and – depending on market conditions – electricity consumers profit from the price reductions. Several scientific studies, some commissioned by the Federal Environment Ministry (most recently [135]), have shown that the merit-order effect has reached substantial dimensions in the past, even on the basis of conservative assumptions. They indicate that the electricity price reduction effect of EEG-assisted electricity generation amounted to around 0.9 cent/kilowatt hours (ct/kWh) in 2011 or – in terms of the entire quantity of electricity traded on the spot market – a good 4.6 billion Euro. Whether, and to what extent, these effects will be reflected in the electricity prices paid by final consumers, depends largely on the electricity suppliers' procurement and market behaviour. The main beneficiaries of the merit-order effect are probably the particularly electricity-intensive companies privileged under the special compensation provisions of the Renewable Energy Sources Act. Whereas their EEG apportionment is limited to 0.05 ct/kWh, they generally tend to gain the most benefit, as special-contract customers, from falling electricity prices on the exchange.

Impacts of the merit-order effect

	Simulated EEG electricity generation	Reduction in Phelix Day Base	Cost reduction due to merit-order effect
Year	[TWh]	[ct/kWh]	[bn EUR]
2009	76.1	0.61	3.1
2010	83.5	0.53	2.8
2011	102.0	0.87	4.6

Sources: Sensfuß [135], [148]

Structure for electricity quantities paid for under EEG since 2000

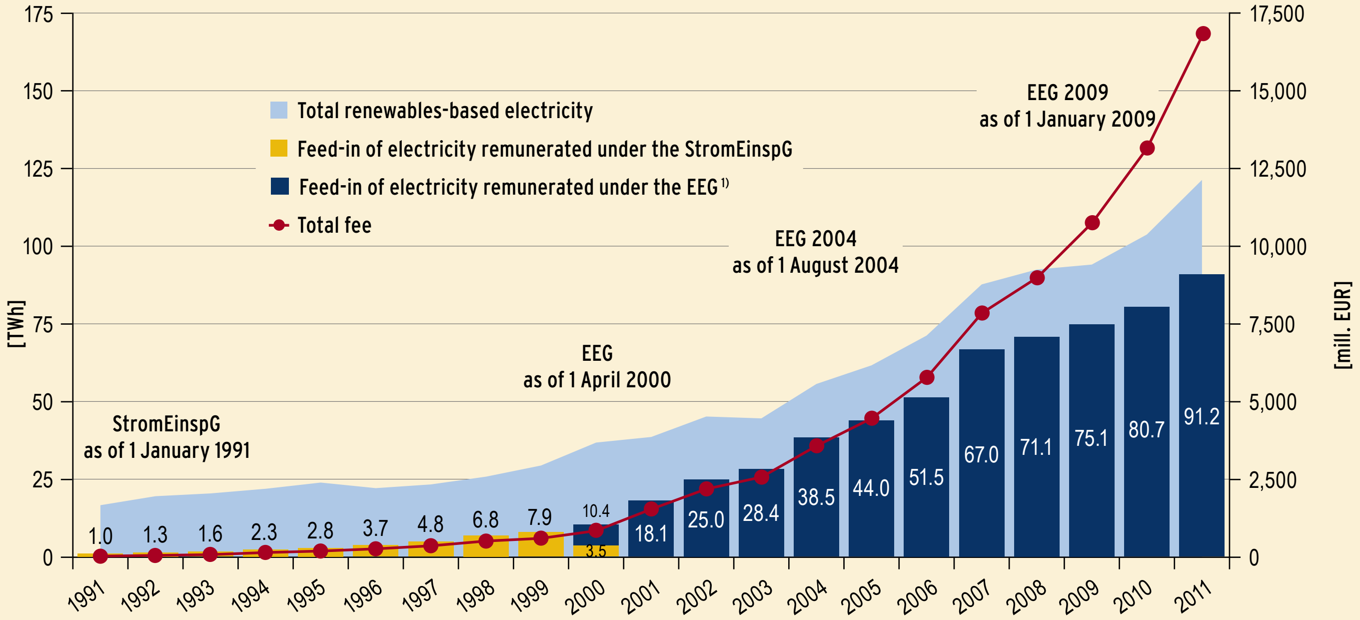
		2000 1)	2002	2004	2006	2008	2010	2011 5)
Total end consumption	[GWh]	**344,663**	**465,346**	**487,627**	**495,203**	**493,506**	**485,465**	**462,205**
Privileged end consumption 2)		–	–	36,865	70,161	77,991	80,665	85,118
Total remunerated EEG electricity 3)		**10,391.0**	**24,969.9**	**38,511.2**	**51,545.3**	**71,147.8**	**80,698.9**	**91,227.6**
Hydropower, gases 4)		4,114.0	6,579.3	4,616.1	4,923.9	4,981.5	5,049.0	2,397.2
Gases 4)		–	–	2,588.6	2,789.2	2,208.2	1,160.0	487.3
Biomass		586.0	2,442.0	5,241.0	10,901.6	18,947.0	25,145.9	23,373.6
Geothermal energy		–	0.0	0.2	0.4	17.6	27.7	18.8
Wind energy		5,662.0	15,786.2	25,508.8	30,709.9	40,573.7	37,633.8	45,611.1
Solar irradiation energy		29.0	162.4	556.5	2,220.3	4,419.8	11,682.5	19,339.5
Average fee 5)	**[ct/kWh]**	**8.50**	**8.91**	**9.29**	**10.88**	**12.25**	**15.86**	**17.94**
Total fee 6)	**[bn EUR]**	**0.88**	**2.23**	**3.61**	**5.81**	**9.02**	**13.18**	**16.76**
Non-remunerated renewables-based electricity	[GWh]	28,790	20,678	17,541	20,112	21,841	23,627	31,958
Total renewables-based electricity	**[GWh]**	**39,181**	**45,648**	**56,052**	**71,657**	**92,989**	**104,326**	**123,186**

1) Short year: 01.04. – 31.12.2000
2) Final consumption privileged under the special compensation provisions of the Renewable Energy Sources Act (EEG) since July 2003
3) These figures do not contain subsequent corrections (2002 to 2010), since the additional feed-in quantities shown by auditors' certificates for previous years cannot be allocated to individual energy sources.
4) Landfill gas, sewage gas and mine gas shown separately for the first time in 2004
5) After deduction of grid charges
6) Total compensation before deduction of avoided grid fees

Further information can be found on the Internet information platform of the German transmission grid operators at www.eeg-kwk.net.

Sources: ÜNB [68]; ZSW [1]

Feed-in and fees under the Electricity Feed Act (StromEinspG) since 1991 and the Renewable Energy Sources Act (EEG) since 1 April 2000



1) Private and public feed-in

Sources: VDEW [28]; ÜNB [68]; ZSW [1]

Expanding the use of renewables in the heat and mobility sectors: Legislation, promotion and impacts

Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz)

More than half of the final energy consumed in Germany is used for heating and cooling purposes. For this reason the expansion of renewable energies in the heating and refrigeration market (in combination with advances in energy saving) plays a central role in achieving the overall objectives. The most important instrument is the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG) for the new buildings sector, in combination with the market incentive programme for renewable energies in the heat sector (MAP) for existing buildings. The Renewable Energies Heat Act entered into force on 1 January 2009 and was most recently amended on 1 May 2011 to transpose European requirements into German law.

The Act lays down a binding target for heat (and cold) from renewable energy sources. In 2020 at least 14 percent of the heat (and cold) in Germany is to be provided by renewable energy. This is intended to reduce CO_2 emissions in the energy supply sector, conserve fossil resources and make a contribution to reliable and sustainable energy supplies.

The Act requires owners of new buildings constructed since 1 January 2009 to use a certain minimum percentage of renewable energy sources for their heating and cooling needs. This use requirement may be satisfied by all forms of renewable energy used to generate heat/cold (e.g. solar radiation, geothermal energy, ambient heat or biomass), including combinations of various renewable energy sources. Instead of technologies for using renewable energy, it is also possible to use other climate-friendly measures, known as “substitute measures”. Possible variants here include the use of heat from combined heat-and-power generation (CHP), exhaust heat or district heating, and also better thermal insulation going beyond the standards of the Energy Saving Ordinance. As a result, the costs of the use requirement and its fulfilment are incurred by the developer or owner of the new building.

Since 1 May 2011 public buildings have been required to set an example in the use of renewables for supplies of heat and cold. In the case of new public buildings, and also major renovation of existing public buildings, the public sector now has to ensure that a minimum proportion of heating and cooling requirements is covered by renewable energies (e.g. solar energy, geothermal energy, ambient heat or biomass). The European Renewable Energy Directive 2009/28/EC requires all Member States to continue expanding the use of renewable energy sources in the heating and cooling sector as well; public buildings are to set an example here. The regulations on this exemplary function take account of the specific needs of the public sector, and especially of local authorities. Since the model function initially gives rise to higher investment costs for local authorities in particular, the Federal Environment Ministry provides targeted assistance under existing support programmes to help local authorities live up to their model function. In particular, support facilities for investment by local authorities are available under the market incentives programme and under the National Climate Initiative in line with the Local Authority Guidelines.

The second pillar of the Act on the Promotion of Renewable Energies in the Heat Sector is financial assistance. Today the Act forms the legal framework for assistance under the market incentive programme for renewable energy sources (MAP). The MAP, in existence since 1994, has been gradually expanded and is now the main support instrument helping to ensure that by 2020 the target of 14 percent of heat supply from renewables is achieved for existing buildings (figure for 2011: 11.0 percent).

The Renewable Energies Heat Act lays down that the federal authorities will provide needs-appropriate support of up to 500 million Euro per year for the use of renewable energy for heat generation in the years 2009 to 2012. Since 2011 the financial resources of the support instrument MAP have come partly from the federal budget and partly from the Energy and Climate Fund (EKF).

The financial assistance provided in the heat sector is thus fundamentally different from the assistance in the electricity sector under the Renewable Energy Sources Act (EEG), which levies a surcharge from electricity consumers (EEG apportionment) to finance the feed-in payments for electricity from renewables.

The market incentive programme (Marktanreizprogramm)

Practical implementation of the market incentive programme (MAP) is by means of administrative guidelines which lay down the content of and requirements for the individual areas of assistance. These “Guidelines on support for measures for the use of renewable energy sources in the heat market” are reviewed regularly, as a rule annually, to bring them into line with the latest technology and the latest market developments.

The market incentive programme provides two kinds of support:

- Investment grants through the Federal Office of Economics and Export Control *(Bundesamt für Wirtschaft und Ausfuhrkontrolle – BAFA)* for small installations by mainly private investors in the single-family or two-family homes segment, and

- Reduced-interest loans with repayment grants under the KfW’s Renewable Energies programme (premium variant) for larger heating solutions, mostly in the commercial or municipal fields.

During the period from 2000 to 2011, the BAFA component provided investment grants to assist some 1.05 million solar thermal installations and more than 270,000 small biomass heating systems. The resulting investments totalled about 8.9 billion Euro in the solar segment and about 3.9 billion Euro in the biomass segment.

Efficient heat pump systems, which have been eligible for assistance since 2008, received about 75,000 investment grants between 2008 and 2011. The resulting volume of investment totalled around 1.3 billion Euro.

In the KfW component, some 10,900 reduced-interest loans with repayment grants were approved during the period 1999 to 2011, resulting in a total loan volume of approx. 2.1 billion Euro, for example for large biomass installations, deep geothermal energy installations, local heating networks and heat storage facilities fed from renewables. Of the total of 10,900 loans approved, more than 2,800 were in the year 2011.

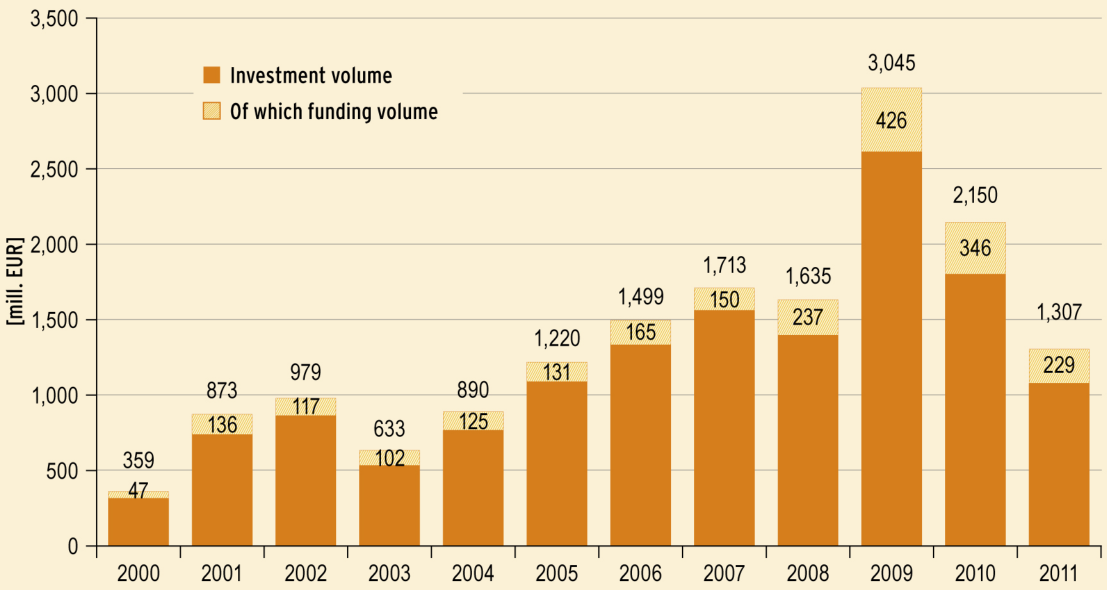
All in all, the market incentive programme with its assistance volume of about 229 million Euro in 2011 triggered an investment volume of 1.3 billion Euro.

Further information on the market incentive programme can be found on the website www.erneuerbare-energien.de in the section on Government Funding.

Information on investment grants under the market incentive programme is available from the Federal Office of Economics and Export Control (*Bundesamt für Wirtschaft und Ausfuhrkontrolle – BAFA*), Tel. +49 6196 908-625, www.bafa.de (section on Energy/Renewable Energy Sources).

Inquiries about reduced-interest loans under the commercial/municipal part of the market incentive programme (KfW Renewable Energy programme, Premium variant) are answered by the information centre of the KfW Banking Group, Tel. +49 1801 335577, www.kfw.de (section on Domestic Promotion/search term: Renewable energies).

Assistance funding and resulting investment volumes of Market Incentive Programme since 2000



Source: BMU – KI III 2

Biofuels: Promotion and relevant legislation

The Biofuel Quotas Act *(Biokraftstoffquotengesetz)* of 2007 requires the oil industry to market a growing percentage of biofuels governed by a quota system. Both admixtures and pure biofuels count towards the quota (in both cases they are subject to the full rate of energy tax for petrol and diesel fuel). Pure biofuels outside the quota enjoy tax concessions until the end of 2012.

Since 2011, assistance for biofuels under the Biofuels Sustainability Ordinance has depended on whether their production meets certain sustainability requirements. In the interests of environmental protection, nature conservation and climate protection, cultivation of such crops must not result in the destruction of areas subject to special protection (e.g. rainforests) or land with a high carbon content (e.g. wetlands, peat bogs). The biofuels must achieve a greenhouse gas reduction of at least 35 percent compared to fossil fuel. And finally, cultivation of biomass within the EU must satisfy the cross compliance requirements.

The biofuels share of total motor fuel consumption (excluding water and air traffic) in Germany was 5.5 percent in 2011.

Under the EU Directive on the promotion of the use of energy from renewable sources, a binding minimum figure of 10 percent for renewables in the transport sector is laid down for every EU Member State for the year 2020, as is the introduction of sustainability standards. This quota does not have to be covered entirely by biofuels, however. The renewables percentage in the electric mobility sector also counts towards the quota.

How society benefits from the use of renewable energies

The preceding pages have provided information on the positive impacts that the expansion of renewable energy has on investments and sales, employment and the reduction in energy imports and their costs. This section explains other positive impacts.

Reducing environmental pollution / Avoiding external costs

Compared to energy supplies from fossil energy sources, using energy from renewable sources involves much lower emissions of greenhouse gases and in some cases of air pollutants as well. In this way renewables make a significant contribution, which as a positive effect can be expressed in monetary terms and set against the costs of renewable energy expansion in a systematic analysis. The complex methodological issues that this raises have been examined more closely in studies for the Federal Environment Agency [126] and the Federal Environment Ministry (cf. [50], [53], [55], [125] and [147]). From these studies it is possible to arrive at a figure of 80 Euro per tonne CO_2 as the current "best estimate" of the harmful climate impacts avoided by using renewables. On this basis, the two following illustrations show the environmental pollution arising from emissions of conventional greenhouse gases (after IPCC, without "black carbon") and air pollutants, as a monetary quantification in cents per kilowatt hours for the main power and heat generation options. Power and heat generation based on fossil energy sources causes much greater environmental damage than generation of heat or power from renewables. However, the environmental damage shown has to be set against expenditure by companies on CO_2 emission allowances; as a rule these are incurred by electricity generators and to a small extent by heat generators for the purchase of CO_2 allowances. This is intended to at least partially offset the environmental damage caused. Thus the expenditure on allowances results in partial internalisation of the environmental damage, though this still falls well short of the environmental damage actually caused.

Simply as a result of the 128 million tonnes (t) CO_2 avoided thanks to all renewable energy sources (power, heat and mobility) in 2011, the above-mentioned estimate of 80 Euro per t CO_2 gives rise to parallel avoidance of climate damage (only CO_2 emissions, without partial internalisation) totalling about 10 billion Euro.

According to [50] and [147], the use of renewable energy sources in the electricity and heat sectors avoided environmental damage (greenhouse gases and air pollutants) of around 10.1 billion Euro. Of this, renewables contributed about 8 billion Euro in the electricity sector and about 2.1 billion Euro in the heat sector. Taking account of the costs for CO_2 allowances, i.e. the partial internalisation of environmental pollution [125], reduces these gross figures for avoided environmental damage to 9 billion Euro (6.9 billion Euro electricity).

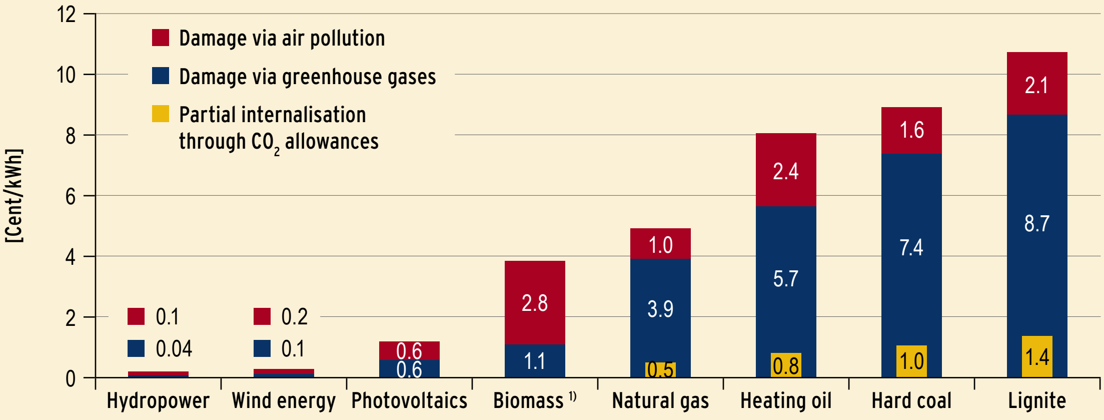
The cost estimates for monetary valuation of the environmental damage caused by emissions result from the sum of

- the costs due to climate change, which include lower yields, loss of land, impacts on health and water resources, and damage to the ecosystem etc., and
- the harmful effects on health, harvest losses, material damage and impairment of biodiversity that are caused by air pollutants.

The basic principle in determining the estimate of damage costs for the individual emission gases is to identify, at current costs, the damage that will occur in the future and in other countries as a result of present-day emissions.

The external costs of nuclear power and other energy supply risks (vulnerability, resource problems etc.) which are avoided by using renewable energy sources are not covered here because of the methodological problems involved in their calculation.

Specific environmental damage and CO_2 costs in cents per kilowatt hour of electricity by energy sources in 2011

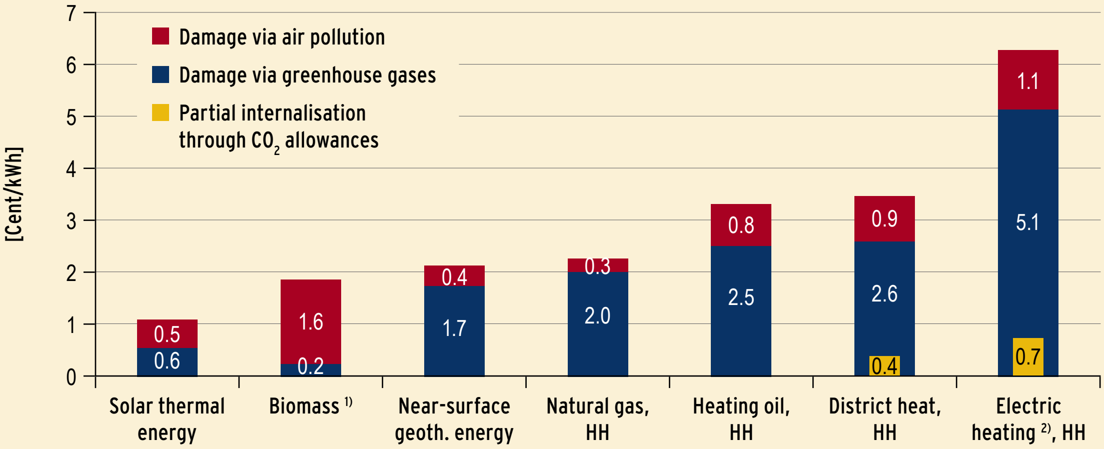


Provisional figures
Note: Average price for CO_2 allowances (2011) of 12.9 Euro per tonnes

1) Weighted average for solid, liquid and gaseous biomass, bandwidth from 1.9 to 7.2 cent/kilowatt hour

Sources: Own calculations Fraunhofer ISI after ISI et al. [147], [53], [50]; NEEDS [128]; UBA [75]; PointCarbon [127]

Specific environmental damage and CO_2 costs in cents per kilowatt hour of heat by energy sources in 2011



Provisional figures;
HH = households.
Note: Average price for CO_2 allowances (2011) of 12.9 Euro per tonnes

1) Weighted average for solid, liquid and gaseous biomass (households and industry), bandwidth from 0.3 to 3.2 cent/kilowatt hour
2) With grid losses

Sources: Own calculations Fraunhofer ISI after ISI et al. [147], [53], [50]; NEEDS [128]; UBA [75]; PointCarbon [127]

Other positive impacts for society of the expansion of renewable energies

In addition to the environmental damage avoided, the expansion of renewable energy sources has further positive impacts on society which have only been partly quantified or not quantified at all (cf. [50], [53]). These include:

- Conserving scarce resources
- Providing innovation impetus for construction of renewable energy installations
- Strengthening decentralised structures and hence also regional value added
- Transferring know-how, technologies and installations to other countries, and
- Reducing dependence on imports and strengthening security of supply by diversifying and reducing the risk potential of energy sources.

Another factor of great importance, which will continue to grow even more significant in the future, is the fact that the use of renewable energy sources reduces the competition for scarce resources and thus makes an indirect contribution to internal and external security. At a macroeconomic level these effects give rise to economic impulses which trigger or influence regional and national developments and which may ultimately have positive impacts on employment and value added.

Renewable energy sources and nature conservation

Climate change and the decline in biological diversity are the central challenges of the future for environmental and nature conservation policy. Without the services provided by nature it would be necessary to employ complex technical solutions involving very high costs. The expansion of renewable energy makes new and far-reaching demands on society and hence on nature conservation and landscape maintenance.

On the one hand the use of renewable energy sources results in the generation of heat and power, and in the motor fuels sector it reduces greenhouse gas emissions by cutting consumption of fossil resources. The climate-friendly effect has a positive impact on nature conservation, because rapid climate change can contribute to the loss of habitats and biodiversity. On the other hand, uncontrolled expansion of renewables can itself exert pressures on nature and landscape, e.g. through wind turbines, photovoltaic installations on open spaces, large-scale cultivation of energy crops, which may involve increasing competition for land use.

A high degree of efficiency, both in the generation and distribution of renewable energy and in the consumption of energy, reduces demand for renewable energy sources and can thus help to reduce the impact of society as a whole on nature and landscape. This means it is also a task of central importance to find appropriate locations for the various installations with a view to minimising the effects on nature and landscape. Financial control measures, such as those in the revised version of the Renewable Energy Sources Act of 1.1.2012, can also be used as incentives to avoid or minimise adverse impacts on nature and landscape and to promote a sustainable approach. For example, the Act counteracts undue cultivation of energy maize by placing a new cap on the use of maize in biogas installations, while at the same time creating financial incentives to make more intensive use of ecologically favourable substrates.

Considering the entire package of measures, the transformation of the energy system can also, given nature-friendly expansion of renewable energies, represent an opportunity for conserving biodiversity as an element of our natural capital and thereby have a positive impact on society as a whole.

Overview of the economic impacts of expanding renewable energies

In the preceding pages we have seen that while the expansion of renewable energy involves costs, it also gives rise to substantial benefits.

Public attention is often focused on the costs of renewable electricity under the Renewable Energy Sources Act. By contrast, other areas of application of renewable energy sources and especially the benefits associated with their expansion often tend to take a back seat. To fill this gap, the Federal Environment Ministry awarded extensive research work to a project team led by the Fraunhofer ISI/ Karlsruhe; in 2010 they published a first detailed report. This report was most recently updated in June 2011 with figures for important key indicators for 2011 [50]. A soundly based overall economic assessment of the economic effects of renewable energy sources in the sense of a cost-benefit analysis needs to take account of a wide range of complex aspects. The following overview of central interactions is one result of this project (compare (ISI et al. [50], [53]).

Interrelationships considered in an economic overview analysis of renewable energies

Category	System-analytical		Distribution aspects		Macroeconomic			Other interrelationships [1]
Impact type	Benefits	Costs	Burdens	Relief	Stimuli [2]	Gross effects [3]	Net effects [4]	
Analysis area	Differential costs, equalisation costs, control costs and grid expansion costs, transaction costs, taxation, support funding, employment and rev enue, avoided external costs, merit order, avoided imports, portfolio effects, ...							
Subject of analysis	Total renewable energies							
	Renewables-based electricity		Renewables-based heat					Other renewable energies [5]
	EEG-related	Independent of subsidies	MAP related	Independent of subsidies	EE-WärmeG			

1) The "miscellaneous effects" cannot be clearly allocated to the three main categories listed. They include possible effects of renewable energy expansion on innovation intensity, for example in the field of renewable energy technologies, spill-over effects in the technical and political fields, impacts on environmental awareness, changes in social norms with regard to ideas about climate protection, and advantages of renewable energy for internal and external security.
2) Investments, for example
3) Gross employment
4) Net employment, gross domestic product (GDP)
5) Transport/mobility, for example

Sources: ISI et al. [50], [53]

Some of the costs and benefits of renewable energy that have been identified up to now have yet to be quantified. This is true, for example, for their importance for internal and external security. In view of the wide range of effects, it is of central importance that quantitative comparisons are only possible within the individual main effect categories. The most useful approach to this to date is a systematic cost-benefit analysis.

A rough calculation of the existing quantitative system costs in the heat and power sectors reveals total costs of just under 11 billion Euro for 2011. In the same year this was offset by a quantified gross benefit of approx. 10 billion Euro, though only some of the benefit effects were quantified, while others were not taken into account (e.g. the lower risk potential of renewable energy sources). This static view of costs in 2011 therefore has to be supplemented by additional (especially dynamic) benefit effects such as spill-over effects of political and research and development (R&D) activities, technical progress and increased (supply) security, which cannot at present be quantified in monetary terms. Here, as in the other categories, there is still a considerable need for research. In view of the significant benefit items, it is nevertheless evident that any analysis of the expansion of renewable energies that is based on costs alone falls considerably short of the mark.

The following table provides an overview of the main cost and benefit effects currently known for heat and power generation from renewables.

Selected key figures for economic analysis of renewable energy expansion in Germany's electricity and heat sectors, 2011

System-analysis cost and benefit aspects			
	Costs	Benefits	
Direct cost differential, electricity	9.3 bn EUR		
Control/balancing energy [1]	approx. 0.16 bn EUR		
Grid expansion [1]	approx. 0.13 bn EUR		
Transaction costs [2]	approx. 0.03 bn EUR		
Total cost differential, electricity	approx. **9.6 bn EUR**	**8.0 bn EUR**	Environmental damage avoided by renewable electricity (gross) [5]
Direct cost differential, heat	**1.4 bn EUR**	**2.1 bn EUR**	Environmental damage avoided by renewable heat (gross) [5]
		n.q. [4]	Other benefit effects, especially dynamic ones, that have yet to be quantified in monetary terms (e.g. spill-over effects of politics and R&D activities, technological progress, reduced risk of major damage, especially nuclear power).
Total [5]	approx. **10.9 bn EUR**	approx. **10.1 bn EUR**	

Distribution effects			
	Total amount	Beneficiaries	Burden bearers
EEG cost differential/micro-economic additional costs	approx. 12.1 bn EUR [3]	Installation operators	All electricity customers except for beneficiaries of special compensation rule in EEG (reduced charge)
Merit-order effect (renewables-based electricity)	4.6 bn EUR	Electricity customers or suppliers, depending on cost transfer, probably power-intensive non-tariff customers in particular because of reduction in electricity exchange price	Conventional electricity producers
Taxation of renewables-based electricity [1]	1.6 bn EUR	Federal budget / state pension scheme	Electricity consumers, possibly renewables-based electricity producers (those who do their own marketing)
Federal assistance for renewable energy	0.6 bn EUR	Installation operators through market promotion, plant manufactures through R&D promotion	Federal budget
Special compensation provision in Renewable Energy Soruces Act [6]	approx. 2.2 bn EUR	Approx. 600 power-intensive companies and railways	All other electricity consumers

Macroeconomic and other effects (selection)	
Sales by German companies including exports (all renewables)	24.9 bn EUR
Employment (all renewables)	approx. 381,600 directly and indirectly employed persons
Energy imports avoided (all renewables)	approx. 7.1 bn EUR (gross); approx. 6.0 bn EUR (net)
Energy price, GDP effect	100 – 200 mill. EUR [7]
Impacts on internal and external security (reduced dependence on imports; lower risks etc.)	n.q. [4]

Provisional figures

1) Average
2) Estimates from 2008
3) Actual values on the basis of final EEG account according to [7]; grid operators forecast for 2010 were 13.5 billion Euro.
4) n.q. = not quantified
5) Simple netting of the different systems-analysis cost and benefit effects for 2010 is not possible, because important benefits have not yet been quantified and environmental damage avoided is only available as gross figures.
6) Grid operators' estimates
7) Latest figure available is for 2008

Sources: ISI [50]; IfnE [7]

Promotion of research and development in the field of renewable energies

Research and development projects on the technologies of renewable energy are promoted under the German government's energy research programme. The Federal Environment Ministry is responsible for promoting application-oriented projects in the field of renewable energy.

Investment in renewable energy sources helps to conserve scarce resources, reduce dependence on energy imports, and protect the environment and climate. Technical innovations reduce the cost of energy generated from renewable sources.

The Ministry also provides assistance for research and development in the renewables sector in relation to site-related and labour market aspects. Assistance for research strengthens the leading international position and competitiveness of German companies and research establishments. This gives rise to new jobs in a market that is growing worldwide.

Aims and key areas of assistance for research

The overarching aims of research assistance are:

- Expanding renewable energy as part of the German government's sustainability, energy and climate policy,
- Strengthening the international competitive position of German companies and research establishments,
- Creating jobs with a future.

To achieve these aims, the Federal Environment Ministry sets the following priorities:

- Optimise energy systems with regard to the growing share of renewable energy sources,
- Continuing technical development of the use of renewable energy sources in the individual segments,
- Ensuring green and nature-friendly expansion of renewable energy sources, e.g. by means of resource-conserving production methods (recycling-friendly design of installations) and ecological support research,
- Continuously reducing the cost of using renewable energy,
- Achieving rapid transfer of know-how and technology from the research sector to the market.

In 2011 the Federal Environment Ministry approved a total of 300 new projects with a volume amounting to more than 245 million Euro in the following fields: photovoltaic, geothermal energy, wind, low-temperature solar thermal energy, solar thermal power plants, marine energy, international cooperation, overall strategy, ecological support research and cross-sectoral issues.

The Ministry attaches great importance to transparent presentation of its assistance for research projects. Detailed information can be found in the Annual Report 2011, the free newsletter and the regularly updated overview of current research projects (www.erneuerbare-energien.de/inhalt/36049/).

The website of the Project Management Jülich (PtJ, www.ptj.de), commissioned by the Federal Environment Ministry, includes amongst others information on funding and on applications for research support programmes in the field of renewable energies.

Projects recently approved by the BMU

	2008			2009			2010			2011		
	[Number]	[1,000 EUR]	Share in [%]	[Number]	[1,000 EUR]	Share in [%]	[Number]	[1,000 EUR]	Share in [%]	[Number]	[1,000 EUR]	Share in [%]
Photovoltaics	38	39,735	26.3	36	31,446	26.6	45	39,842	28.3	96	74,332	30.3
Wind energy	32	40,097	26.6	45	28,227	23.8	37	52,956	37.6	74	77,102	31.5
Geothermal energy	18	16,381	10.9	14	14,892	12.6	30	15,045	10.7	42	24,056	9.8
Low-temp. solar thermal energy	20	10,129	6.7	17	7,013	5.9	16	6,795	4.8	21	9,367	3.8
Solar thermal power stations	15	8,217	5.4	22	8,612	7.3	16	9,667	6.9	20	11,164	4.6
System integration	26	28,184	18.7	6	11,458	9.7	22	12,227	8.7	26	26,269	10.7
Cross-sectoral research	11	3,004	2.0	16	3,314	2.8	16	3,517	2.5	17	4,896	2.0
Other	9	5,066	3.4	7	13,478	11.3	2	649	0.5	4	18,000	7.3
Total	**169**	**150,813**	**100.0**	**163**	**118,440**	**100.0**	**184**	**140,698**	**100.0**	**300**	**245,186**	**100.0**

Source: BMU – KI III5

Long-term sustainable use potential of renewable energies for electricity, heat and fuel production in Germany

	Final energy 2011	Achievable potential Yield	Output	Remarks
Electricity generation	**[TWh]**	**[TWh/a]**	**[MW]**	
Hydropower [1]	18.1	25	5,200	Running water and natural inflow to reservoirs
Wind energy [2]	48.9			
on land	48.3	175	70,000	Power calculated on the basis of the average value of 2,600 h/a
at sea (offshore)	0.6	280	70,000	Power calculated on the basis of the average value of 4,000 h/a
Biomass [3]	36.9	60	10,000	Some generation as CHP generation
Photovoltaics	19.3	150	165,000 [4]	Only suitable rooftop, facade and municipal areas
Geothermal energy	0.02	90	15,000	Range of 66–290 TWh, depending on requirements pertaining to heat use (CHP generation)
Total	**133.2**	**780**		
Share with respect to gross electricity consumption in 2011	**20.3 %**	**128.8 %**		
Heat generation	**[TWh]**	**[TWh/a]**		
Biomass [3]	131.6	170		Including useful heat from CHP generation
Geothermal energy	6.3	300		Only energy production from hydrothermal sources
Solar thermal energy	5.6	400		Only suitable rooftop and municipal areas
Total	**143.5**	**870**		
Share with respect to final-energy consumption for heat in 2011 [5]	**11.0 %**	**66.6 %**		
Fuels	**[TWh]**	**[TWh/a]**		
Biomass	34.2	90		2.35 million ha cultivation area for energy crops (of a total of 4.2 million ha cultivation area)
Total	**34.2**	**90**		
Share with respect to fuel consumption in 2011	**5.5 %**	**14.5 %**		
Share with respect to total final energy consumption in 2011	**12.5 %**	**72.1 %**		The percentage share of renewable energy use potential increases due to improvements in energy efficiency and energy savings, making a 100% supply of renewable energies possible in the long term.

The figures do not include renewables-based energy imports.
1) Excluding marine energy
2) Provisional figures (ongoing expert review)
3) Including biogenic waste
4) Capacity based on module output (megawattpeak); the corresponding alternating current capacity is around 150 gigawatt
5) Space heating, hot water and other process heat

Sources: BMU on the basis of AGEE-Stat; Scholz [25]; ZSW [1]; consortium: WI, DLR, IFEU [76]

Estimates of potential may show very considerable variations as a result of differing assumptions about the availability of suitable sites, the technical properties of the technologies used and other factors.

The guide values shown here take account of nature and landscape conservation issues in particular, and therefore represent a lower limit for the technically exploitable potential.

Use of biomass for energy purposes displays great flexibility. Depending on requirements, the allocation of potential to the heat, power and motor fuel sectors may vary. This applies in particular to the production of energy crops (determined here on the basis of 4.2 million hectares).

Long-term scenario 2011 for renewables expansion in Germany

The German government's Energy Concept of 2010 and the related legislation package from summer 2011 set out a long-term roadmap for climate protection and the transformation of the energy supply system in Germany. Under the Energy Concept, greenhouse gas emissions in Germany are to be cut by between 80 percent and 95 percent of 1990 figures by 2050. In the case of energy-induced CO_2 emissions this target requires a reduction ranging from at least 85 percent up to – ultimately – zero-emission energy supplies. The challenges of the necessary transformation of the energy system are considerable, and their full implications have yet to be grasped. The long-term scenarios 2011, commissioned by the Federal Environment Ministry and published in March 2012, present the findings of systems analysis studies. Like all their precursors, they are goal-oriented scenarios. On the basis of the technical and structural possibilities, and having regard to economic, political and social factors and interests and the resulting barriers and incentives, they identify consistent trends that can in principle result in achievement of the targets laid down in the Energy Concept.

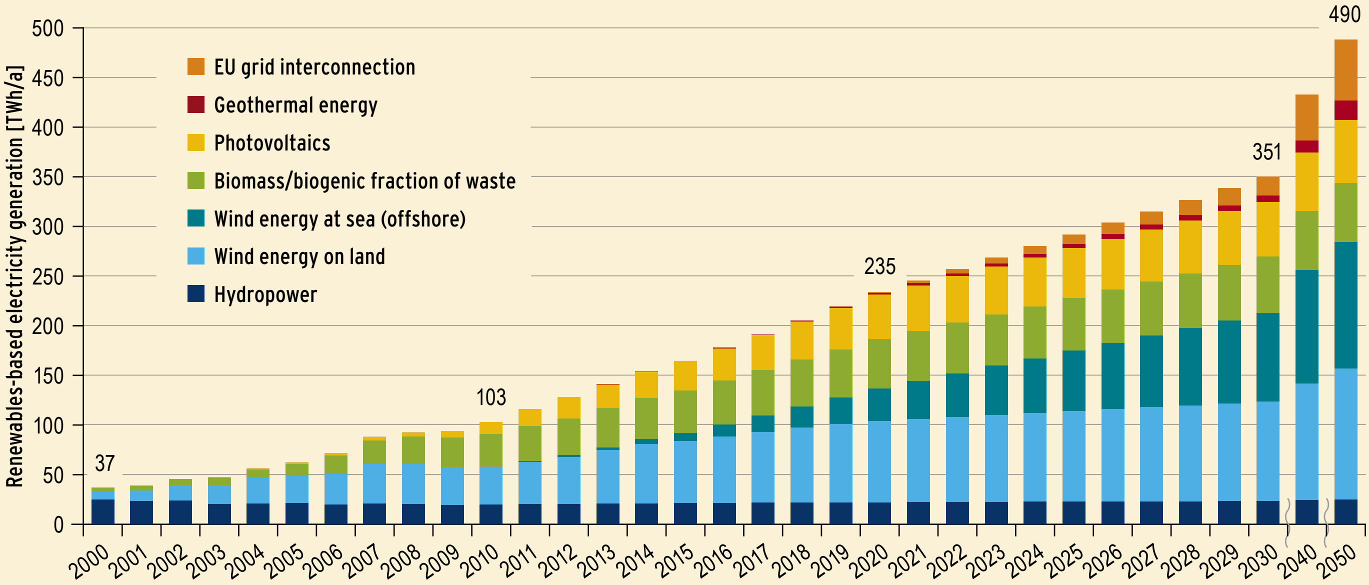
Strategies for achieving climate objectives: Expansion of renewable energies and extensive efficiency measures

The scale and relative importance of the principal strategies "Efficiency improvement" and "Renewables expansion" are defined within certain limits in the Scenarios 2011 by the individual targets of the Energy Concept. This basic objectives structure, which reflects the results of numerous earlier systems analysis studies, may be regarded as relatively well balanced and reliable. In the Scenarios 2011, which target an 80-percent reduction in greenhouse gas emissions by 2050, primary energy consumption falls to between 50 and 53 percent of the 2010 figure by 2050, and in 2020 it is already 19 percent lower. If the target of a 50-percent reduction in consumption by 2050 is to be achieved, primary energy productivity will have to increase by an annual average of 2.5 percent over the entire 40-year period on the basis of the assumed growth in gross domestic product (GDP). From 1990 to 2010 the average productivity increase was only around 1.6 percent per annum, which means that future efficiency improvements will have be considerably more effective.

Renewable energy sources predominate in 2050 with a share of 53 to 55 percent, and as early as 2020 their contribution to primary energy consumption is to double from present levels to 20 percent. Within the last decade the renewables share has tripled, corresponding to an average annual growth rate of 11 percent. The objectives targeted by the Energy Concept continue to call for extremely dynamic and steady growth of all renewable energy technologies up to the middle of the century. This applies primarily to electricity generation from renewable sources. By as early as 2020 their contribution is to rise to 235 terawatt hours (TWh) per annum (a) (Scenario 2011 A), a share of 41 percent. In 2030 renewables will provide 350 TWh/a, or around 63 percent of gross electricity consumption (compare diagram on page 61). The contribution of 490 TWh/a by renewable electricity generation that is necessary to achieve a greenhouse gas reduction of 80 percent by 2050 is made up of 53 percent wind power, 26 percent solar power (photovoltaic and solar electricity imports) and 4 percent geothermal electricity. The remaining 17 percent is met by hydropower and biomass, which with a combined total of 85 TWh per annum have exhausted their potential.

The scenarios describe various energy use options that become relevant for efficient use of large renewables shares from about 2030 onwards. In one case renewable electricity is used directly on a large scale as the future "main energy source" in all consumption sectors (Scenario C). Electricity storage in chemical form as hydrogen is used only to safeguard electricity supplies, and hydrogen is not used as a fuel. In the second case (Scenario A) renewable energy is also used on a large scale in the transport sector, while in the third case (Scenario B) hydrogen is replaced by synthetic methane. The target of a 95-percent reduction in greenhouse gases, corresponding to a supply system based almost entirely on renewable energy in all sectors, is described in another scenario (2011 THG95).

Development of electricity generation from renewable energies in Scenario 2011A



Source: DLR [134]

The marked expansion of renewable electricity, especially from sun and wind, leads to a distinct rise in renewable electricity generation capacity. The lower limit is characterised by Scenario C, the upper limits by Scenario THG95. From 65 gigawatts (GW) in 2011, installed renewable electricity generation capacity in Germany rises to between 164 and 217 GW by 2050. Around 80 percent of renewable electricity capacity derives from fluctuating sources: wind and photovoltaic. This calls for increasingly flexible residual load cover by means of easily controlled conventional generation capacity and, to an increasing extent, storage facilities. By contrast, the capacity of conventional power plants shows a continuous decline. In the longer term a controllable conventional capacity requirement in the order of 40 GW will continue to exist in the form of flexible gas-fired plants of various sizes, including on the basis of flexible combined heat-and-power generation (CHP) plants with heat reservoirs, and also storage facilities. To varying extents, the installed gas-fired plant capacity will in the longer term be supplied by hydrogen and/or methane. Together with the available component of renewable electricity capacity (biomass, hydro power, geothermal energy, imports of solar thermal electricity), this combination guarantees reliable electricity supplies at all times.

Costs and cost-effectiveness: Falling costs of renewable energy sources versus rising costs of fossil fuels

The total volume of investment in renewable energies in 2010 came to 27.9 billion Euro per annum, and 90 percent of this was in the electricity sector. The substantial rise in recent years is due to photovoltaic installations, investment in which accounted for a share of 70 percent. In the medium term the volume of investment in renewable energies will level out at between 17 and 19 billion Euro per annum. Up to the end of 2010 a total of around 150 billion Euro was invested in renewable energy installations for power and heat generation. In the coming decades up to 2050 the level of investment in renewable energies will be around 200 billion Euro per decade. This investment needs to show a considerably larger increase, to between 250 and 350 billion Euro per decade, if the upper climate objective (-95 percent greenhouse gas emissions) is to be achieved by 2060.

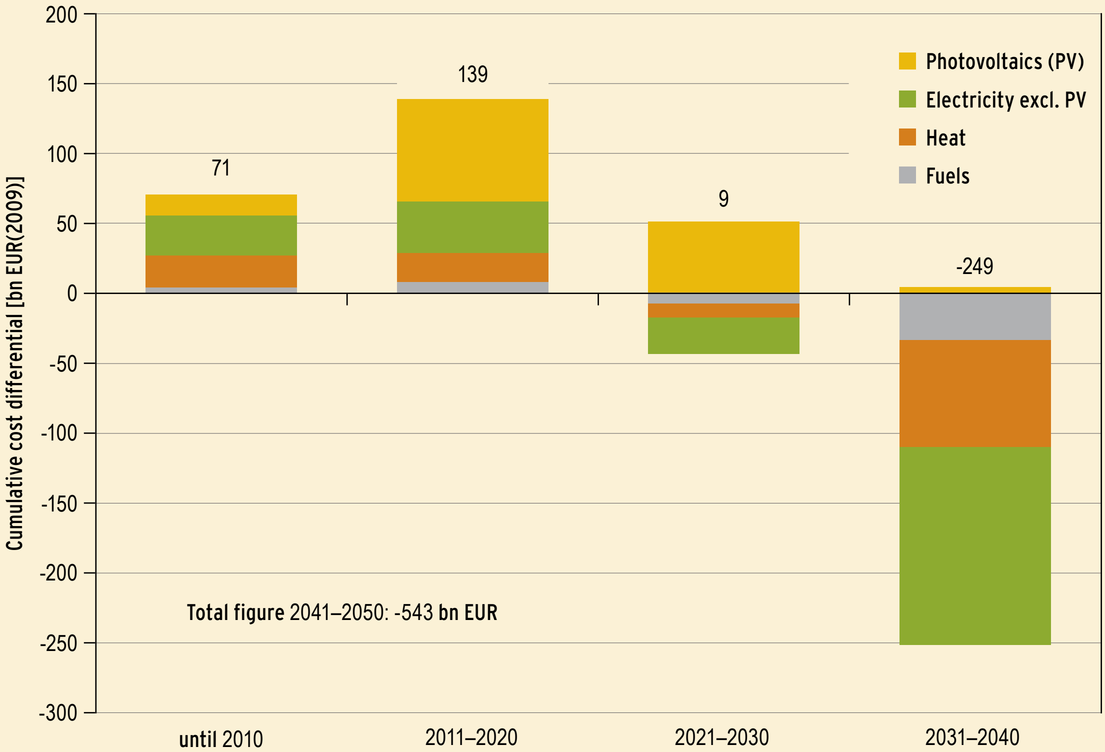
The replacement of fossil fuel power plants by renewables-based installations goes hand in hand with a massive shift in “energy expenditure” to the investment sector. This will substantially reduce expenditure on buying increasingly expensive fossil fuels. In 2010, renewable energies were already avoiding imports of fossil fuels to the tune of about 6 billion Euro. The cost savings for imports in the scenarios rise to between 30 and 40 billion Euro per annum by 2030 and between 60 and 70 billion Euro per annum by 2050. This is only one of the beneficial aspects of renewable energy expansion.

The national cost of introducing renewable energies is set out in the form of differential costs compared with a fictitious energy supply that meets its energy requirements without renewable energy. As a central result, the diagram on the following page shows the cumulative differential costs revealed by systems analysis for the entire renewable energy expansion project for the price path A: “Substantial”. Total system-analytical differential costs accumulated up to 2010 for overall renewable energy expansion came to 71 billion Euro, compared with applicable energy costs to date. If one adds the following 10-year blocks to this figure, the cumulative differential costs rise to 210 billion Euro by 2020, with only a small further rise to 219 billion Euro by 2030. Of this, renewable electricity expansion accounts for 76 percent and renewable heat supply for 15 percent. By 2040 the cumulative system-analytical differential costs of all renewable energy technologies are fully offset, with a net balance of -30 billion Euro (219 – 249 billion Euro). By the middle of the century, renewable energy supplies will already have saved some 570 billion Euro in potential additional expenditure that would have been incurred by continuing the fossil energy supply system.

The model economic calculations show that the transformation of the energy system targeted in the Energy Concept can only be pursued on a market-driven basis if energy price signals adequately reflect the avoided costs of climate change and other unconsidered harmful impacts of fossil energy procurement. This calls for a substantial change in market design compared with the present situation. Short-term marginal costs of electricity supply in combination with an unsatisfactory emissions trading scheme are not suitable signals for the road to a sustainable energy future.

At present the necessary incentives in the form of funding instruments and other governmental "guard rails" tend to be regarded more as additional costs and hence as "burdens". Energy policy must therefore devote special attention to the necessary and ultimately beneficial task of correcting this "market failure" and ensuring acceptance of the incentives.

Cumulative system-analytical differential costs of electricity, heat and fuel supply from renewable energy sources [1)]



Note: Compared with a fossil energy system, assuming a future increase in fossil fuel prices in line with price path A: "Marked".
1) Scenario 2011A for 10-year periods

Source: DLR [134]

PART II: RENEWABLE ENERGIES 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 came into force in June 2009, sets ambitious targets: by 2020, energy from renewable energy sources is to meet 20 percent of gross final energy consumption and at least 10 percent of energy requirements in the transport sector.

Directive 2009/28/EC of the European Parliament and of the Council entered into force on 25 June 2009. This new EU directive on the promotion of renewable energy is part of the European Climate and Energy Package implementing the decisions of the spring summit of heads of state and government (European Council) of 9 March 2007. The binding target of this directive is to raise the renewables-based share of total gross final energy consumption in the EU from about 8.5 percent in 2005 to 20 percent in 2020.

The Directive takes the EU target of 20 percent and breaks it down into differentiated overall national targets for the Member States for renewable energy as a percentage of gross final energy consumption in 2020. These binding national targets are based on the initial figures for the baseline year 2005 and individual national potential. On this basis, the national targets for the EU Member States for 2020 range from 10 percent for Malta to 49 percent for Sweden. A national target of 18 percent is laid down for Germany.

As well as the national target, the Directive lays down a uniform target for renewable energy in the transport sector of at least 10 percent of energy consumption. Thus in addition to biofuels, the Member States can also count electricity from renewable energies that is used for rail traffic or electric vehicles.

For achieving the national targets, the Directive largely puts its faith in national promotion programmes. The Member States are free in the design of their promotion system, so that they can exploit their potential in the best possible way. In addition, the Directive introduces flexible cooperation mechanisms which give Member States the opportunity to cooperate if necessary to meet their targets. These cooperation mechanisms are: statistical transfer of renewable energy surpluses, joint projects for promoting renewable energy, or (partial) merging of national promotion systems of two or more Member States.

The Directive provides that the Member States shall approve national action plans for achieving their targets, and shall submit regular progress reports to the Commission until 2020. It also requires that electricity from renewable sources is to be given priority access to the grid and defines – for the first time – sustainability requirements for the production of biomass for use as energy. However, the sustainability criteria in the Directive apply only to biofuels and biogenic liquid fuels. In February 2010 the European Commission presented a report on sustainability criteria for gaseous and solid bioenergy. Unlike the binding sustainability criteria in the directive, however, the report merely contains recommendations for the Member States.

The Directive introduces the first overall legislation in the EU for all sectors of renewable energy: power, heat/cold, and transport. The Directive thus replaces the expired EU-wide provisions on the promotion of renewable energy, the EU Directive on the promotion of renewable energy sources in the electricity market, and the Biofuels Directive. The Electricity Directive which came into force in 2001 provides for an increase in the percentage of electricity generation due to renewable energy from 14 percent in 1997 to 21 percent by 2010 in the EU-25. The Biofuels Directive lays down a target of 5.75 percent for biofuels as a percentage of motor fuel consumption in 2010.

The new, all-embracing EU Directive on the promotion of renewable energy sources creates a reliable EU-wide legal framework for the necessary investments and thereby lays the foundations for continuing successful expansion of renewable energy up to 2020.

Progress report pursuant to Article 22 of Directive 2009/28/EC on the promotion of the use of energy from renewable sources

The first progress report for the years 2009 and 2010 submitted to the European Commission in accordance with Directive 2009/28/EC on the promotion of the use of energy from renewable sources shows Germany's progress towards achieving its targets in the expansion of renewable energies.

At the end of 2011 the Member States presented to the European Commission the first progress report under EU Directive 2009/28/EC on the situation with regard to national development of renewable energy (to be followed by similar reports every two years).

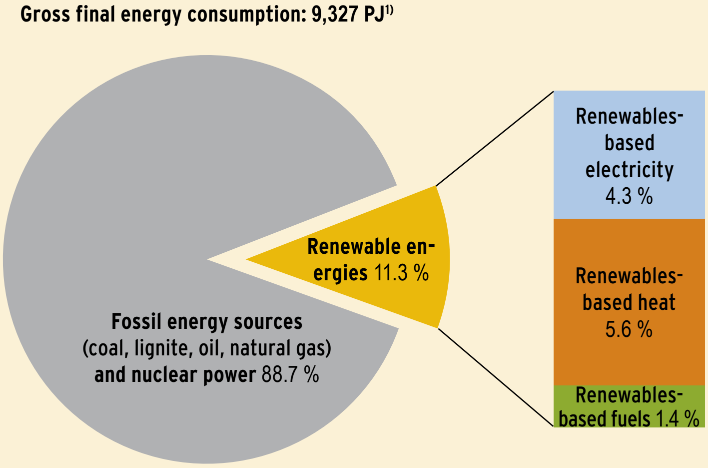
Calculations on the basis of data for 2010 using the method in the EU directive yielded a figure of 11.3 percent for renewable energy as a percentage of gross final energy consumption in Germany. After 10.2 percent in 2009, this is an increase of 1.1 percentage points, despite the fact that total gross final energy consumption in 2010 was up by more than 4 percent on 2009 as a result of economic and weather conditions (from 8,947 petajoule (PJ) to 9,327 PJ).

Thus Germany remains well on course to achieve its ambitious targets for the expansion of renewable energy: by 2020 renewable energy sources are to account for 18 percent of total gross final energy consumption. According to the development path shown in Germany's National Renewable Energy Action Plan (NREAP), the German government believes that the renewables share of gross final energy consumption may be as high as 19.6 percent. The percentage of electricity due to renewable energy sources in 2020 is put at 38.6 percent.

With the renewables share of 11.3 percent of gross final energy consumption in 2010, Germany has already exceeded the national interim target of EU Directive 2009/28/EC for the years 2013/2014 (9.46 percent). Further efforts are nevertheless essential, especially in the heat sector, to ensure reliable long-term achievement of the targets for 2020.

Information on the national progress reports of each Member State can be found on the website of the European Commission www.ec.europa.eu/energy/renewables/reports/2011_en.htm.

Renewable energy shares of gross final energy consumption in Germany 2010 in accordance with EU Directive 2009/28/EC



The Directive contains detailed instructions for calculating renewable energy sources as a percentage of gross final energy consumption. In view of special rules, the results obtained with this method are not comparable with the data on national development (see p. 12 ff.). For explanations of the method used in the EU Directive, see Section 9 of the Annex to this brochure.

1) EEFA estimate [67]

Sources: BMU on basis of AGEE-Stat, ZSW [1]; provisional figures, as at 31.12.2011

Future development of renewable energies in the EU – Estimate based on the National Renewable Energy Action Plans (NREAPs) of the EU Member States

Planned development of renewable energy supplies in the EU on the basis of the National Action Plans of the EU Member States

	Renewables-based energy supply [TWh]				Average annual growth rate [%/per annum]			Share [%]
	2005	2010	2015	2020	2005/2010	2010/2015	2015/2020	2020
RE – electricity	479	638	901	1,216	5.9	7.1	6.2	**34.5**
RE – heating/cooling	632	789	985	1,297	4.5	4.6	5.7	**21.4**
RE – transport 1)	36	163	230	345	35.2	7.1	8.5	**9.5** 2)
Total renewable energy	**1,147**	**1,591**	**2,117**	**2,860**	**6.8**	**5.9**	**6.2**	**20.8**

The Energy Research Centre of the Netherlands (ECN) was commissioned by the European Environment Agency to process and evaluate the NREAPs with the aim of generating estimates for EU-27. The published report [119] contains two different approaches which in some cases lead to slightly different results: either the data were determined on the basis of the detailed plans, or aggregated data were taken over from the NREAPs.
The data documented in the table were determined on the basis of detailed plans in the NREAPs.

1) Having regard to Art. 5.1 of EU Directive 2009/28/EC
2) Does not correspond to the renewables share in the transport sector according to the EU directive.

Source: ECN [119]

In 2009 the EU set itself the binding target that by the year 2020 one fifth of gross final energy consumption was to be met by renewable energy sources. The way to achieving this target is described in the National Renewable Energy Action Plans (NREAP) of the EU Member States, which detail the existing and planned measures, instruments and policies for supporting the expansion of renewable energy in relation to the individual national targets. In their National Action Plans, twelve EU Member States have expressed the expectation that they will exceed the national targets set out in the EU Directive: Austria, the Czech Republic, Denmark, Germany, Hungary, Lithuania, Malta, the Netherlands, Poland, Slovenia, Spain and Sweden.

The ECN analysis of all NREAPs shows that the binding EU target of 20 percent in 2020 will not only be achieved, but will probably be exceeded with a figure of 20.8 percent. The National Action Plans also set out targets for the various use sectors which provide information about the development of sectoral shares in the EU. The electricity sector will have a renewables share of 34.5 percent by 2020. Figures of 21.4 percent and 9.5 percent respectively are forecast for renewable energy in the heating/cooling sector and the transport sector [119].

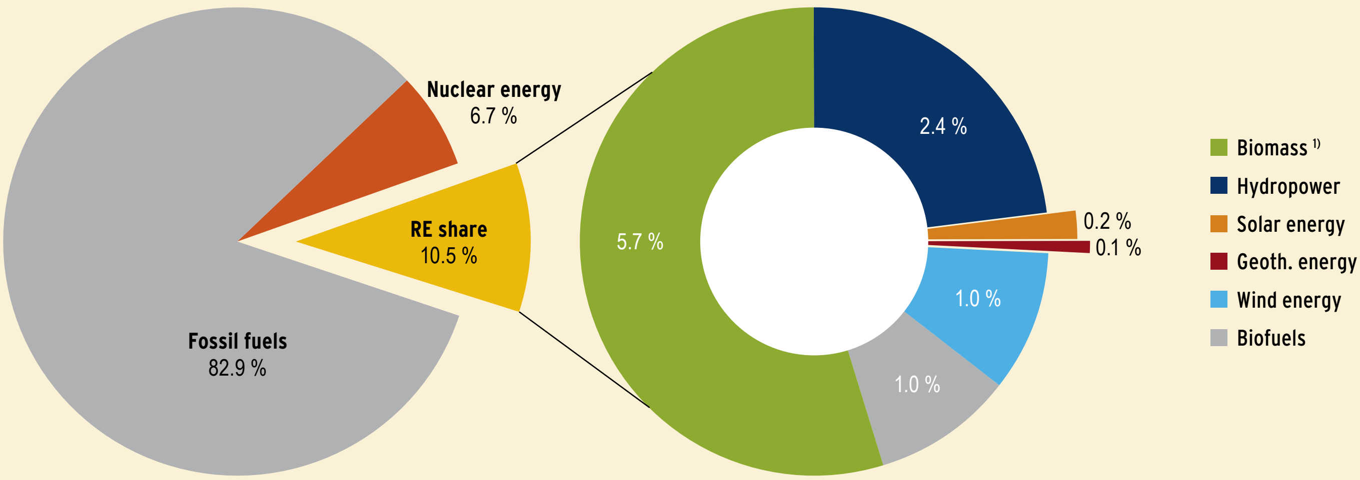
Use of renewable energies in the EU

A competitive, sustainable and secure energy supply is the key element for continued favourable development of industry and the economy in the EU and the prosperity of the population. Thus the expansion of renewable energy supplies is an essential element of the EU Strategy 2020. The introduction of the Electricity Directive in 2001 gave a positive impetus to the expansion of renewables in the electricity sector. Further expansion in all use sectors is largely governed by EU Directive 2009/28/EC.

Looking back over the last decade, two technologies have displayed particularly rapid development: photovoltaics and wind power. Starting from a total installed capacity of 180 megawatt peak (MW_p) in 2000, development in the photovoltaic sector has been exponential. At the end of 2011 photovoltaic modules with a total capacity of 51.4 gigawatt peak (GW_p) were in place in the EU, following the addition of some 21.5 GW_p new capacity during the year. On a global scale, installed photovoltaic capacity at the end of 2011 was more than 67 GW_p [120, 143].

Wind power capacity in the EU Member States has shown more than a fivefold increase in the last decade. New wind power installations constructed during 2011 had a capacity of 9,616 MW. As a result, total available capacity in the EU Member States at the end of 2011 came to around 94 GW. This corresponds to 40 percent of global wind power capacity [111].

Structure of final energy consumption in the EU by energy sources, 2009



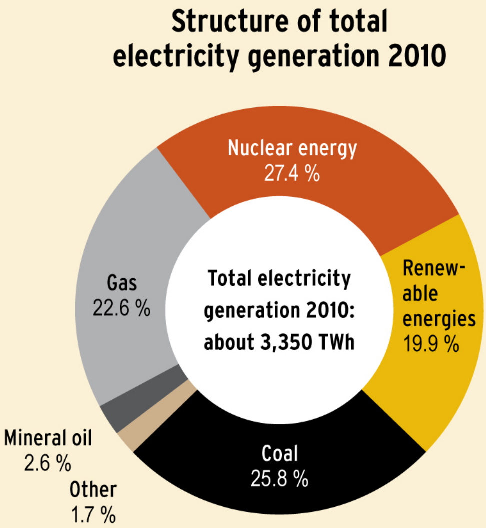
Note: Here final energy consumption is not calculated in accordance with the requirements of EU Directive 2009/28/EC. The share due to marine energy stood at 0.004 percent (0.5 terawatt hours) and is too small to be seen in the diagram. Owing to rounding, the sum of the individual renewables shares does not correspond to the total renewables share of 10.5 percent.

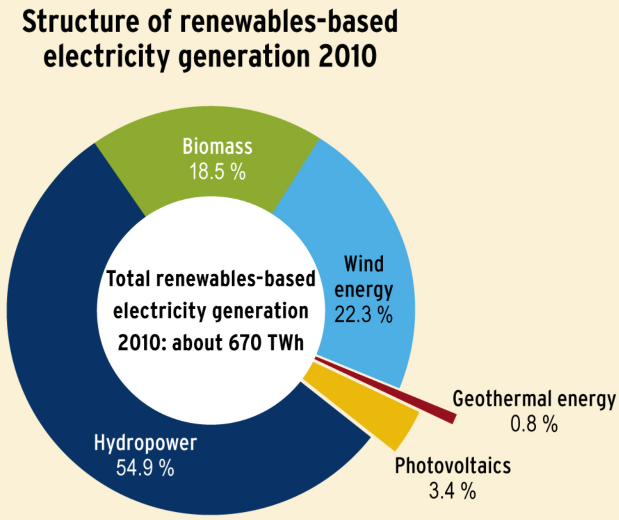
To date, statistics on final energy consumption have usually only shown the consumer shares. The diagram here shows a breakdown by individual energy sources and is calculated on the basis of various IEA statistics. The shares shown are merely intended to indicate the relative scale of the individual components.

1) Including biogenic fraction of municipal waste

Source: ZSW [1] after according to IEA [104]

Renewables-based electricity supply in the EU





Other = industrial waste, non-renewable municipal waste, pumped storage etc.
Generation in solar thermal power stations and tidal energy are not shown due to the small quantities involved.

Source: ZSW [1] according to Eurostat [98]

Renewables-based electricity supply in the EU

	1990	1997	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	[TWh]												
Biomass [1]	14.3	25.9	34.1	36.5	41.9	48.4	58.9	69.1	78.0	87.1	93.9	107.2	123.3
Hydropower [2]	286.2	331.8	352.5	372.5	315.0	305.8	323.2	305.6	309.3	310.0	327.3	328.2	366.2
Wind energy	0.8	7.4	22.3	26.7	36.3	44.4	58.9	70.4	82.3	104.3	119.5	133.0	149.1
Geoth. energy	3.2	4.0	4.8	4.6	4.8	5.4	5.5	5.4	5.6	5.8	5.7	5.5	5.6
Photovoltaics	0.01	0.06	0.1	0.2	0.3	0.5	0.7	1.5	2.5	3.8	7.4	14.0	22.4
Solar therm. power	–	–	–	–	–	–	–	–	–	0.008	0.02	0.10	0.69
Total [3]	**305.1**	**369.7**	**414.4**	**441.0**	**398.8**	**405.0**	**447.8**	**452.5**	**478.2**	**511.5**	**554.4**	**588.5**	**667.8**
RE share of gross electricity consumption [%] [4]	**11.6**	**13.0**	**13.6**	**14.2**	**12.7**	**12.6**	**13.6**	**13.6**	**14.2**	**15.1**	**16.4**	**18.3**	**19.9**

1) Including biogas and the renewable fraction of municipal waste
2) In the case of pumped storage systems, generation from natural inflow only
3) Including electricity generated by the La Rance tidal power station in France. In view of the present small contribution of marine energy to total electricity supply, the time series for this technology is not shown here.
4) Gross electricity consumption = gross electricity generation plus imports minus exports

This overview reflects the present state of available statistics (see Sources).

Source: ZSW [1] after according to Eurostat [98]

Renewables-based electricity supply in the EU Member States in 2010

	Biomass 1)	Hydropower 2)	Wind energy	Geothermal energy	Photovoltaic power	Total	RE share of gross elec. consumption	Target values (EU directive 2001/77/EC)
	[TWh]						[%]	[%]
Belgium	4.3	0.3	1.3	–	0.6	6.5	6.8	6.0
Bulgaria	0.04	5.1	0.7	–	0.02	5.8	15.1	11.0
Denmark	4.6	0.02	7.8	–	0.01	12.5	33.1	29.0
Germany	33.7	20.4	37.8	0.03	11.7	103.6	16.9	12.5
Estonia	0.7	0.03	0.3	–	–	1.0	10.8	5.1
Finland	11.0	12.9	0.3	–	0.01	24.2	26.5	31.5
France	4.7	62.0	10.0	–	0.6	77.8 3)	14.5	21.0
Greece	0.2	7.5	2.7	–	0.2	10.5	16.7	20.1
Ireland	0.3	0.6	2.8	–	–	3.7	12.8	13.2
Italy	9.4	51.1	9.1	5.4	1.9	77.0	22.2	25.0
Latvia	0.1	3.5	0.05	–	–	3.6	48.5	49.3
Lithuania	0.1	0.5	0.2	–	–	0.9	7.8	7.0
Luxembourg	0.1	0.1	0.1	–	0.02	0.3	3.1	5.7
Malta	–	–	–	–	N/A	–	–	5.0
Netherlands	7.0	0.1	4.0	–	0.1	11.2	9.3	9.0
Austria	4.6	38.4	2.1	–	0.1	45.1	61.4	78.1
Poland	6.3	2.9	1.7	–	–	10.9	7.0	7.5
Portugal	2.6	16.1	9.2	0.2	0.2	28.4	50.0	39.0
Romania	0.1	19.5	0.3	–	–	19.9	34.2	33.0
Sweden	12.2	66.4	3.5	–	0.01	82.1	54.5	60.0
Slovakia	0.7	5.3	0.01	–	–	5.9	20.5	31.0
Slovenia	0.2	4.5	–	–	0.01	4.7	33.1	33.6
Spain	3.9	42.3	44.2	–	6.4	97.4 4)	33.1	29.4
Czech. Republic	2.2	2.8	0.3	–	0.6	5.9	8.3	8.0
Hungary	2.3	0.2	0.5	–	–	3.0	7.1	3.6
United Kingdom	11.9	3.6	10.2	–	0.03	25.7	6.7	10.0
Cyprus	–	–	0.03	–	0.01	0.04	0.7	6.0
EU	**123.3**	**366.2**	**149.1**	**5.6**	**22.4**	**667.8**	**19.9**	**21.0**

This overview reflects the present state of available statistics (see Sources). These figures may differ from national statistics, partly because of different methods. All figures are provisional; any discrepancies in totals are due to rounding differences

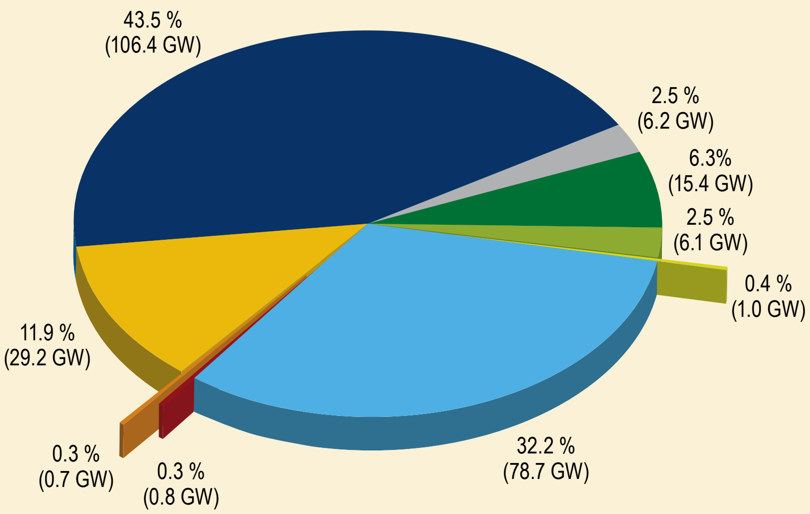
1) Including landfill gas and sewage gas, other biogases and the biogenic fraction of municipal waste
2) Gross generation; in the case of pumped storage systems, generation from natural inflow only
3) Total includes 0.53 terawatt hours of electricity generated by the La Rance tidal power station.
4) Total includes 0.69 terawatt hours of electricity generated in solar thermal power plants.

Source: ZSW [1] according to Eurostat [98]

More than half the electricity generated in the EU in 2010 was produced from fossil energy sources. The EU Electricity Directive which came into force in 2001 gave an important boost to the expansion of renewables in the electricity sector, one of the aims being to reduce the EU Member States' dependence on imports.

In the Renewable Energy Directive 2009/2008/EC, the EU set itself the binding target of supplying 20 percent of total gross final energy consumption from renewable energy sources by 2020. To achieve this target it will be necessary to increase the renewables share in the electricity sector to over 30 percent.

Structure of total installed capacity for renewables-based electricity generation in the EU, 2010



Total installed capacity for renwables-based electricity supply approx. 244 GW

- Hydropower
- Waste [1)]
- Wood/wood waste
- Biogas [2)]
- Biogenic liquid fuels
- Wind energy
- Geothermal energy
- Solar thermal energy
- Photovoltaics

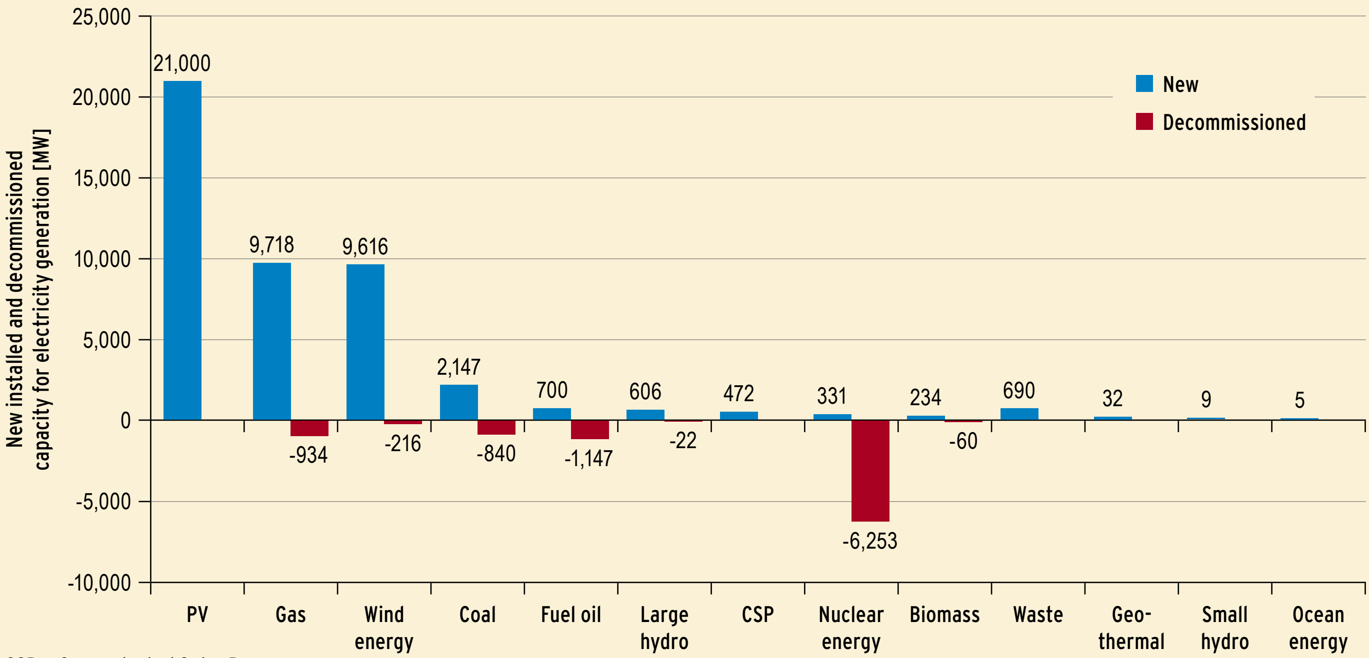
Provisional figures

1) Renewable and non-renewable fractions of municipal waste
2) Including landfill gas and sewage gas

Source: ZSW [1] according to Eurostat [98]

At the end of 2010, renewables-based power generation capacity through the EU totalled about 244 gigawatts (GW). The European Wind Energy Association (EWEA) estimates new construction of all power generation technologies in the course of 2011 at a total of over 45 GW, of which about 72 percent was due to renewables. With a figure of 21 GW, the photovoltaic sector was responsible for nearly half of all new construction, followed by gas with a capacity increase of around 9.7 GW and wind with around 9.6 GW. For the second year in succession, more capacity was added (approx. 2.2 GW) than shut down (0.84 GW) in the coal-fired power plant sector. Nuclear power generation capacity was reduced by more than 6 GW in 2011. The expansion of capacity in the heating oil sector (0.7 GW) failed to offset the loss of 1.1 GW due to capacity shut down [100].

Electricity generation capacity added and decommissioned in the EU in 2011

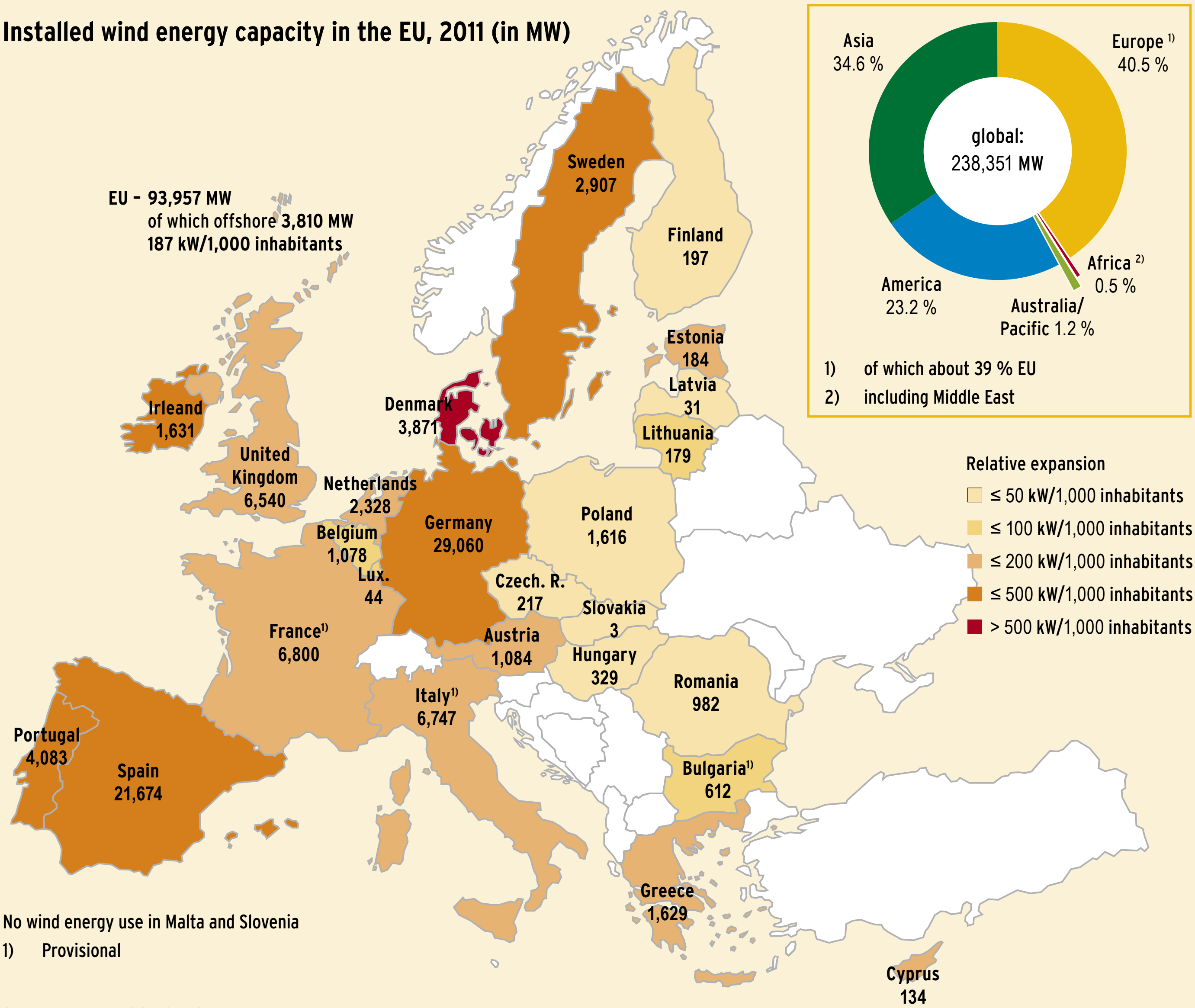


CSP = Concentrated Solar Power

Source: EWEA [100]

Wind energy use in the EU

Installed wind energy capacity in the EU, 2011 (in MW)



No wind energy use in Malta and Slovenia

1) Provisional

Sources: EWEA [100]; GWEC [111]

At the end of 2011 wind energy installations were in use in about 75 countries for electricity generation, and as many as 22 countries had broken the gigawatts (GW) barrier. Total global wind energy capacity was around 238,351 megawatts (MW), following the addition of more than 41,000 MW during the year. With new record additions of 18,000 MW, nearly half the global market volume, China once again headed the Top Ten list of market players. It was followed, at a considerable distance, by the USA with 6,810 MW. The other rankings with additions of more than 1 GW were India (3,019 MW), Germany (2,086 MW), United Kingdom (1,293 MW), Canada (1,267 MW) and Spain (1,050 MW) [111], [146].

In terms of cumulative wind energy capacity, China also further improved its leading position with 62,733 MW, followed by the USA (46,919 MW) and Germany (29,060 MW) [111].

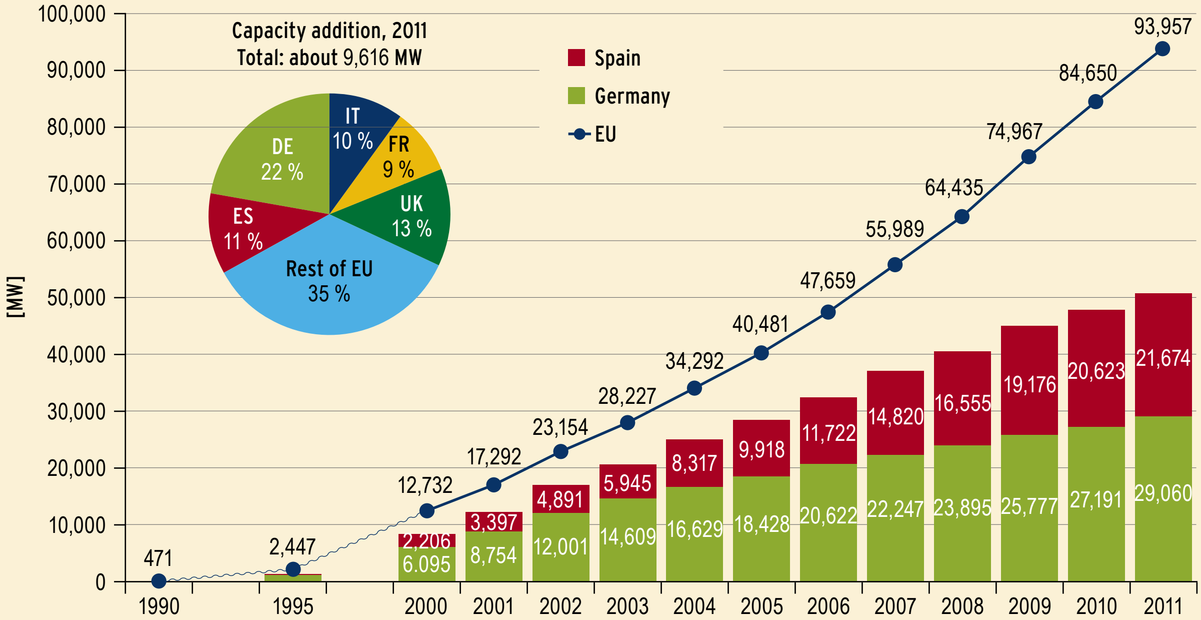
Notwithstanding the turbulent economic developments of recent years, the use of wind energy in the EU is continuing to show steady expansion. At the end of 2011, total installed wind energy capacity came to 93,957 MW – an increase of 11 percent compared to the year before. Germany continues to lead the field with a total capacity of 29,060 MW, ahead of Spain, France, Italy and the United Kingdom [100]. The picture is different when it comes to relative expansion, however. Here Denmark leads with 696.1 kilowatt (kW) per 1,000 inhabitants, while Germany, with 355.5 kW per 1,000 inhabitants, is only in fifth place after Spain (469.6 kW/1,000 inhabitants), Portugal (383.9 kW/1,000 inhabitants) and Ireland (364 kW/1,000 inhabitants). The average for the EU was 187 kW/1,000 inhabitants.

An additional 9,616 MW of wind energy capacity was constructed during 2011. With additions of 2,086 MW, Germany was by far the largest wind energy market in the EU. The United Kingdom took second place with 1,300 MW, and Spain was the third-largest market with 1,050 MW [100].

According to the European Wind Energy Association (EWEA), the wind energy capacity currently installed in the EU can generate 204 terawatt hours (TWh) of renewable electricity in a normal wind year, thereby supplying 6.3 percent[1)] of total electricity consumption in the EU [100]. EurObserv'ER estimates actual wind power generation for the years 2010 and 2011 at 149.1 TWh and 172.1 TWh respectively [101].

1) Basis of calculation: Gross electricity consumption 2009: 3,225.2 TWh (Eurostat).

Development of cumulative wind energy capacity in the EU Member States



Note: Data for 2011 provisional

Total wind energy capacity in 2011 does not correspond exactly to the sum of installed capacity at the end of 2010 plus additions in 2011; this is due to repowering and closures of existing wind turbines (see also p. 73) and to data rounding.

Source: EWEA [100]; Eurostat [98]

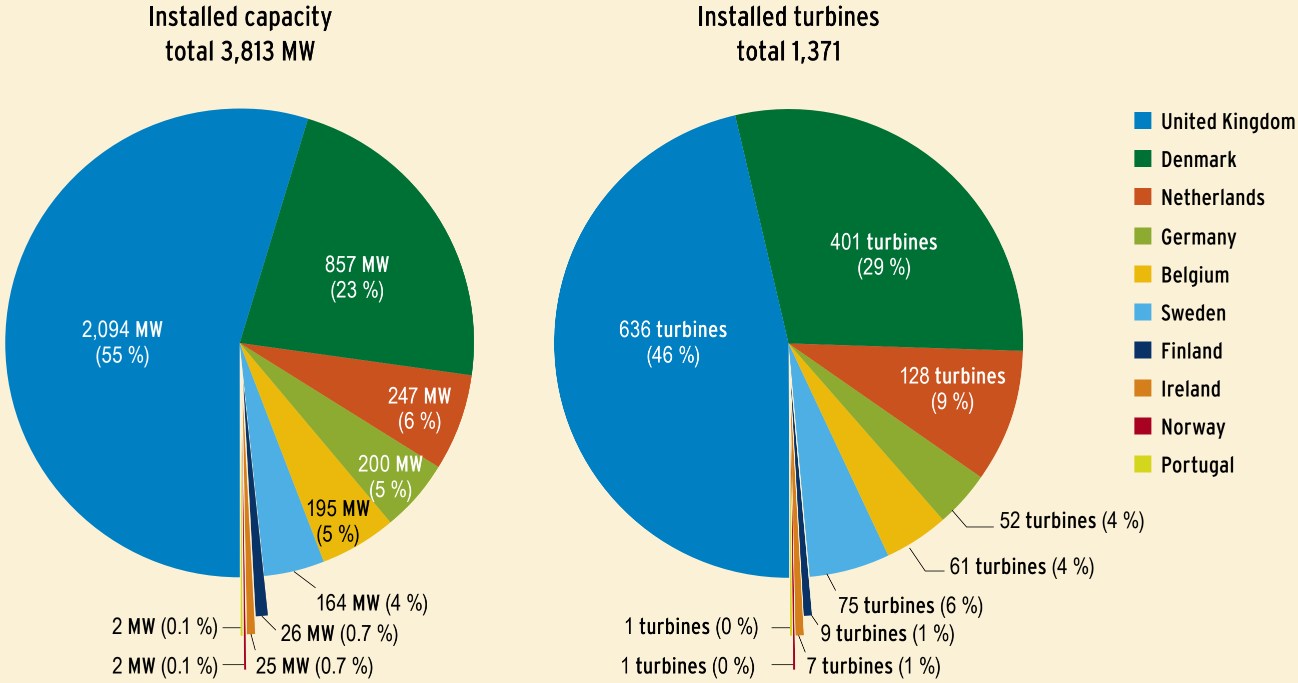
Wind energy use at sea – offshore

In the course of 2011, some 235 offshore wind turbines were installed in 9 wind farms in EU waters. This amounts to an additional capacity of 866 megawatts (MW) and involved investment totalling 2.4 billion Euro. The main actor in this sector was the United Kingdom, as more than 750 MW of this offshore wind energy capacity was constructed in British waters. Additional capacity installed in German waters came to 108 MW [108].

At the end of 2011, ten European countries had 1,371 offshore wind turbines with a total capacity of 3,813 MW connected to the grid. The offshore share of total wind energy capacity in the EU stood at around 4 percent [108].

A report by the European Wind Energy Association (EWEA) published in mid 2011 analysed all offshore wind farm projects in the EU Member States. In the framework of this analysis a total of 141 gigawatt (GW) of offshore wind energy capacity was identified. Of these, about 26 GW were in operation, under construction, or had received a construction permit. A further 115 GW were at the planning stage. The EWEA expects that offshore use of wind energy in EU waters will expand to 40 GW by the end of 2020 [116].

Installed wind energy capacity and number of offshore wind turbines in Europe at the end of 2011



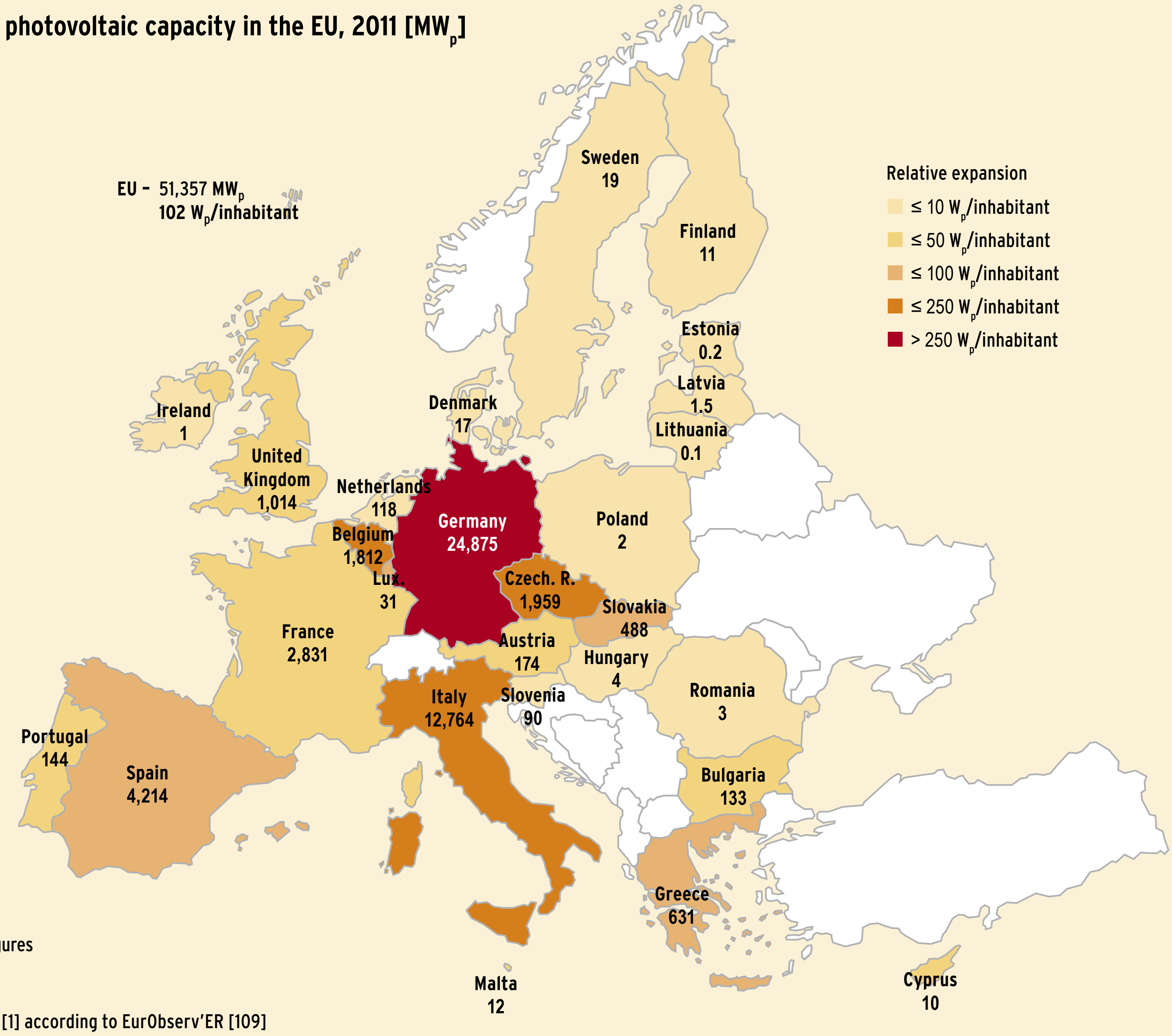
Source: EWEA [108]

Around 462,000 direct and indirect jobs could be in existence in the entire wind energy industry by 2020, more than 300,000 of them in the offshore sector [116].

Offshore wind turbines are often subject to extreme weather conditions, and not enough is yet known about the impacts of such conditions. Three research platforms, Fino 1-3, have been established in the German North Sea and Baltic Sea in order to fill knowledge gaps, generate reliable planning data for the design and operation of offshore wind farms and investigate the impacts on the marine environment. The data collected there can be tapped by various research institutions – for example the research programme RAVE (Research at alpha ventus), which was established in connection with the German offshore test field alpha-ventus. In 2010 the Federal Environment Ministry approved assistance totalling nearly 30 million Euro for alpha ventus. RAVE has so far received 43.1 million Euro assistance from the Federal Environment Ministry [142], [143].

Solar energy – Electricity from renewable sources

Installed photovoltaic capacity in the EU, 2011 [MW_p]



Estimated figures

Source: ZSW [1] according to EurObserv'ER [109]

The photovoltaic market in the EU displayed further marked expansion in 2011 compared with the year before. Additions to photovoltaic capacity totalled 21.5 gigawatt peak (GW_p). This is more than 75 percent of the global market for photovoltaic systems. With a total share of 60 percent, global additions were mainly effected in two countries: Italy and Germany. For the first time Italy headed the photovoltaic market with additions of around 9.3 GW to installed capacity. At 7.5 GW the German photovoltaic market remained at roughly the same level as the year before (7.4 GW) [109, 120].

Spain again continued to push ahead with rapid expansion of solar thermal power stations in 2011. A total of 420 megawatts (MW) of additional power station capacity went into operation, with the result that by the end of the year total installed capacity for renewable electricity generation came to 1,151.4 MW. According to REE (Red Eléctrica de España), this was used to generate more than 2 terawatt hours (TWh) of renewable electricity in 2011. At the beginning of 2012 new solar thermal power stations with a total capacity of more than 1,000 MW were under construction in Spain [149]. Across the EU, 1,157.2 MW of solar thermal power station capacity was in operation at the end of 2011 [149].

In their National Action Plans, six EU Member States have set themselves targets for 2020 for expansion of solar thermal power station capacity. A total capacity of more than 7,000 MW could be available by 2020. If the National Action Plans are implemented as planned, Spain will continue to occupy the leading position with a total capacity of 5,079 MW, followed by Italy (600 MW), France (540 MW), Portugal (500 MW), Greece (250 MW) and Cyprus (75 MW) [102].

Renewables-based heat supply in the EU

About 40 percent of the total final energy supply in the EU-27 is due to the heating/cooling sector. However, the renewables contribution in this segment was only around 13 percent in 2010. Thus renewable energy sources are less important in this sector than in the electricity market (see preceding pages). If the additional capacity in the renewables-based heating/cooling sector which is envisaged in the National Renewable Energy Action Plans (NREAP) is implemented as planned, the share due to renewable energy sources could rise to over 21 percent by 2020.

By far the largest renewable resource in the heating sector is biomass, with a share of around 96 percent or 765 terawatt hours (TWh), the greatest part being due to wood in private households. The contribution by the other two segments, solar thermal and geothermal energy, is comparatively unimportant at 2 percent and 1 percent respectively.

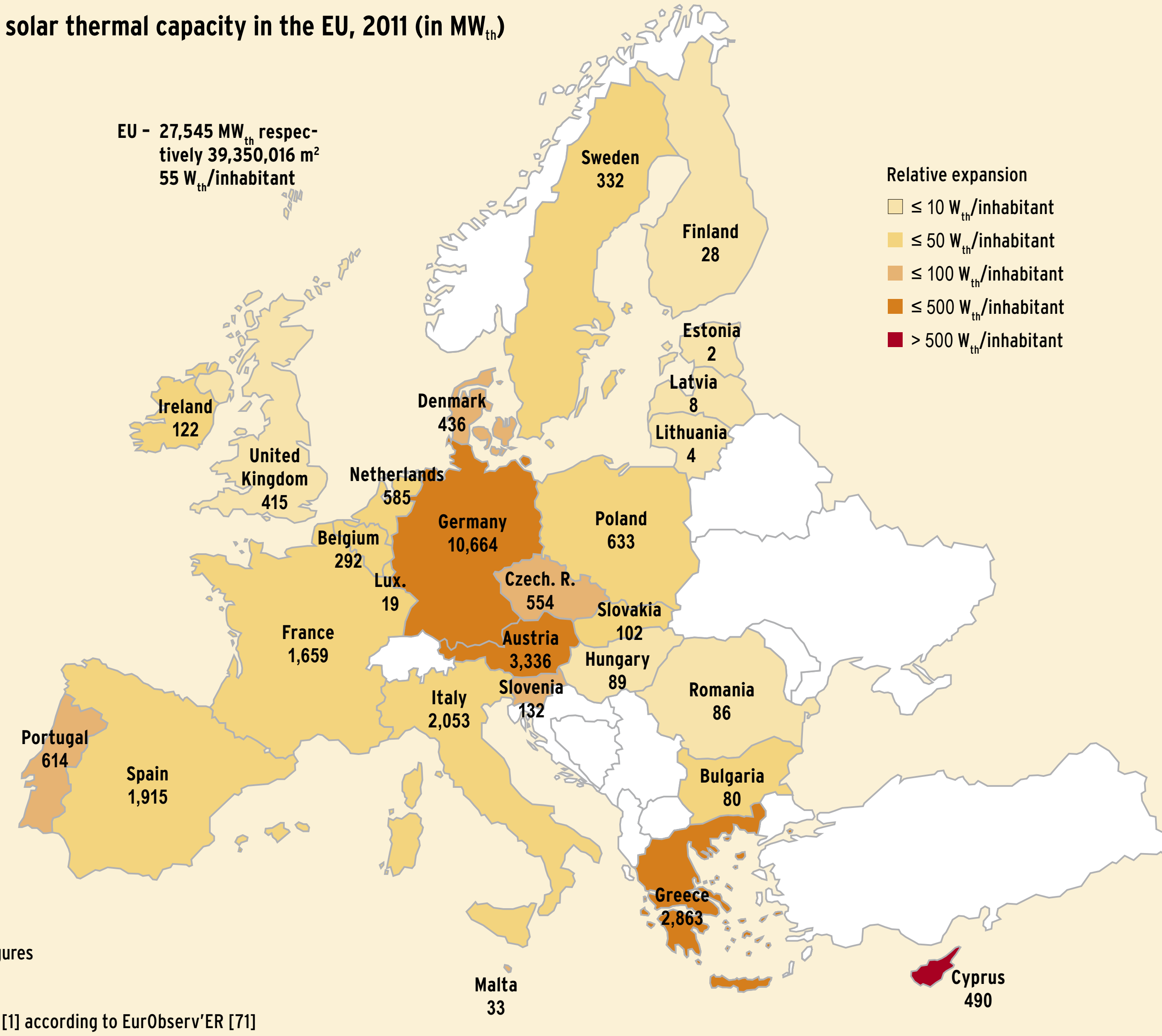
Renewables-based heat supply in the EU

	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Final energy [TWh]												
Biomass, of which	437.4	492.1	541.5	540.9	541.4	560.6	574.1	584.0	601.5	635.1	653.9	658.5	736.7
Wood/wood waste	429.3	483.6	529.5	523.4	520.4	548.4	561.4	571.0	588.1	601.5	617.7	631.2	699.6
Biogas	7.6	7.2	9.3	14.0	17.0	7.8	8.1	8.3	9.2	23.5	25.3	21.1	30.5
Biogenic fraction of waste	0.4	1.3	2.6	3.5	3.9	4.4	4.6	4.7	4.2	10.1	10.9	6.2	6.6
Solar thermal energy	1.6	3.2	4.9	5.4	5.9	6.4	7.2	7.9	9.0	10.9	12.6	14.5	17.1
Geothermal energy	4.8	6.5	6.6	6.7	6.9	6.8	6.9	7.4	7.7	7.7	8.3	10.8	10.9
Total renewables based heat	**443.8**	**501.9**	**552.9**	**552.9**	**554.2**	**573.9**	**588.1**	**599.3**	**618.1**	**653.7**	**674.8**	**683.8**	**764.7**

Source: ZSW [1] according to Eurostat [98]

Development of the solar thermal market

Installed solar thermal capacity in the EU, 2011 (in MW_{th})



Estimated figures
th = thermal

Source: ZSW [1] according to EurObserv'ER [71]

Estimates by EurObserv'ER indicate that nearly 2.6 gigawatt thermal (GW_{th}) of solar thermal capacity was added in 2011, corresponding to an additional collector area of around 3.7 million square metre (m^2). At the end of 2011, total cumulative solar collector capacity in the EU stood at around 27.5 megawatt thermal (MW_{th}) (corresponding to 39.4 million m^2) [71].

To date, the most important application for solar thermal energy is hot water. In recent years, however, increasing numbers of combined systems have been installed which not only produce hot water, but also boost central heating systems. For example, the share of combined systems installed in Germany during 2011 was about 50 percent in terms of the number of additional installations, and around two thirds in terms of installed collector capacity.

At the end of 2010 there were some 149 large installations (> 500 square metre (m^2); > 350 kilowatt thermal) operating in Europe with a total capacity of 215 MW_{th}, mainly for supplying solar thermal district/local heating systems. The largest solar district heating system in Europe, with a collector area of 18,365 m^2 and a thermal capacity of 12.9 megawatt thermal (MW_{th}), is located in Marstal (Denmark). Under the Sunstore-4 project, assisted by the EU's seventh framework programme, the existing system is to be expanded by a further 15,000 m^2 [106, 110].

In July 2011 the world's largest solar thermal installation – with a solar collector area of 36,305 m^2 – started operation for the Princess Nora University at Riyadh, Saudi Arabia. Germany's largest solar local heating plant is to be found in Crailsheim, with a capacity of 7 MW_{th} and a collector area of 10,000 m^2.

The world's largest installation for solar-powered cooling is currently under construction for the United World College in Singapore. When completed, the system will supply the 2,500 persons on the campus with air conditioning and hot water [99, 107, 110].

Around the world, some 196 gigawatt thermal (GW_{th}) of solar collector capacity was operating at the end of 2010 (IEA-SHC [110] puts the capacity for 2011 as high as 245 GW_{th}). This installed capacity produced around 162 terawatt hours thermal (TWh_{th}) (584 PJ), thereby saving some 53 million tonnes of the greenhouse gas carbon dioxide. An estimated 375,000 people were employed in the solar thermal sector worldwide in 2011 [110].

Renewables-based motor fuels in the EU

By 2020, renewables-based energy in the individual EU Member States is to account for at least 10 percent of final energy consumption in the transport sector. This binding target was laid down in EU Directive 2009/28/EC. The road to achieving this target at national level is described in the Member States' National Renewable Energy Action Plans. An analysis of these action plans shows that consumption of bioethanol and biodiesel could double by 2020. Consumption of biodiesel is set to rise from around 125 terawatt hours (TWh) in 2010 to 252 TWh (including imports of 91 TWh) in 2020. At the same time, demand for bioethanol will increase from around 34 TWh to 85 TWh (including imports of 37.4 TWh) [119].

Renewables-based fuel supply in the EU Member States in 2009 and 2010

	2009				2010 1)				2010 2)
	Bioethanol	Biodiesel	Other 3)	Total	Bioethanol	Biodiesel	Other 3)	Total	RE share of fuel consumption
	[TWh]				[TWh]				[%]
Belgium	0.5	3.3	–	3.8	0.6	3.6	–	4.2	N/A
Bulgaria	–	0.1	–	0.1	–	0.4	–	0.4	1.0
Denmark	0.1	0.04	–	0.1	0.4	0.01	–	0.4	0.3
Germany	6.8	25.9	1.0	33.7	8.7	26.5	0.6	35.8	5.7
Estonia	–	–	–	–	–	–	–	–	0.2
Finland	0.9	0.7	0.0004	1.5	0.9	0.7	0.0007	1.6	3.9
France	4.8	23.7	–	28.5	5.7	24.9	–	30.6	N/A
Greece	–	0.9	–	0.9	–	1.5	–	1.5	1.9
Ireland	0.3	0.6	0.02	0.9	0.3	0.9	0.02	1.3	2.4
Italy	1.4	12.2	–	13.6	1.8	15.1	–	16.9	4.8
Latvia	0.01	0.04	–	0.1	0.1	0.2	–	0.3	3.3
Lithuania	0.2	0.4	–	0.6	0.1	0.4	–	0.5	3.6
Luxembourg	0.01	0.5	–	0.5	0.01	0.5	–	0.5	2.0
Malta	–	0.01	–	0.01	–	0.01	–	0.01	0.3
Netherlands	1.6	2.7	–	4.3	1.6	1.1	–	2.7	3.0
Austria	0.7	3.7	1.4	5.9	0.7	4.1	1.4	6.3	5.4
Poland	1.7	6.6	–	8.4	2.2	8.3	0.04	10.5	5.9
Portugal	–	2.6	–	2.6	–	3.8	–	3.8	5.6
Romania	0.6	1.5	–	2.1	0.5	2.2	–	2.7	3.2
Sweden	2.3	1.9	0.4	4.6	2.4	2.3	0.6	5.3	7.7
Slovakia	0.5	1.4	–	1.9	0.5	1.5	–	2.1	7.8
Slovenia	0.02	0.3	–	0.3	0.03	0.5	–	0.5	2.9
Spain	1.8	10.6	–	12.3	2.7	13.9	–	16.6	4.7
Czech. Republic	0.6	1.5	–	2.0	0.7	2.0	–	2.7	4.6
Hungary	0.5	1.4	–	2.0	0.7	1.4	–	2.0	N/A
United Kingdom	1.9	9.6	–	11.4	3.7	9.6	–	13.3	3.0
Cyprus	–	0.2	–	0.2	–	0.2	–	0.2	2.0
EU	**27.1**	**112.4**	**2.8**	**142.3**	**34.3**	**125.4**	**2.6**	**162.4**	**4.7 4)**

1) Estimate by EurObserv'ER
2) Quotation from Eurostat: "This indicator is calculated on the basis of energy statistics covered by the Energy Statistics Regulation. The method required for the relevant indicator is described in Directive 2009/28/EC. However, this indicator includes all biofuels, not only those which meet sustainability criteria."
3) Vegetable oil consumption in Germany, Austria and Ireland; biogas in Sweden and Finland.
4) Estimate by Eurostat

Sources: Eurostat [98]; EurObserv'ER [102]

Socio-economic aspects of renewable energies in the EU, 2010

Turnover from renewable energies in 2010

	Photo-voltaics	Wind energy	Solid biomass	Biofuels	Biogas	Solar thermal energy	Heat pumps 1)	Small hydro-power 2)	Geoth. energy	Total countries
	[mill. EUR]									
Germany 3)	20,240	3,780	6,060	3,050	1,510	1,160	720	250	90	36,860
Italy	8,000	3,450	942	1,318	900	490	N/A	464	600	16,164
France	4,695	2,989	1,176	2,110	227	577	280	400	148	12,602
Sweden	70	725	5,986	2,052	0	30	1,000	295	N/A	10,158
Denmark	270	6,860	5	750	36	50	N/A	5	<5	7,981
Spain	2,845	1,800	1,437	950	53	300	0	471	<5	7,861
United Kingdom	1,200	4,500	350	170	1,044	75	75	N/A	<5	7,419
Austria	750	470	2,829	424	55	420	207	500	N/A	5,655
Czech. Republic	4,000	25	5	286	86	110	40	60	N/A	4,612
Belgium	1,200	370	2,173	85	0	35	22	10	30	3,925
Netherlands	1,000	840	71	170	100	55	85	0	75	2,396
Poland	<1	550	565	500	36	100	75	28	15	1,870
Romania	5	500	1,057	38	<1	20	N/A	14	26	1,661
Portugal	180	700	214	350	0	157	N/A	N/A	<5	1,606
Finland	5	780	106	214	10	<5	145	26	0	1,291
Greece	500	140	203	110	0	175	0	22	N/A	1,150
Rest of EU	603	785	1,441	704	29	105	79	128	115	3,991
Total sectors	**45,564**	**29,264**	**24,621**	**13,281**	**4,084**	**3,864**	**2,728**	**2,673**	**1,119**	**127,203**

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

1) Ground-source heat pumps (geothermal heat pumps)

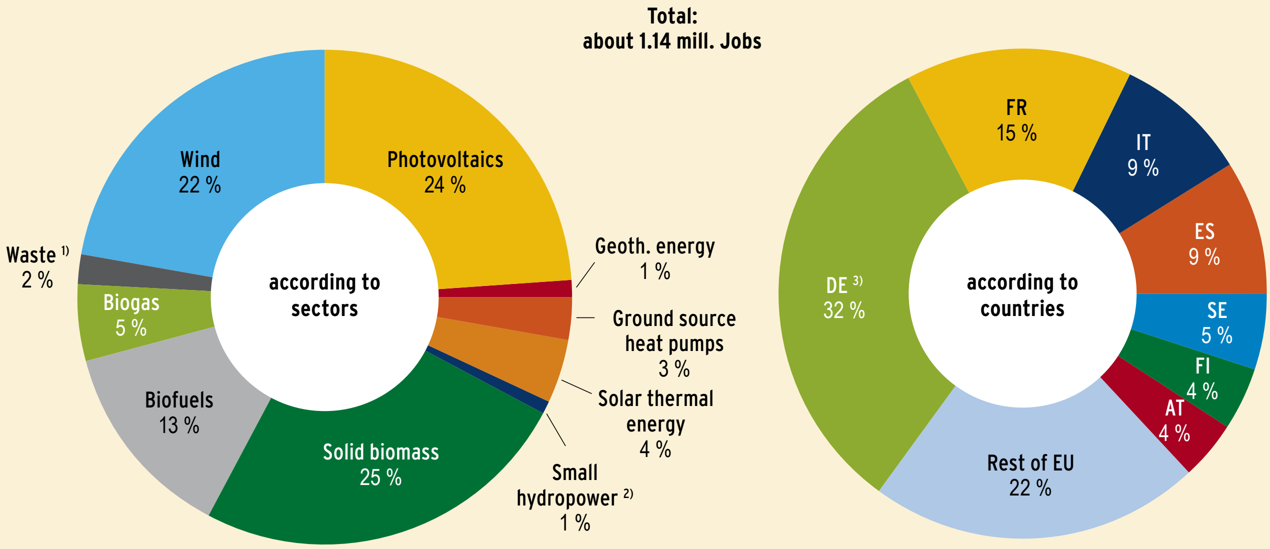
2) < 10 megawatt installed capacity

3) For consistency reasons, the figures for Germany are taken from the stated source; since the figures on pages 38–39 were calculated on the basis of a different system, comparisons are not possible.

Source: EurObserv'ER [102]

According to EurObserv'ER, sales of more than 127 billion Euro were made by the renewable energy sector in the EU in 2010. The country rankings are headed by Germany, with total sales of nearly 37 billion Euro. It is followed after a considerable gap by Denmark, France and Sweden, which together made a further 39 billion Euro. Thus a total of nearly 60 percent of sales by the entire renewable energy sector in the EU was due to these four countries. With more than 45 billion Euro – and thus nearly one third of the total volume – the photovoltaic sector made the most sales in 2010, overtaking the wind energy sector which took second place with close to 30 billion Euro [102].

Jobs in the renewable energies sector in 2010



1) Only direct jobs

2) < 10 megawatt installed capacity

3) The figures for Germany differ from the data shown on page 40, since EurObserv'ER determines the number of jobs without taking account of large-scale hydro power. Neither do the figures include jobs in publicly assisted research and administration.

Source: EurObserv'ER [102]

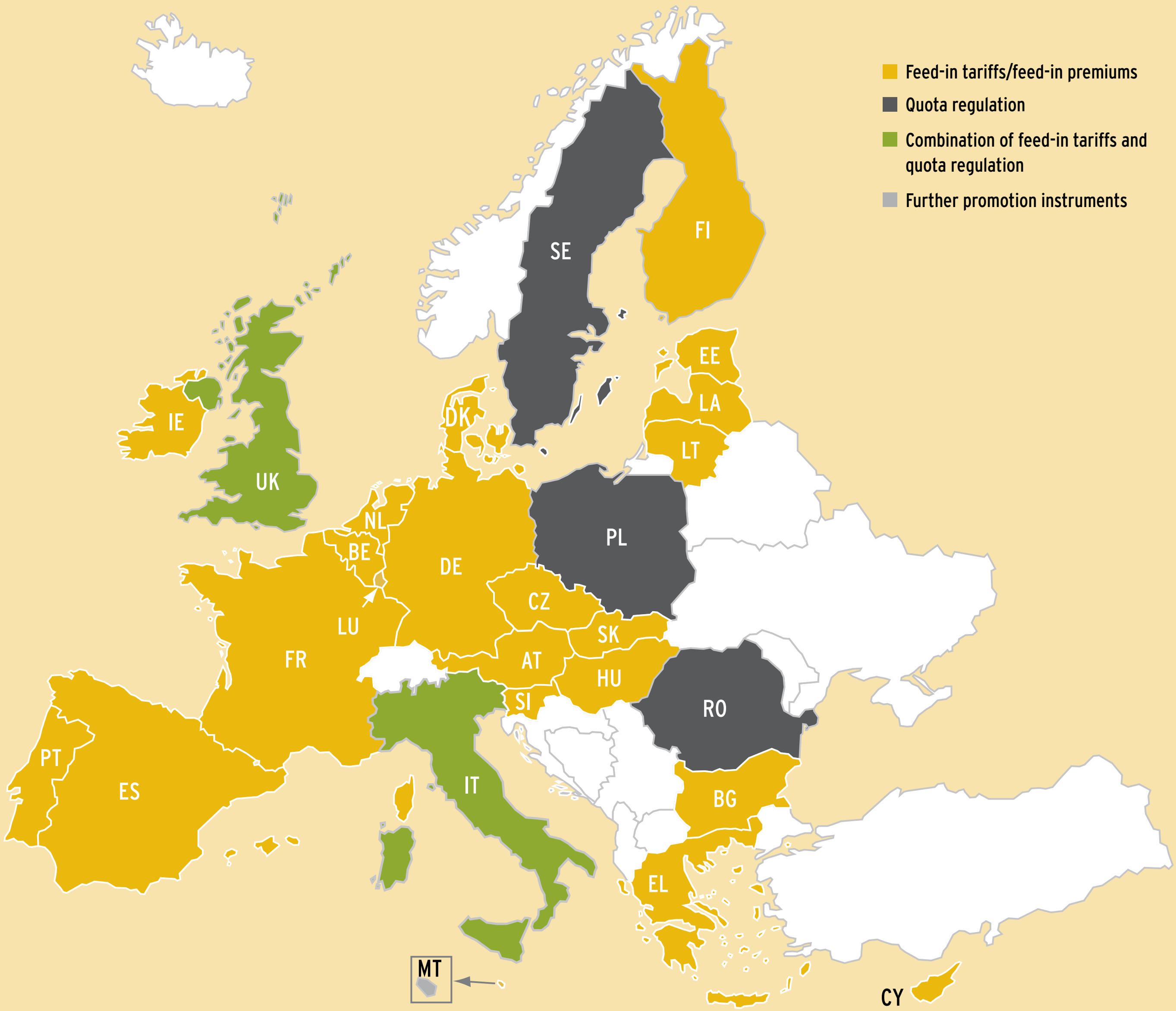
In 2010 more than one million people were employed in the renewable energy industry throughout the EU. Germany is not only the EU country with the biggest sales, but also accounts for one third of the jobs in the industry. France takes second place with a share of 15 percent [102].

According to an estimate by REN21 [113], roughly 5 million people around the world were either directly or indirectly employed in the renewable energy industry in 2011 (see also p. 91).

Instruments for promoting renewable energy sources in the EU electricity market

The new EU Renewable Energy Directive (2009/28/EC) is intended to increase the renewables-based share of total final energy consumption in the EU to 20 percent by 2020 (see also pages 64-65). With an expected EU share of around 34 percent, electricity from renewable sources will make a substantial contribution to this.

The main instruments for promoting electricity from renewable energy sources in the EU Member States



Quelle: Klein et al. [114]

The examples of wind energy and photovoltaic in particular show that the success of expansion in the electricity sector varies considerably between the individual EU states (see also page 71). This is due above all to the individual framework conditions in terms of environmental and energy policy. Feed-in tariffs and bonuses are currently in exclusive or partial use in over 20 Member States. On a European comparison the instrument of feed-in regulations, especially the German Renewable Energy Sources Act (EEG), has made a very successful contribution to the expansion of electricity from renewable sources and has proved to be a particularly cost-effective arrangement. For example, feed-in systems were responsible for 93 percent of the capacity installed in the EU up to the end of 2010 in the onshore wind energy sector and nearly 100 percent of installed capacity in the photovoltaic sector.

Further information on promotion systems is available from www.res-legal.de, a free Internet database on “Legal sources for electricity generation from renewable energy” (“RES LEGAL”). Here it is possible to search for legal information about the promotion of electricity from renewable energy sources in the 27 Member States of the EU, and also on grid access. Technology-specific regulations are also explicitly listed.

The International Feed-In Cooperation (IFIC)

At the International Conference for Renewable Energies, held in Bonn in 2004, Spain and Germany decided to exchange information on their experience with feed-in systems for renewables-based electricity and to intensify their cooperation (International Feed-In Cooperation). This cooperation was placed on a firm footing with the signing of a Joint Declaration in October 2005. In January 2007 Slovenia also signed the Joint Declaration and joined the IFIC. At the Ninth Workshop of the IFIC in Athens in January 2012, Greece was admitted as the fourth member of the IFIC.

The aims of the Cooperation are to promote sharing of experience concerning feed-in systems, optimise such systems, support other countries in their endeavours to improve and develop feed-in systems, and contribute knowledge to international forums, in particular to the policy debate in the European Union.

At a global level, at least 65 countries and 27 states/provinces had introduced feed-in systems for renewables-based electricity (on similar lines to the German EEG) by the beginning of 2012 [113]. Further information on the IFIC is available on the Internet from www.feed-in-cooperation.org.

PART III: GLOBAL USE OF RENEWABLE ENERGIES

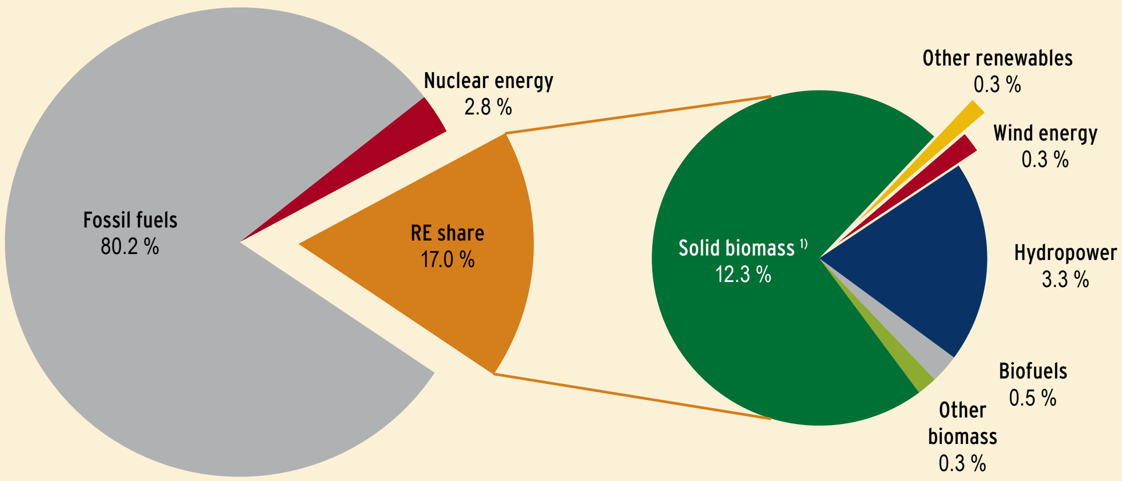
Finding sustainable ways of meeting the energy needs of the world's growing population is one of the major challenges of the future. Renewable energy already makes an important contribution – about 17 percent of global energy consumption comes from renewable sources.

On a global scale too, future energy supplies will only satisfy the sustainability criteria if there is further rapid and continuous expansion of renewable energy sources. Their further expansion is also a crucial factor with regard to implementing the objectives of the Kyoto Protocol, in order to reduce emissions of climate-relevant greenhouse gases. At the same time the expansion of renewable energies has to satisfy all sustainability requirements – environmental, economic and social.

Renewable energy sources are also an opportunity for developing countries, because access to energy is a key factor in the fight against poverty. A large proportion of the population in these countries live in rural areas. Lack of transmission grids means that conventional energy supplies are not possible here. In view of their decentralised character, renewables can provide basic energy supply, e.g. in the form of remote photovoltaic systems for domestic needs, or installations using renewables to supply electricity at village level. Thus renewable energy sources offer more people access to modern forms of energy – especially electricity – and hence to better living conditions and economic development opportunities.

Global energy supply from renewable energies

Structure of global final energy consumption in 2009



The renewables share of global final energy is larger than the renewables share of global primary energy. This is partly due to traditional biomass, which falls in the category of final energy consumption only. The size of the renewables share of primary energy also depends on the method used to calculate the primary energy equivalent of the renewable energy sources.

Statistics on final energy consumption usually only show the consumer shares. This diagram shows the breakdown by individual energy sources and is calculated on the basis of various IEA statistics. The shares shown are merely intended to indicate the relative scale of the individual components.

Other renewables = geothermal, solar and marine energy

1) Including biogenic fraction of waste

Source: ZSW [1] according to IEA [104]

In 2009 one sixth of global demand for final energy was already being met by renewable energy sources. With a total share of around 12.3 percent, biogenic energy sources were the dominant renewable resource. This large share is due above all to traditional use of biomass. About 3.3 percent is due to hydropower, and the remaining share of 1.4 percent is spread among the other renewable energy sources.

Today the renewables share of final energy consumption is, especially in the EU, the preferred indicator for their development, since Directive 2009/28/EC defines the target for 2020 on this basis. Many statistics, however, such as those of the IEA, continue to show the traditional indicator – the renewables share of primary energy consumption.

Global primary energy consumption has more than doubled since 1971 (2009: around 509,000 petajoule (PJ)). In 2009, however, the upward trend was interrupted – with primary energy consumption falling 5,000 PJ short of the previous year's figure of 514,000 PJ. Nevertheless, primary energy supply from renewable sources displayed growth of nearly 2 percent in 2009 to reach 67,000 PJ. At 13.1 percent, the renewables share of global primary energy consumption in 2009 was only 0.1 percentage points above the figure for the year 2000.

Top Ten investors in the renewable energy sector

Rank	Country	2011 EE-Investment [1]	2010 EE-Investment [1]
		[bn USD]	
1	USA	48.0	33.7
2	China	45.5	45.0
3	Germany	30.6	32.1
4	Italy	28.0	20.2
5	Rest of EU	11.1	15.2
6	India	10.2	6.6
7	Unit. Kingdom	9.4	7.0
8	Japan	8.6	7.0
9	Spain	8.6	6.9
10	Brazil	8.0	6.9

1) Private-sector investment

Source: PEW [121]

Top Ten countries/regions related to installed renewable energy capacity, by the end of 2011

Country	Total renewables-based power capacity	Capacity per capita	Total renewables-based power capacity
	excluding hydropower		including hydropower
	[GW]	[kW/inhabitant]	[GW]
China	70	0.05	282
USA	68	0.22	147
Germany	61	0.75	65
Spain	28	0.60	48
Italy	22	0.37	40
India	20	0.02	62
Japan	11	0.09	39
EU	**174**	**0.35**	**294**
World	**390**	**0.06**	**1,360**

Source: REN21 [113]

According to a study by PEW Charitable Trusts [121], global investment in the renewable energy sector reached a record level of 263 billion USD[1)] in 2011, an increase of 6.5 percent on the year before.

Renewable energies receive particularly generous assistance in Germany; a total of 30.6 billion USD has been invested in renewable energy technologies. Germany is thus the world's number three, after the USA with 48 billion USD and China with 45.5 billion USD. Private-sector investment within the EU totalled 78.3 billion USD [121].

1) Total investment, i.e. public and private sectors including research and development

Employment worldwide due to renewable energy technologies

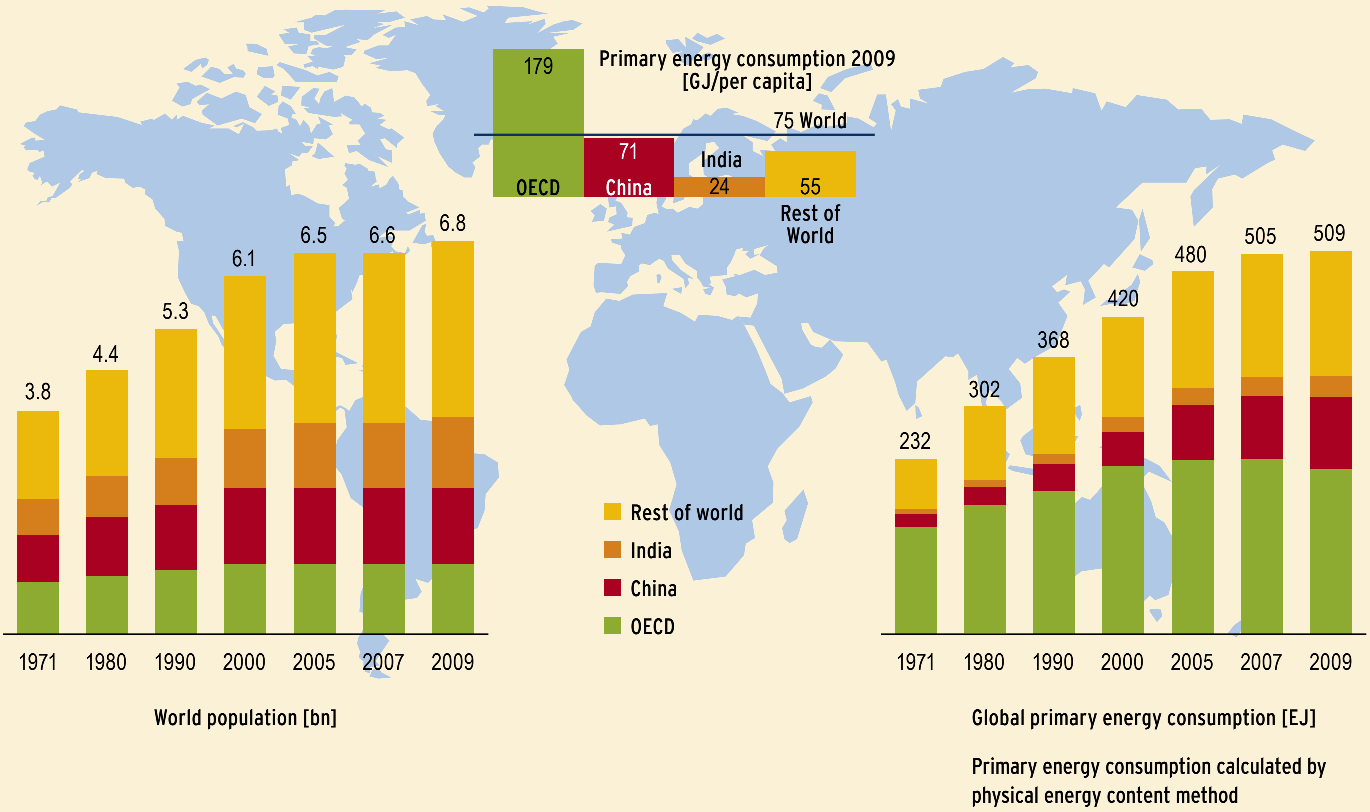
Technology	Global	China	India	Brazil	USA	EU	Germany	Spain	Other
	[1,000 Jobs]								
Biomass (electricity/heat)	750	266	58	–	152	273	51	14	2 [1)]
Biofuels	1,500	–	–	889 [2)]	47–160	151	23	2	194 [3)]
Biogas	230	90	85	–	–	53	51	1	–
Geoth. en. (electricity/heat)	90	–	–	–	10	53	14	1	–
Small hydropower	40	–	12	–	8	16	7	2	1 [1)]
Photovoltaics	820 [4)]	300	112	–	82	268	111	28	60 [5)]
Solar thermal power plants	40	–	–	–	9	–	2	24	–
Solar thermal energy (heating/cooling)	900	800	41	–	9	50	12	10	1 [1)]
Wind energy	670 [4)]	150	42	14	75	253	101	55	33 [6)]
Total [7)]	**5,000**	**1,606**	**350**	**903**	**392–505**	**1,117**	**372**	**137**	**291**

1) Australia
2) Including 200,000 indirect jobs
3) APEC member states excluding USA
4) On the basis of a different calculation method, Bloomberg New Energy Finance estimates 675,000 jobs worldwide in the photovoltaic sector and 517,000 jobs in the wind sector.
5) Bangladesh
6) Various
7) Rounded

Note: All figures are rough estimates

Source: REN21 [113]

Development of world population and global primary energy consumption

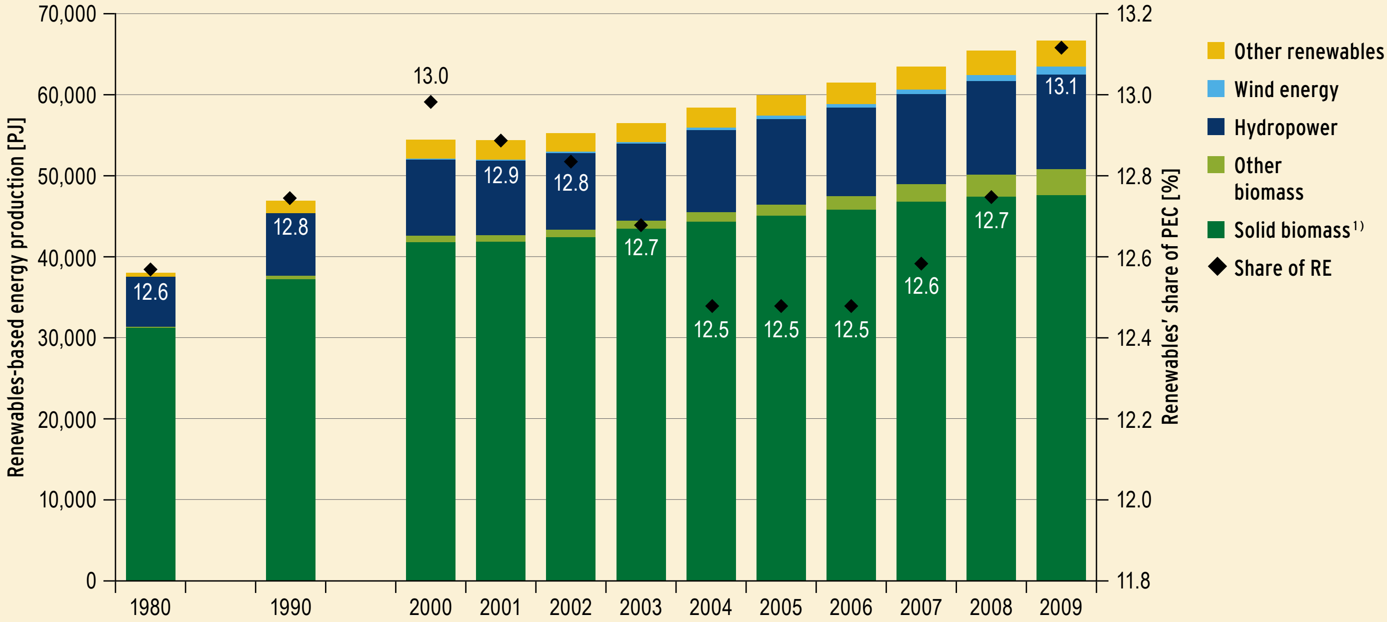


Source: ZSW [1] according to IEA [97], [104]

Since the year 2000, global primary energy requirements have grown by an annual average of 2.3 percent. All in all, some 509,000 petajoule (PJ) of primary energy was consumed worldwide, and the renewables share was 13.1 percent. Turning to per capita consumption of energy, it is clear that the figure of 179 gigajoule (GJ) per head in the industrialised countries (OECD) is 2.4 times higher than the global average (75 GJ per head). In China and India, the most populous countries, per capita energy requirements are actually as little as 71 and 24 GJ respectively. But the energy requirements of the developing and newly industrialising countries are growing: not only is per capita consumption rising in these countries, but their population growth is faster than in the industrialised countries.

Against this background there is a clear need not only to improve the efficiency of energy use, but also to step up the pace of development of renewable energies to meet the challenges for global energy supply and especially for climate change mitigation. This applies above all to wind, solar and marine energy, but also to geothermal energy technologies and to modern methods of biomass utilisation. The main classic uses to date – heat from firewood and wood charcoal (traditional biomass use) and electricity generation from hydro power – are increasingly reaching their limits and in some cases cannot be classified as sustainable use of renewable energy sources.

Development of global renewables-based primary energy production and the renewables share of primary energy consumption

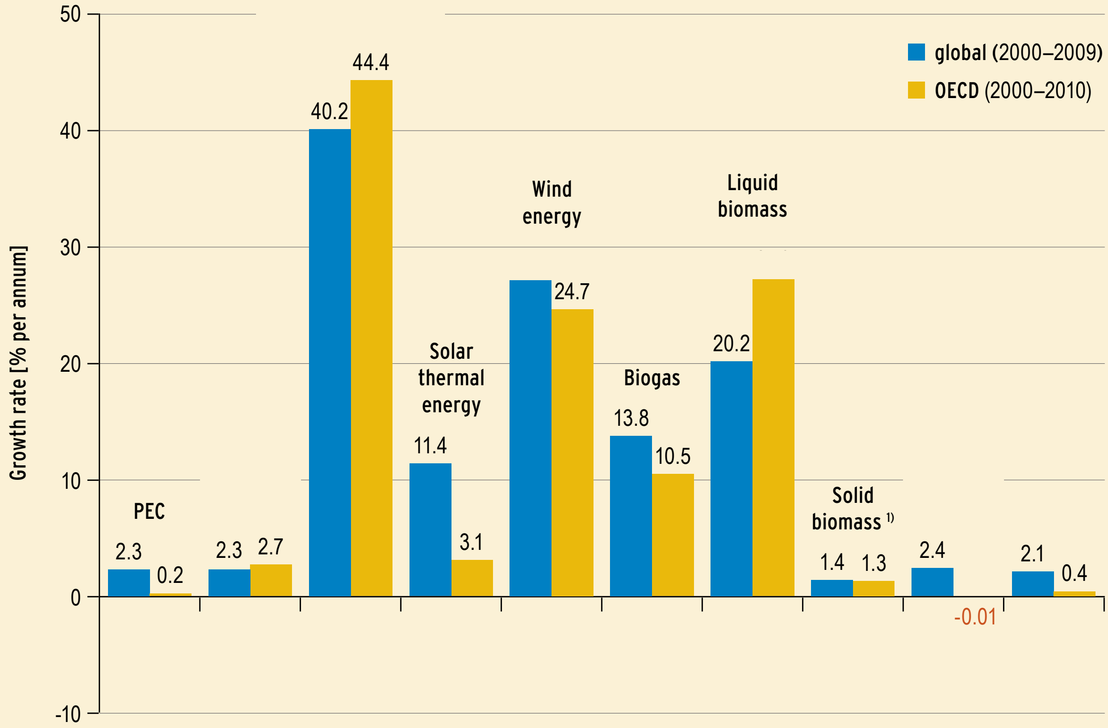


PEC = Primary energy consumption calculated by the physical energy content method

1) Including biogenic fraction of waste

Source: ZSW [1] according to IEA [104]

Average growth rates of renewable energies



The OECD Member States are listed in Section 8 of the Annex.

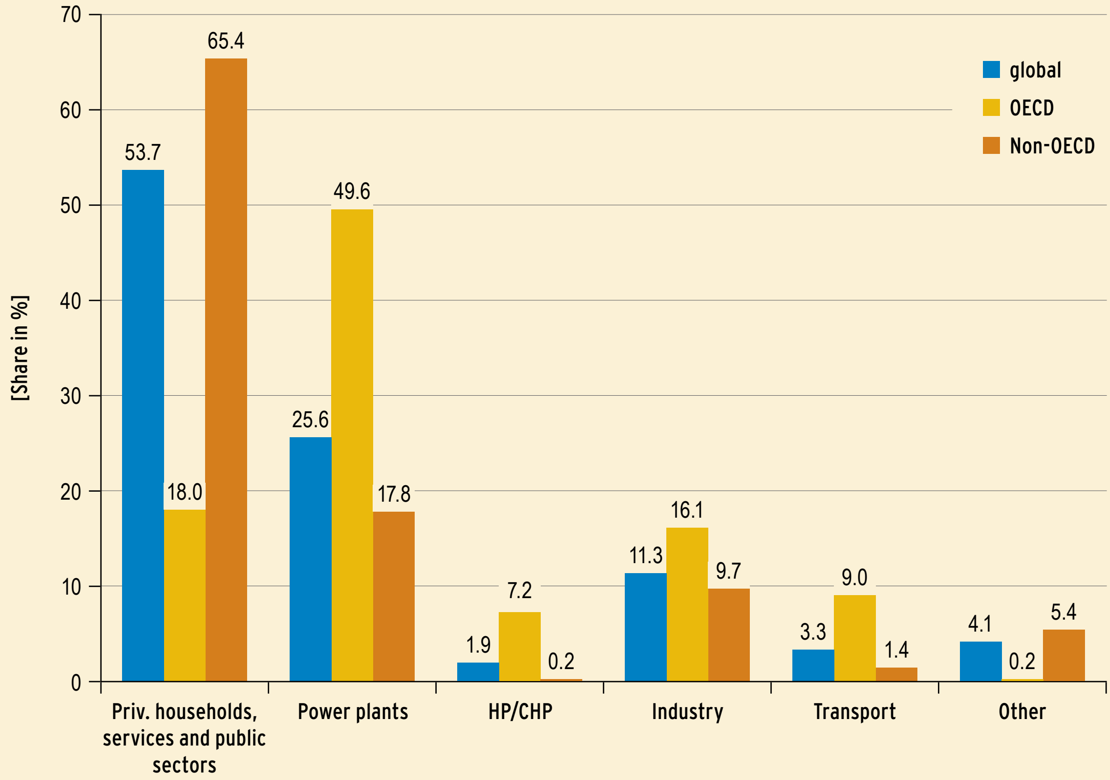
1) Including biogenic fraction of municipal waste

Source: ZSW [1] according to IEA [104]

During the period 2000-2009, the annual growth of the global energy supply from renewable sources averaged 2.3 percent, the same level as the growth of total global primary energy consumption. Particularly rapid growth of 40.2 percent per annum can be seen in the photovoltaic sector, and wind energy and liquid biomass also achieved substantial increases of 27.2 percent and 20.2 percent per annum respectively. However, it is important to note that these growth rates started from a very low absolute level. In the same period solid biomass, which accounts for about 43 percent of energy supply from renewable sources, and hydropower with a share of 28 percent grew by only 1.4 percent and 2.4 percent per annum respectively.

More than 40 percent of total global primary energy is consumed in the OECD countries. Over the ten-year period (2000-2010), however, the pace of growth has shown a marked drop to only 0.2 percent per annum. By contrast, energy supply from renewable sources grew by an average of 2.7 percent per annum. In particular, the photovoltaic sector, biogenic liquid fuels and wind energy averaged considerable annual growth of 44.4 percent, 27.3 percent and 24.7 percent respectively. Only hydro power, the most important renewable energy source after solid biomass, did not show any growth, but actually declined slightly.

Renewables-based shares of energy demand in the various sectors in 2009



The OECD Member States are listed in Section 8 of the Annex.
HP/CHP Heating plant/Combined heat and power plant

Source: ZSW [1] according to IEA [103]

On a global scale, more than half the renewable energy supply is used for decentralised heating in private households and in the public and service sectors. The main factor here is the widespread traditional use of biomass in the non-OECD countries. Some 65.4 percent of consumption of renewable energies in the non-OECD countries takes place in this sector. In the industrialised countries (OECD) the share was only around 18.0 percent.

With a global share of around 25.6 percent, electricity generation is the second main area of application. Here too there are considerable regional differences, however: whereas the industrialised countries use nearly half their renewable energy to generate electricity, the figure in non-OECD countries is only 17.8 percent.

In the OECD the contribution of renewables in the transport sector is also becoming increasingly important. In 2009 the share already stood at 9 percent, whereas the share of 1.4 percent in the non-OECD countries is comparatively unimportant.

Regional use of renewable energies in 2009 – around the globe

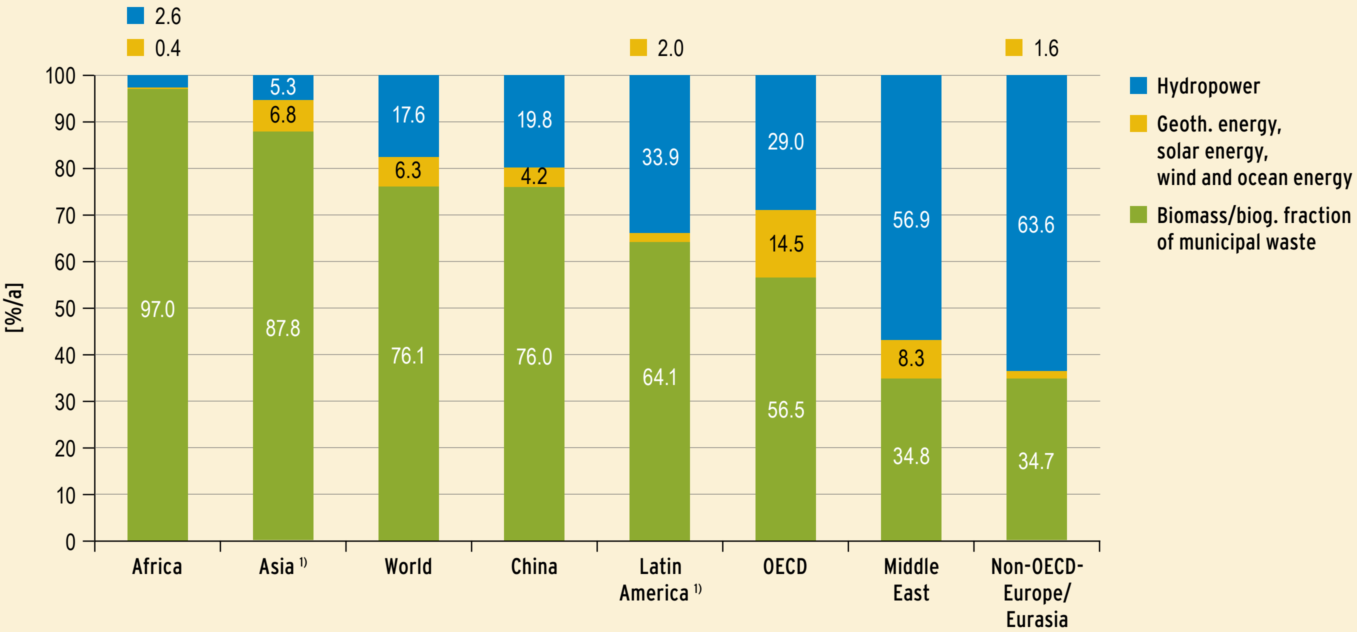
	PEC	Of which renewable	RE as a share of PEC	Principal RE as a share of total RE [%]		
	[PJ]	[PJ]	[%]	Hydropower	Other [1)]	Biomass [2)]
Africa	28,199	13,805	49.0	2.6	0.4	97.0
Latin America [3)]	22,610	7,114	31.5	33.9	2.0	64.1
Asia [3)]	61,095	16,426	26.9	5.3	6.8	87.8
China	95,128	11,218	11.8	19.8	4.2	76.0
Non-OECD-Europe/Eurasia	43,982	1,654	3.8	63.6	1.6	34.7
Middle East	24,640	82	0.3	56.9	8.3	34.8
OECD	219,298	16,390	7.5	29.0	14.5	56.5
Global [4)]	**508,716**	**66,690**	**13.1**	**17.6**	**6.3**	**76.1**

1) Geothermal energy, solar energy, wind, tidal energy
2) Including the biogenic fraction of municipal waste
3) Latin America excluding Chile and Mexico; Asia excluding China, Japan and Korea
4) Including fuel stocks for shipping and air traffic (around 13,800 petajoule)

Primary energy consumption calculated by the physical energy content method
The OECD Member States are listed in Section 8 of the Annex.

Source: ZSW [1] according to IEA [104]

Renewable energy generation by regions – Renewable technology shares in 2009



1) Latin America excluding Chile and Mexico; Asia excluding China, Japan and Korea
The OECD Member States are listed in Section 8 of the Annex.

Source: ZSW [1] according to IEA [104]

2009	Persons using traditional biomass [mill.]			Persons without access to electricity [mill.]		
	Rural areas	Urban areas	Total	Rural areas	Urban areas	Total
Africa	481	176	657	466	121	587
Sub-Saharan Africa	477	176	653	465	120	585
Asia	1,694	243	1,937	716	82	799
China	377	47	423	8	0	8
India	765	90	855	380	23	404
Rest of Asia	553	106	659	328	59	387
Latin America	60	24	85	27	4	31
Developing countries [1]	2,235	444	2,679	1,229	210	1,438
World [2]	**2,235**	**444**	**2,679**	**1,232**	**210**	**1,441**

1) Including Middle East

2) Including OECD and transition countries; transition economies: countries which are undergoing a phase of transition from planned economy to marked economy; the IEA uses this term to refer to the countries of non-OECD Europe and the countries of the former USSR.

Source: IEA [105]

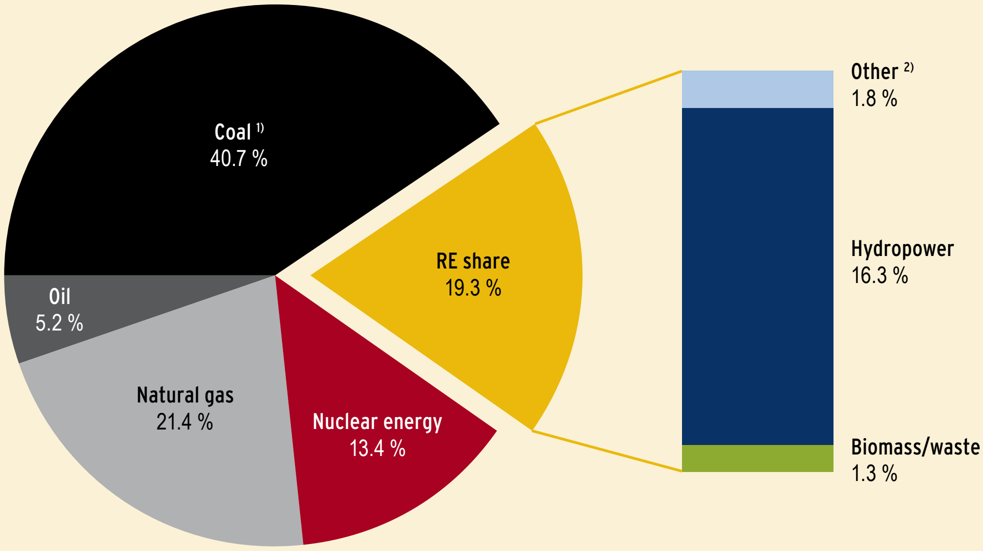
The proportion of energy forms generally described as renewable is particularly large in Africa. The main reason for this is the traditional use of biomass, though to a large extent this is not sustainable. Simple forms of cooking and heating result in harmful effects on health due to open fires, and in many cases they cause irreversible deforestation.

In the developing countries – especially in rural areas – some 2.7 billion people are dependent entirely on traditional biomass for cooking and heating; this corresponds to about 40 percent of the world's population. In view of the pace of population growth, the IEA expects this figure to increase to around 2.8 billion by the year 2030 [105].

In some cases the use of hydropower from large dams is not a sustainable use of renewable energy either, since they sometimes have serious social and environmental impacts.

Global electricity generation from renewable energies

Renewable energies: shares of worldwide electricity generation in 2009



Worldwide electricity generation from hydropower, at 16.3 percent, accounts for more than nuclear power (13.4 percent). But if one looks at the shares of primary energy consumption, the situation is reversed: nuclear power, with 5.8 percent, accounts for a much larger share of primary energy consumption than hydropower with 2.3 percent. The reason for this distortion is that under international agreements, electricity from nuclear energy is assessed for primary energy purposes on the basis of an average conversion efficiency of 33 percent, whereas electricity generation from hydropower by the physical energy content method is assumed to have an efficiency of 100 percent.

1) Includes the share of miscellaneous non-renewable energy resources (total 0.3 percent), e.g. non-renewable municipal waste

2) Geothermal energy, sun, wind, marine energy

Source: IEA [103]

In 2009 roughly one fifth of worldwide electricity production was generated using renewable energy sources. The most intensively used renewable energy source was hydropower, which alone supplied 16.3 percent of worldwide electricity consumption. This corresponds to a share of 84 percent of renewable energies.

The contribution of biogenic energy sources was around 1.1 percent. Although the other renewable energy technologies – geothermal, solar and wind energy – can boast rapid growth, in 2009 their combined contribution only came to 1.8 percent of global electricity generation.

On average, both renewable electricity generation and total global electricity generation have grown by around 2.8 percent per annum since 1990. The renewables share of global electricity generation was around 19.5 percent in 1990 and showed a slight drop to 19.3 percent in 2009. An important factor in this decline was the slow growth of hydropower: its contribution fell from 18.1 percent in 1990 to 16.3 percent in 2009. A glance at the other renewable energy sources shows that their share increased by 1.7 percentage points to 3 percent in 2009 [103]. Since the potential for hydropower in most industrialised countries has already been largely exhausted, the necessary contribution by these countries to increasing the renewables share of electricity at global level can only come from increased expansion of other renewable technologies. Nevertheless, a recent study by the IEA [112] draws attention to the relevance of hydropower for the years ahead. For example, the absolute growth of electricity generation from hydropower in the last 5 years, with a total of 320 terawatt hours, was faster than the combined growth of all other renewable energy technologies. This is largely ascribed to the massive expansion of hydropower in China – especially in connection with the Three Gorges Dam.

In the OECD countries, renewable electricity generation has increased by an annual average of 1.7 percent since 1990, compared with a growth rate of 4 percent in the non-OECD countries. However, the average growth of total electricity requirements in the non-OECD countries, at 4.5 percent, was slightly faster than that of renewable electricity generation. There is reason to expect that in view of the faster population growth and rising incomes, total electricity demand in the non-OECD countries will continue to grow faster than in the OECD. The challenge for the future is that the growth of renewable energies will have to more than keep pace with the increase in energy consumption.

Electricity generation from renewable energies in various regions, 2009

	Hydro-power	Solid biomass 1)	Other biomass	Wind energy	Geoth. energy	Other RE 2)	Total renew-ables-based electricity	Share of renewables-based electricity
	[TWh]							[%]
Africa	98.1	0.8	–	1.7	1.4	–	102.0	16.2
Asia 3)	242.9	9.8	0.1	18.8	19.6	0.3	291.6	15.1
Australia	12.2	1.5	1.3	3.8	–	0.3	19.1	7.3
Latin America 3)	668.9	31.8	0.0	1.9	3.0	0.0	705.5	69.8
EU-27	327.5	77.1	29.9	132.7	5.5	14.6	587.2	18.5
Brazil	391.0	23.1	–	1.2	0.0	–	415.3	89.0
China	615.6	2.4	–	26.9	0.2	0.3	645.4	17.3
India	106.9	2.0	–	17.9	0.0	0.0	126.9	14.1
Japan	75.2	17.4	–	2.9	2.9	2.8	101.2	9.7
Canada	363.8	5.9	0.8	4.6	0.0	0.1	375.2	62.2
Russia	174.2	0.0	–	–	0.5	–	174.7	17.6
USA	275.6	49.9	9.4	74.2	17.0	2.5	428.7	10.3
Non-OECD	1,930.9	44.9	0.2	50.0	24.6	0.6	2,051.4	21.3
OECD	1,320.7	160.4	42.4	223.1	42.1	20.9	1,809.7	17.4
World	**3,251.7**	**205.4**	**42.7**	**273.2**	**66.7**	**21.5**	**3,861.1**	**19.3**

1) Including biogenic fraction of municipal waste
2) Solar and marine energy
3) Asia excluding China and Japan; Latin America excluding Mexico and Chile

Source: ZSW according to IEA [104]

International networks for renewable energy sources

International Renewable Energy Conferences (IRECs) – renewables2004 – and the follow-up process

The International Conference for Renewable Energy Sources "renewables2004" in Bonn, initiated by the German government, put the issue of renewable energy on the global agenda and ushered in a series of high-ranking political conferences. 3,600 high-ranking representatives of governments, international organisations, industry and non-governmental organisations from 154 countries took part in the conference in Bonn. Their numerous declarations of intent to do more to further renewable energy gave the global renewables movement a strong voice. The conference in Bonn was also responsible for a number of initiatives: for example, the founding of the global policy network REN21 and the signing of the IEA Implementing Agreement on Renewable Technology Deployment (RETD). The conference was also responsible for the stimulus that led to the founding of the International Renewable Energy Agency (IRENA).

The great success of "renewables2004" continued with the series of International Renewable Energy Conferences (IRECs) in other countries. As early as 2005 the global community met once again for an IREC. 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 among other things on the development of renewable energy expansion in industrialised countries. Like "renewables2004" before it, WIREC brought about

a large number of voluntary undertakings, thereby carrying forward the ideas of the Bonn conference. The most recent 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 parties to the conference to support increased worldwide expansion of renewable energy.

Future IRECs are also to discuss the increased use of renewable energy sources and the associated opportunities for climate protection, access to energy, and sustainable development. The next International Renewable Energy Conference will be held in Abu Dhabi (ADIREC) at the beginning of 2013.

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

To establish a link between the many and various stakeholders of the Bonn “renewables2004” conference and help to conserve the momentum of the conference, the global Renewable Energy Policy Network for the 21st Century (REN21) was created in 2005. Members of the REN21 network include governments, international organisations, non-governmental organisations, and representatives of industry, the finance sector, and civil society in the energy, environment and development sectors.

REN21 supports the governments of the IREC host countries in the organisation and running of the conferences and thereby helps to preserve the spirit of the IREC conferences and facilitate the integration of the network’s broad spectrum of stakeholders. REN21 also manages the pledges made by the IREC conferences, which are presented in a publicly accessible database on the REN21 website.

REN21 enjoys worldwide recognition through the publication of reports on renewable energy topics, and especially the “Renewables Global Status Report” (GSR). The GSR has become a standard reference in the field of reporting on the progress of worldwide expansion of renewable energy sources and the propagation of funding policies. REN21 participates in the online information platform REEGLE (jointly with REEEP), and on its own website it runs an interactive world map on renewable energy, the Renewables Interactive Map.

Since its foundation, REN21 has become one of the leading platforms in the renewable energy sector. As a network consisting of different groups of members, it is in a position to exploit synergies between all participants.

The REN21 Secretariat is located in Paris and is provided jointly by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the United Nations Environment Programme (UNEP).

For further information, see www.ren21.net

The third meeting of the IRENA Council, the governing body of the Agency, took place in June 2012. In addition to the 21 elected members of the Council (including Germany), another 70 countries attended as observers. Federal Foreign Minister Westerwelle gave a speech at the meeting.

International Renewable Energy Agency – IRENA –

The renewables2004 conference also gave extra impetus to the establishment of a special intergovernmental institution that promotes the expansion of renewable energies worldwide. Spurred on by Germany and its partners, especially Denmark and Spain, this idea was put into practice at the founding conference of the International Renewable Energy Agency (IRENA) in Bonn on 26 January 2009.

Since the agency's foundation, the Statute has been signed by 157 states and the European Union. In mid June 2012 Egypt, on signing the IRENA Statute, was welcomed as the 100th full member of the young organisation. The rapid growth in the number of members is an overwhelming success and demonstrates the great support enjoyed by IRENA and with it the call for global expansion of renewable energy in general.

Equipped with a budget totalling 28.4 million US dollars for 2012 and a staff of 75 employees this year, IRENA will analyse the worldwide potential of renewable energy, design scenarios for expanding it, and support its technological development. IRENA will offer its member states policy advice on creating the right framework conditions, on targeted expansion of competencies, and on improving funding and optimising technology and knowledge transfer for renewable energy sources. IRENA is to become a globally recognised knowledge centre for renewable energy sources, and provide quick and easy access to relevant information for political decision makers, users, investors and the interested public. To this end IRENA will cooperate closely with existing international organisations, such as individual UN organisations or the International Energy Agency (IEA), and with networks like REN21. The Agency's head office is in Abu Dhabi, capital of the United Arab Emirates (UAE). The Director General of IRENA is a Kenyan, Adnan Amin.

The IRENA Innovation and Technology Centre (IITC) in Bonn was opened in October 2011 at a ceremony on the Petersberg attended by high-ranking representatives. Headed by its Dutch director Dolf Gielen, the IITC in Bonn implements parts of the IRENA work programme. As an integral component of the IRENA Secretariat, the IITC is concerned with scenarios and strategies for the expansion of renewable energy and technological developments in this sector. Its tasks include drawing up "technology roadmaps" and analysing favourable framework conditions for technological innovations. The IITC also analyses costs and cost trends in the generation of energy from renewable sources and works on technological standards and test methods. The IITC is also involved in the preparation of a roadmap for achieving the target of "Doubling the renewables share of the global energy mix by 2030" as part of the initiative "Sustainable Energy For All" (see below). In 2012 Germany provided funds of 4 million US dollars for the IITC in Bonn, thereby making a significant contribution to the organisation's activities.

The third assembly of the IRENA member states will be held in Abu Dhabi in January 2013.

For further information, see www.irena.org

The International Energy Agency – IEA –

The International Energy Agency (IEA), founded in 1973, is an organisation with 28 member states that supports reliable supplies of clean and affordable energy.

In recent years the IEA has issued numerous publications in the field of renewable energy sources. These analyses are concerned, for example, with investigating the efficiency and cost-effectiveness of policies for promoting renewable energy, or analysing the potential and challenges of integrating large quantities of renewable energy in the energy systems of individual countries. The IEA also publishes technology roadmaps for renewable energies and analyses of renewable energy markets.

The Federal Environment Ministry is represented on the IEA Renewable Energy Working Party (REWP). Close cooperation between the IEA and the International Renewable Energy Agency (IRENA) is assured by a partnership agreement signed by the two organisations in January 2012.

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

The IEA Implementing Agreement – RETD –

At the initiative of the Federal Environment Ministry, the IEA Implementing Agreement "Renewable Energy Technology Deployment (RETD)" was signed in 2005. RETD currently numbers nine member states and is the only cross-technology agreement among the IEA's implementing agreements on renewable energy. In this function RETD supports the large-scale market introduction of all technologies for the use of renewable energy sources, and is devoted to cross-sectional issues such as system integration of renewable energies, funding instruments for renewable energy, or resource and capacity shortages that could arise from the continued growth of renewable energies.

Furthermore, RETD comments on the IEA's scenario work on renewable energy, and every year it runs international workshops jointly with the IEA Renewable Energy Working Party (REWP) and with IRENA.

For further information, see www.iea-retd.org/

Clean Energy Ministerial – CEM –

The Clean Energy Ministerial (CEM) is a multilateral forum established at the initiative of the USA. Ahead of the COP-15 climate conference in Copenhagen in 2009, the "major economies" as substantial emitters of greenhouse gases drew up ten technology action plans for a number of low-carbon technologies. By indicating existing possibilities for technological cooperation, these were to make a constructive contribution to the negotiations. In this context the Federal Environment Ministry jointly heads, together with Denmark and Spain, the multilateral working group on implementing the action plans for wind and solar energy. This is currently active in three areas: pilot projects have been run in the field of capacity building; the working group is working with IRENA on the preparation of a global wind and solar atlas; and it is also discussing the potential of the economic added value resulting from wind and solar energy technologies.

The range of implementation initiatives, which were officially presented at the first CEM conference in Washington in 2010, includes not only renewable energy sources, but also efficiency, electric mobility, CO_2 capture and storage (CCS) and smart grids.

Annual conferences at ministerial level will report progress on the initiatives. To this end the second CEM conference was held in Abu Dhabi (UAE) in April 2011, and the third CEM conference in London in April 2012. The fourth CEM will be hosted by India in spring 2013.

For further information, see www.cleanenergyministerial.org/solarwind/

The "Sustainable Energy for All" initiative – SE4ALL –

Sustainable energy for all by 2030 – that is the aim of the initiative "Sustainable Energy for All" launched by UN Secretary General Ban Ki-moon in 2011. As well as ensuring universal access to modern energy services, the initiative seeks to raise the annual improvement in energy efficiency from 1.2 to 2.4 percent and to double the renewables share of the global energy mix. These targets are to be achieved by 2030.

2012 INTERNATIONAL YEAR OF SUSTAINABLE ENERGY FOR ALL

Today 1.3 billion people around the world live without access to electricity. Forecasts say that there will be hardly any reduction in this figure by 2030 without additional efforts. The same applies to a further billion people who only have access to unreliable electricity supplies and 2.7 billion who have to rely on using traditional biomass.

A high-ranking group of advisors consisting of 46 representatives of industry, politics and civil society has drawn up an action agenda which uses a roadmap to demonstrate ways and means of operationalising the three individual targets. A central challenge here will be to ensure appropriate coordination of the efforts of the public and private sectors and civil society and thereby increase their impact. At the United Nations Conference on Sustainable Development in Rio (Rio+20), 50 states from Africa, Asia, Latin America and the group of small island developing states, plus a large number of companies, local governments and groups from civil society presented their own commitments in support of the action agenda. In this way the initiative made use of the political momentum of the Rio+20 negotiating context to mobilise support.

For more information, see www.sustainableenergyforall.org

UN Secretary-General Ban Ki-moon addressed the second meeting of the IRENA Assembly in Abu Dhabi in January 2012 and announced the launch of his "Sustainable Energy for All" initiative. One of the goals is to double the share of renewables in the global energy mix. IRENA plays a key role in reaching this goal.

UN Conference Rio plus 20

Energy was one of the issues discussed at the United Nations Conference on Sustainable Development (Rio+20), held in Rio de Janeiro from 20 to 22 June 2012. In its closing document the conference supports the increased use of renewable energy. It acknowledges the important role that increasing the share of renewable energy plays in sustainable development, and also that of using clean, energy-efficient technologies and improving energy efficiency. For example, it reaffirms the goal of increased integration of renewable energies in national energy mixes, and also the use of other low-emission technologies, more sustainable use of traditional energy sources and improvements in energy efficiency. It calls upon governments to create suitable framework conditions for these activities. The conference noted the continuing support for the above-mentioned Sustainable Energy for All Initiative (SE4All) of Secretary General Ban Ki-moon, which addresses the issues of access to energy, energy efficiency and the expansion of renewables.

The conference also confirmed the pledges made by some states in the section on sustainable consumption and production regarding the abolition of harmful subsidies for fossil fuels and called upon others to consider making similar commitments themselves.

Further information can be found on the BMU website at www.bmu.de/47266

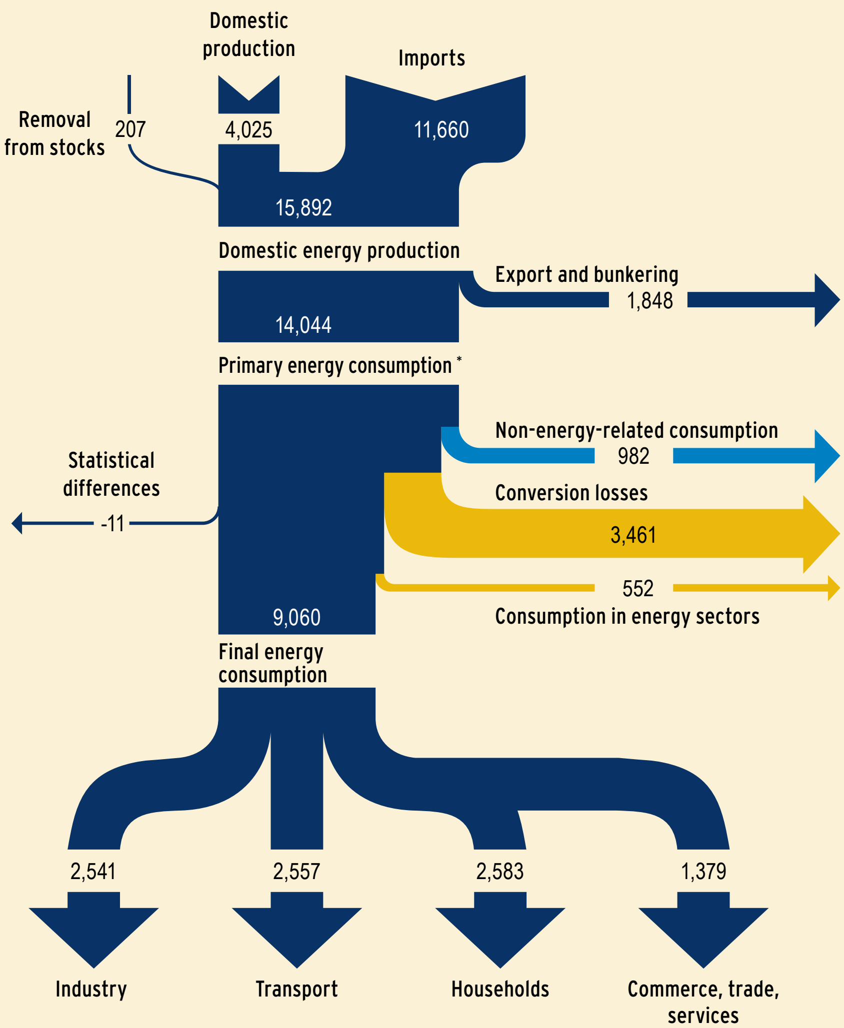
View of the plenary session at the UN Conference on Sustainable Development Rio plus 20

ANNEX: METHODOLOGICAL NOTES

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

The normal terminology of 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 of energy to another (e.g. heat, electricity, mechanical energy). This process is not entirely reversible, however, so some of the technical work capacity of the energy is lost.

Schematic diagram of energy flows in Germany in 2010 (PJ)



The renewables-based share of primary energy consumption came to 9.4 percent in 2010.
* All figures provisional/estimated.

29.308 petajoule (PJ) ≙ 1 million t coal equivalent (TCE)

Source: Arbeitsgemeinschaft Energiebilanzen (AGEB) July 2011, download from www.ag-energiebilanzen.de

1. Energy supply from photovoltaics and solar thermal systems

Photovoltaic systems

Electricity generation from 2001 to 2011 corresponds to the annual statements of the transmission grid operators under the Renewable Energy Sources Act. Up to the end of 2000, electricity generation was calculated on the basis of the installed capacity at the beginning of the year plus half the relevant year's capacity increase, multiplied by a specific power yield. The specific power yield was made available as an average figure for Germany by the Solar Energy Association [26]. The capacity increase was halved to take account of the fact that new installations can only make a pro rata contribution to electricity generation in the first year.

Solar thermal systems

The heat supply quoted is calculated from the installed collector area and a mean annual heat yield. In the case of hot-water supply installations this is 450 kilowatt hours per square metre (kWh/m^2) per annum. In recent years installations solely for hot-water generation have been joined by increasing numbers of solar thermal installations for combined hot water supply and central heating support.

Because the generation potential of installations for central heating support cannot be fully exploited in the summer months, a reduced heat yield of 300 kWh/m^2 per annum is used for calculation purposes here. A yield of 300 kWh/m^2 per annum is also used for swimming pool absorber systems.

Because the gradual addition of new installations means that the collector area available during the year is smaller than the installed capacity at the end of the year, only half of the increase in area for the year is used when calculating the heat supply.

A factor of 0.7 kWth/m^2 is used for converting area into capacity [131].

CO_2 equivalent and SO_2 equivalent

The "Kyoto gases" CO_2, CH_4, N_2O, SF_6, PFC and HFC, are important greenhouse gases which are subject of reduction under the Kyoto Protocol. The extent to which they contribute to the greenhouse effect differs. To be able to compare the greenhouse effect of the individual gases, they are each assigned a factor – the relative global warming potential (GW_p) – which serves as a measure of their greenhouse effect in terms of the reference substance CO_2.

Global warming potential is specified in the unit "CO_2 equivalent" and is calculated by multiplying the global warming potential by the mass of the gas in question. It states the quantity of CO_2 that would have the same greenhouse effect as the gas in question over a period of 100 years.

In view of the poor data availability situation, only the greenhouse gases CO_2, CH_4 and N_2O are taken into account.

Gas	Relative greenhouse potential [1)]
CO_2	1
CH_4	21
N_2O	310
Gas	**Relative acidification potential**
SO_2	1
NO_x	0.696
NH_3	1.88

The acidification potential of SO_2, NO_X, HF, HCl, H_2S and NH_3 is determined in a similar way to global warming potential. It is expressed in the unit "SO_2 equivalent" and shows the quantity of SO_2 that has the same acidifying effect.

In view of poor data availability, only the air pollutants SO_2 and NO_X are taken into account when calculating the emissions avoided.

1) The calculations in this brochure use the IPCC figures from 1995 [56]. These are prescribed for greenhouse gas reporting under the Framework Convention on Climate Change and under the Kyoto Protocol in accordance with the UNFCCC Guidelines [34].

Global warming potential is based on a time horizon of 100 years, with CO_2 as reference substance.

3. Calculating avoidance factors and avoided emissions for renewables-based electricity generation

The emissions avoided by using renewables are calculated on the basis of the quantities of electricity generated from renewables and on substitution and emission factors.

Substitution factors indicate the fossil fuels that are replaced by the renewable source in question. Emission factors specify the quantity of greenhouse gases and air pollutants emitted per kilowatt hour (kWh) of fossil or renewable electricity. They are made up of direct emissions during electricity generation and the emissions arising from the upstream chain. The upstream chain comprises the pollutant emissions arising from manufacture of the generating installations and from the production, refining and transport of the fossil and renewable energy sources. In the case of combined heat-and-power generation, allocation is in accordance with the "Finnish method" laid down in EU Directive 2004/8/EC.

The substitution factors used are based on the "Report on CO_2 reduction in the electricity sector through the use of renewable energy sources in 2008 and 2009" (*Gutachten zur CO_2-Minderung im Stromsektor durch den Einsatz erneuerbarer Energien im Jahr 2008 und 2009* (Klobasa et al. [88]). An electricity market model was used to calculate the extent to which renewables replace conventional energy sources, given the existing portfolio of power plants. To date, renewables have not yet replaced the base load supplied by nuclear power plants, because the latter have lower variable costs than lignite power plants.

Compared with previous years, the latest report (Klobasa et al. [88]) shows much lower replacement of electricity from lignite power plants. The reasons lie partly in a changed generation mix (less electricity generated from nuclear power), and partly in a revised method, which now takes account of imports and exports of electricity. As a result, the calculated greenhouse gas saving due to renewable energies in the years 2008 to 2010 is two to four million tonnes CO_2 equivalent lower than a calculation based on the substitution factors used in earlier years.

The emission factors for fossil and renewable electricity production are taken from various databases or deduced from research projects. The direct emission factors for fossil power generation are calculated using an implicit method on the basis of the Federal Environment Agency (UBA) database for national inventory reporting (CSE) [92]. The fuel efficiency of the individual power plant types is also taken into account when calculating the implicit emission factor. The underlying data for this purpose are taken from the special table on gross power generation by energy sources [64] and the AGEB's energy balance evaluation tables [2].

The emissions due to upstream chains for fossil fuels are taken from the GEMIS database at the Öko-Institut [90]. For the renewable energy emission factors, representative datasets were selected from various databases, and in some cases modified. Special mention must be made of the sources: Öko-Institut [90], Ecoinvent [84], UBA [92], Vogt et al. [89], Ciroth [83] and Frick et al. [86].

Detailed information on the calculation methods and data sources can be found in UBA [75].

Substitution factors for renewables-based electricity in Germany, 2011

	Substitution factors for renewables-based electricity [1)]				
	Nuclear en. [2)]	Lignite	Hard coal	Natural gas	Mineral oils
	[%]				
Hydropower	0	6	63	31	0
Wind energy	0	6	64	30	0
Photovoltaics	0	5	65	31	0
Solid biomass	0	6	64	31	0
Liquid biomass	0	6	64	31	0
Biogas	0	6	64	31	0
Landfill gas	0	6	64	31	0
Sewage gas	0	6	64	31	0
Biog. fraction of waste [3)]	0	6	64	31	0
Geoth. energy	0	6	63	31	0

1) This means, for example, that of the electricity replaced by 1 kilowatt hour (kWh) hydro power, 6 percent comes from lignite power plants, 63 percent from coal-fired power plants and 31 percent from gas-fired power plants.

2) Given the underlying model assumptions, renewable energies do not replace the base load supplied by nuclear power plants.

3) Biogenic fraction of waste is taken as 50 percent

Source: Klobasa et al. [88]

4. Calculating avoidance factors and avoided emissions for renewables-based heat generation

The emissions of greenhouse gases and air pollutants that are avoided by using renewable energy in the heat sector are calculated in three stages:

First, the substitution factors are determined for each of the renewable heat supply paths. These indicate which fossil primary and also secondary energy sources such as district heating or electricity would have to take over the renewable heat supply if the latter were not available. Important information for this purpose is provided by the findings of an empirical survey on the use of solar thermal energy, heat pumps and wood-burning systems in private households [87]. Use was also made of information from the Working Group on Energy Balances (AGEB) on energy consumption by the sectors: processing of mined and quarried products, the paper industry, and other industries (including timber industry) and private households. In the case of supplies of renewable district and local heating from wood, geothermal energy and biogenic fractions of waste, it is assumed that these are a 100 percent substitute for fossil district heating and that the distribution losses are comparable.

In a second step, emission factors for renewable heat supplies in private households, agriculture and industry, and also for the relevant savings in fossil heat supplies, are taken from or deduced from UBA [92], Öko-Institut [90], Ecoinvent [84], Vogt et al. [89], Ciroth [83], Frick et al. [86]. The emission factors used take account of the entire upstream chain for supplies of fossil and renewable energy sources. In the case of combined heat-and-power generation, allocation to heat and power follows the “Finnish method” laid down in EU Directive 2004/8/EC.

In the final step, the fossil emissions avoided are compared to the emissions arising from the use of renewables to determine the net avoidance of greenhouse gases and air pollutants. Detailed information on the calculation methods and data sources can be found in UBA [75].

Substitution factors for renewables-based heat in Germany, 2011

	Substitution factors for renewables-based heat					
	Heating oil	Natural gas	Hard coal	Lignite	District heat	Elec. Heating
	[%]					
Wood – stand-alone stoves (HH)	41	50	0	1	2	6
Wood – central heating systems (HH)	65	20	2	3	0	10
Solid biomass (industry)	11	55	9	15	10	0
Solid biomass (HP/CHP)	0	0	0	0	100	0
Liquid biomass (industry)	5	69	10	3	13	0
Liquid biomass (HH)	29	51	1	1	9	8
Biogas, sewage gas, landfill gas (BCHP)	61	36	4	0.1	0	0
Biogenic fraction of waste (HP/CHP)	0	0	0	0	100	0
Deep geothermal energy (HP/CHP)	0	0	0	0	100	0
Solar thermal energy (HH)	45	51	0	0	2	3
Heat pumps (HH)	45	44	1	2	5	3
Total	**37**	**40**	**3**	**3**	**13**	**4**

Sources: UBA [75], [92] on the basis of AGEE-Stat and Frondel et al. [87]; AGEB [2], [4]

5. Calculating avoidance factors and avoided emissions for biofuels

Calculation of the emissions avoided by using biofuels is based on the following key points:

- Largely based on the typical values of the EU Renewable Energy Directive (2009/28/EC), supplemented by IFEU [5]
- Takes account of the nature and origin of the raw materials used for biofuel production in Germany and includes imports and exports
- Allocation of main products and by-products on the basis of lower calorific value
- Takes account of differences in production technologies/energy supply

The substitution relationships are laid down as follows: 1 kilowatt hour (kWh) bioethanol replaces 1 kWh petrol, and 1 kWh biodiesel or vegetable oil replaces 1 kWh mineral diesel. No distinction is made between vehicle emissions arising from biofuels and those from conventional motor fuels.

The nature of the underlying raw materials and the origin of the raw materials are an important factor for the size of emission reductions due to the use of biofuels. The following table provides an overview.

Different raw materials' shares of total biofuels used in Germany, 2011

	Rapeseed	Soya	Palm oil	Waste [1]	Grain	Sugar cane	Beets	Other
	[%]							
Biodiesel	87	1	5	7	–	–	–	–
Vegetable oil	100	0	0	0	–	–	–	–
Bioethanol	–	–	–	–	79	1	19	1

Figures rounded

1) German biodiesel production on the basis of waste is considerably higher.

Quellen: UBA [75] on the basis of BDBe [82]; VDB [81]; Greenpeace [78]; BLE [96]

The size of the emission reduction is also determined by the emission factors for the various biogenic and fossil motor fuels. The calculations of greenhouse gas emission reductions are largely based on the typical figures from the EU Renewable Energy Directive (2009/28/EC) (exception: biodiesel from waste – IFEU [5]). The final step is to determine the net reduction in CO_2 and all greenhouse gases by netting the fossil emissions avoided against the emissions caused by the use of renewables. Detailed explanations of the calculation methods and information on the data sources can be found in UBA [75].

Direct and indirect land use changes – which play a major role in cultivated biomass – are not taken into account in the calculations for 2011. Since land use changes may cause high emissions of greenhouse gases and are therefore of considerable relevance, they ought to be included in the accounts. Methodological approaches for indirect land use changes are currently being developed, by the European Commission among others. Since January 2011, direct land use changes have largely been ruled out by the provisions of the Biofuels Sustainability Ordinance.

Greenhouse gas emission factors used [1)]

Fuel (underlying raw material)	Emission factor [g CO_2 eq./kWh]
Petrol/diesel (fossil)	301.7
Biodiesel (rapeseed)	165.6
Biodiesel (soya)	180.0
Biodiesel (palm oil)	115.2
Biodiesel (waste)	57.6
Vegetable oil (rapeseed)	126.0
Bioethanol (grain)	183.7
Bioethanol (beets)	118.8
Bioethanol (sugar cane)	73.1
Biodiesel (weighted)	**156**
Vegetable oil (weighted)	**126**
Bioethanol (weighted)	**169**

1) Based on IPCC 2007

Sources: UBA [75] on the basis of AGEE-Stat and EP/ER [85]; BR [79], [80]; IFEU [5]

6. Fossil fuel savings due to renewable energy sources

The calculation of the fossil energy savings achieved by using renewable energy sources in the electricity, heat and transport sectors is closely based on the methods and data sources of the emission balances (see also Annex, Section 3-5). Depending on the substitution ratio, the various renewable energy supply paths save different fossil fuels including the need for their upstream chains.

The saving of fossil fuels in the **electricity sector** is calculated from the renewable energy substitution factors determined by Klobasa et al. [88] (cf. Annex, Section 3), the average fuel efficiencies of German power plants, and the cumulative primary energy needed to make the fossil fuels available.

Average fuel-use efficiency of the relevant power station sector

Energy source	[%]
Lignite	38.4
Hard coal	42.4
Natural gas	54.5
Mineral oil	45.9

Source: AGEB [2], [4]

The gross saving in fossil fuels is then compared with the fossil primary energy needed to produced biogenic fuels and to produce and operate installations for electricity generation from renewable sources.

Primary energy input for energy supply

Electricity sector	Consumption of primary energy (fossil fuels)
Energy sources	[kWh_{prim}/kWh_{el}]
Lignite (power plant)	2.68
Hard coal (power plant)	2.64
Natural gas (power plant)	2.04
Petroleum (power plant)	2.48
Hydropower	0.01
Wind energy	0.04
Photovoltaics	0.31
Solid biomass (CHP)	0.06
Liquid biomass (BCHP)	0.26
Biogas (BCHP)	0.37
Sewage/landfill gas (BCHP)	0.00
Biogenic fraction of waste	0.02
Geothermal energy	0.47

Sources: Öko-Institut [90]; Ecoinvent [84]; Vogt et al. [89]; Frick et al. [86]

Heat sector	Consumption of primary energy (fossil fuels)
Energy sources	[kWh_{prim}/kWh_{final}]
Natural gas (heat. systems)	1.15
Heating oil (heat. systems)	1.18
Lignite briquettes (stoves)	1.24
Hard-coal coke (stoves)	1.39
District heat [1]	1.20
Electricity [2]	1.71
Firewood (heating systems)	0.04
Wood pellets (heat. systems)	0.11
Biomass (industry)	0.15
Biomass (CHP)	0.02
Liquid biomass (BCHP)	0.09
Biogas (BCHP)	0.06
Biogenic fraction of waste	0.01
Deep geothermal energy	0.47
Heat pumps	0.58
Solar thermal energy	0.12

1) Fossil mix excluding waste and renewables; incl. grid losses
2) Share of fossil primary energy excluding uranium; incl. grid losses

Sources: Öko-Institut [90]; Ecoinvent [84]; Vogt et al. [89]; Frick et al. [86]

Transport sector	Consumption of primary energy (fossil fuels)
Energy sources	[kWh_{prim}/kWh_{final}]
Petrol	1.19
Diesel	1.11
Biodiesel (rapeseed)	0.57
Biodiesel (soya)	0.69
Biodiesel (palm oil)	0.52
Biodiesel (waste)	0.40
Vegetable oil (rapeseed)	0.23
Bioethanol (grain)	0.53
Bioethanol (beets)	0.43
Bioethanol (sugar cane)	0.18

Sources: Öko-Institut [90]; IFEU [5]

The primary energy saving in the **heat sector** is also calculated from the substitution factors and the cumulative fossil energy needed to supply heat from both fossil and renewable sources (cf. Appendix, Section 4).

The savings in the secondary energy sources "district heating" and "electricity" are allocated in the same proportion as the primary energy sources used to produce the district heating and electricity. On this basis the fossil fuel mix saved by district heating works out at 51 percent natural gas, 27 percent hard coal, 2 percent oil, 8 percent lignite and 12 percent other energy sources. The fuel mix for electricity generation is 25 percent lignite, 18 percent nuclear power, 19 percent hard coal, 14 percent natural gas, 4 percent miscellaneous and 20 percent renewable energy sources. Grid and other losses are applied at a flat rate of 8 percent for district heating and 14 percent for electricity.

The saving in fossil primary energy in the **transport sector** is due to replacement of diesel fuel by biodiesel and vegetable oil, and of petrol by bioethanol. The size of the primary energy saving due to biofuels is determined not only by the agricultural production and origin of the biofuels, but also, in particular, by the allocation method used to split the energy consumption among main products and by-products. The records allocated on the basis of the energy value of the products are taken from the GEMIS database of the Öko-Institut [90] (fossil motor fuels) and from the IFEU short report [5] (biofuels).

7. Revenue resulting from the use of renewable energies

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 due in particular – in the form of investments – to the construction of installations. And as the number of installations increases, the operation of these installations is becoming a growing economic factor. The economic thrust resulting from the operation of installations includes not only expenditure on operation and maintenance of the installations, especially in the form of personnel expenses and ancillary energy costs, but also the provision of renewable heating fuels and biofuels.

The cost of operating and maintaining installations is determined on the basis of technology-specific values. Cost calculations from various scientific studies are used for this purpose. These include the research projects related to the Renewable Energy Sources Act [35], among other the research report on the Renewable Energy Sources Act Progress Report, the research report monitoring of electricity generation from biomass – final report [57]), the evaluation of the market incentives programme [145] and the evaluations of KfW assistance in the field of renewable energy sources [140].

In determining sales resulting from the supply of heating fuel for electricity- and heat production, the costs of solid and liquid heating fuels and of the substrates used to produce biogas are taken into account. The relevant solid biomass fuels include in particular waste wood, residual wood from forestry and industry, wood pellets, wood chips, wood briquettes, and commercially traded firewood. Liquid fuels for stationary use include palm oil, rapeseed oil and other vegetable oils; the main component of the relevant substrates for biogas production is maize silage and grass silage. Total sales resulting from the supply of biogenic heating fuels are assessed at 4.2 billion Euro.

In the fuel sector, sales are determined on the basis of wholesale and retail prices. Here it is necessary to take account of the different types of fuel and distribution channels. For example, sales of biodiesel as an admixture to petroleum diesel are based on an assumed average net price of 94.69 cent per liter (ct/l), whereas the net figure for sales to commercial vehicles at own filling stations is 116.93 ct/l.

The revenues described in the main text as arising from the operation of installations are not comparable with the figures for the years before 2010, because they have been determined on the basis of a new system.

8. Organisation for Economic Cooperation and Development (OECD)

The Organisation for Economic Cooperation and Development (OECD) was founded on 30. September 961 as the successor organisation to the Organisation for European Economic Cooperation (OEEC). The organisation's founding document, the OECD Convention, was signed by 18 European states plus the USA and Canada. By the end of 2009 a worldwide total of 30 countries belonged to the organisation: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA. In 2010 another four states – Chile, Estonia, Israel and Slovenia – were admitted to the organisation.

The main task of the OECD is to promote a policy that facilitates optimum economic development and employment in the Member States in conjunction with rising standards of living. The basis for this is maintaining the financial stability of the Member States. At the same time this goal has a positive influence of the development of the global economy.

But the focus is not only on the economic development of the Member States. The organisation also seeks to help non-members to achieve sound economic growth. And the OECD is intended to make a contribution to the growth of world trade.

The OECD is based in Paris, France.

9. Effect of EU Directive 2009/28/EC on renewable energy statistics

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. To some extent these differ from the calculation methods used in Germany to date, which form the underlying methods used in this brochure. The following differences in particular should be noted:

- The target is based on gross final consumption of energy,
- Electricity supplied by hydro power and wind energy is normalised,
- There are special requirements for calculating the shares of heat consumption and in the transport sector.

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.*

In the national statistics to date (e.g. in this brochure), final energy consumption has been defined as the portion used for energy purposes of that energy quantity within Germany that reaches the final consumer. Gross final energy according to the Directive corresponds to final energy plus grid losses and plus the internal consumption of the generating plants, and is therefore higher.

When calculating the contributions of wind energy and hydro power, the effects of climate fluctuations on electricity yield are taken into account. As a result of this "normalisation" in terms of an average year, the figure for wind and hydro power no longer corresponds to the actual yield for the year in question, but provides a better picture of the relevant expansion.

Target achievement calculations in the transport sector only take account of sustainably produced biofuels plus the contribution due to the electricity which is generated from renewable sources and consumed in all types of electric vehicles. Furthermore, a factor of 2 is applied to biofuels from residues, lignocellulose, biomass-to-liquids (BtL) and biogas from residues, and a factor of 2.5 to renewable electricity in the road traffic sector.

Thus comparisons between data determined in accordance with the requirements of the EU Directive and statistics from other sources, such as the data under the Renewable Energy Sources Act or the national statistics, may be of limited value.

Conversion factors

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

Units of energy and output

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

Legally binding units in Germany since 1978. The 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 relate to the calorific value.

Greenhouse gases

CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
SF_6	Sulphur hexafluoride
HFC	Hydrofluorocarbons
PFC	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 abbrevations

APEC	Asia-Pacific Economic Cooperation
AusglMechV	Ordinance on the equalisation mechanism (Ausgleichsmechanismusverordnung)
BauGB	Ferderal Building Code (Baugesetzbuch)
BiokraftQuG	Biofuel Quota Act (BioKraftQuG)
BioSt-NachV	Biomass-electricity sustainability ordinance (Biomassestrom-Nachhaltigkeitsverordnung)
BCHP	Block-type heating power station
BtL	Biomass-to-Liquids
CHP	Combined heat and power plant
CHP Act	Combined heat and power (Cogeneration) Act
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
GDP	Gross domestic product
GHG	Greenhouse gas
GSR	Renewables Global Status Report
HH	Households
HP	Heating Plant
HVDC	High-voltage direct current transmission
MAP	Market Incentive Programme (Marktanreizprogramm)
MinöStG	Mineral Oil Tax Act (Mineralölsteuergesetz)
N/A	Not available
N.q.	Not quantified
NREAP	National Renewable Energy Action Plan
PEC	Primary energy consumption
RE	Renewable energies
REEGLE	Information gateway for renewable energy and energy efficiency
REEEP	Renewable Energy and Energy Efficiency Partnership
R & D	Research and development
StromEinspG	Act on the Sale of Electricity to the Grid (Stromeinspeisungsgesetz)
TSO	Transmission system operator
USD	United States Dollars

Country codes:

BE	Belgium
BG	Bulgaria
DK	Denmark
DE	Germany
EE	Estonia
FI	Finland
FR	France
EL	Greece
IE	Ireland
IT	Italy
LV	Latvia
LT	Lithuania
LU	Luxembourg
MT	Malta
NL	The Netherlands
AT	Austria
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SK	Slovakia
SI	Slovenia
ES	Spain
CZ	Czech Republic
HU	Hungary
UK	United Kingdom
CY	Cyprus

Glossary

Acidification 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.
Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG)	The Act on the Promotion of Renewable Energies in the Heat Sector (for short: Renewable Energies Heat Act – EEWärmeG) dating from 2009 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.
Air pollutant	Any substance present in the air which can have harmful effects on human health or on the environment as a whole.
Avoidance factor	Avoided emissions per unit of final energy from renewable sources (electricity, heat or motor fuel).
Biodiesel	Diesel-quality methylester 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. Can also be refined from soya and palm oil and sunflowerseed oil. As well as vegetable oils, it is also possible to use residual substances such as frying oil and animal oils to produce biodiesel.
Bioethanol	Ethanol produced from biomass and/or the biodegradable fraction of waste and intended for use as a biofuel. A biofuel obtained by fermenting plants containing starch or sugar (e.g.: maize, sugar cane). Bioethanol, like biodiesel, is regarded as a first-generation biofuel. Unlike biodiesel, however, bioethanol is used in spark-ignition engines. If bioethanol is added to conventional motor gasoline, the product is known, for example, as E5 (5 percent admixture), E10 (up to 10 percent) or E85 (up to 85 percent).
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 cleaned 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 arises in agriculture, fisheries and forestry, industry and households. It includes, for example: waste wood and residual wood, straw, garden waste, slurry, biowaste, 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 from “bio bins”, 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 percent.
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 regrowable raw materials (energy crops) and organic residues and waste.
Biomethane (bio natural gas)	Treated crude biogas (CO_2 content approx. 30 to 45 percent by volume) in natural gas quality. The treatment process removes carbon dioxide and trace substances to obtain a product with a methane content and purity comparable to natural gas (CO_2 content not exceeding 6 percent by volume).

Block-type combined heat-and-power plant (CHP plant)	Block-type combined heat-and-power (CHP) plants are installations for generating electricity and heat that work on the co-generation principle. Diesel or petrol engines drive generators and generate electricity. At the same time the exhaust heat of the engines is used. The utilisation of the fuel may be as high as 90 percent.
Bottleneck capacity	Maximum continuous capacity of a power plant that can be achieved under normal conditions. It is limited by the weakest part of the installation (bottleneck) and is determined by measurement and recalculated in terms of normal conditions.
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 above all 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 temperature at the Earth’s surface. 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	Unit for the global warming potential (GW_P) of a gas. It states the quantity of CO_2 that would have the same greenhouse effect as the gas in question over a period of 100 years. It is used to compare the greenhouse effect of different gases and express their contribution to the global warming. The equivalence factors used follow the values specified in the IPCC Second Assessment Report: Climate Change (1995), which are used for national emission reporting. Methane (CH_4) has a CO_2 equivalent of 21.
Coal equivalent (TCE)	Unit for the energy content of primary energy sources. Quantity of energy produced by the combustion of a standardised kilogram of hard coal.
Combined heat and power (CHP)	Co-generation of electricity and heat. This principle brings a marked improvement in fuel utilisation in power stations.
Combined solar thermal installations	Solar thermal installations used to provide not only hot water, but also heating support.
Condensing power plant	Thermal power station which generates electricity only (without using the exhaust heat produced).
District heating	Thermal energy supplied to the consumer via a system of insulated pipes.
Electric mobility	Use of electric vehicles on road and rail.
Emissions	Emissions are the gaseous, liquid and solid substances that are output into the environment (soil, water, air) from an installation, building or means of transport. Releases of heat, radiation, noise and odours also count as emissions.
Emission allowance	Vested right to emit a certain quantity of a pollutant in a certain period. This is an important instrument of the Kyoto Protocol for limiting emissions of greenhouse gases. Emission allowances can be traded.
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 by the conventional energy sources that are replaced by renewable energies, while the emissions caused 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.
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 either 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 sunflowerseed, fast-growing trees, poplars and willows, and beet and hemp.
Energy sources	Substances and physical manifestations which can be used or converted to produce energy.
Non-energy consumption	Those parts of certain energy sources that are not used for energy purposes. For example, oil is a raw material for the plastics industry.
External costs	External costs do not play any part in the polluter’s cost calculations, but have to be borne by third parties. One example is the emission of substances that contribute to acid rain. Such emissions do not give rise to any direct costs for the polluter, because the resulting damage is borne by the general public. Another example is the release of greenhouse gases, which have impacts in Germany and other parts of the world, the cost of which is borne by the general public.
Final energy	That part of primary energy, after deduction of transmission and distribution losses, which reaches the consumer and is then available for heating, hot water and ventilation, for example. Final energy forms include district heating, electricity, liquid hydrocarbons such as petrol, kerosene or fuel oil, and various gases such as natural gas, biogas and hydrogen.
Final energy consumption	Comprises that part of national energy supply used for energy purposes, after conversion, which is used directly for generating useful energy. Final energy consumption is broken down by certain groups of consumers: private households; trade, commerce and services; industry; and transport.
Finnish allocation method	This method is used to allocate fuel input and the resulting emissions of CHP plants to the individual products electricity and heat. The saving in primary energy compared with separate generation of electricity and heat is divided equally between the units of electricity and heat produced. To this end the EU Commission has laid down efficiency reference values for separate power and heat generation.
Fossil fuels	Energy resources with carbon compounds of varying chain lengths that have been formed from biomass under high pressure and temperature over millions of years: oil, coal, gas.
Fuel cell	Fuel cells are electrochemical energy converters. They supply electricity by “cold combustion” of oxygen and hydrogen on catalytically active materials.
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, expressed as global warming potential (GWP, CO_2 = 1). The GWP of a substance depends on the length of the period (usually 100 years) on which this parameter is based.

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 gas	Atmospheric trace gases which contribute to the greenhouse effect and which are of both natural and 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 less electricity exports.
Gross electricity generated	Gross electricity generated is the electrical work generated by a generating unit, including internal consumption.
Gross employment	Employment attributable to the renewable energy industry in Germany and encompassing all persons directly employed in the construction, operation and maintenance of installations for using renewable energy and the supply of fuels, and those employed indirectly as a result of this sector's demand for upstream products and services. Unlike net employment, it thus takes no account of negative or positive influences on employment outside the renewable energy sector.
Gross final energy consumption	Includes the quantities of energy needed for the internal consumption of energy conversion operations plus transmission and distribution losses, and is therefore always higher than final energy consumption.
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.
Immission	Action of emissions (air pollutants, noise, radiation) on soil, water, humans, animals, plants and material assets. The parameter measured may be the concentration of a pollutant per square metre of soil or per cubic metre of air.
Kreditanstalt für Wiederaufbau (KfW)	Bank of the federal and Land authorities. Assists various projects by providing low-interest loans.
Kyoto Protocol	Supplementary protocol to the United Nations Framework Convention on Climate Change. Among other things it is intended to restrict worldwide emissions of greenhouse gases.
Landfill gas	Energy-rich gas formed by rotting waste. May contain up to 55 percent methane (CH_4) and 45 percent 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 run by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to promote installations for generating heat from renewable energy sources.
Merit-order effect	Shift of market prices along the merit-order curve or the supply curve due to market entry of power stations with lower variable costs (marginal costs). This displaces the power stations with the highest production costs from the market (assuming unchanged demand) and admits lower-priced electricity on the market.

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 IPCC Second Assessment Report: Climate Change (1995) its climate impact is some 21 times greater than that of CO_2, 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, technical installations or infrastructure facilities. Heat is abstracted from the ground by means of a heat exchanger and adjusted to the desired temperature level 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 waters or the upper layers of the soil. It is characterised by a relatively low level of heat which can be harnessed by heat pumps.
Nitrous oxide (N_2O)	N_2O (nitrous oxide / laughing gas) is a colourless gas belonging to the group of oxides of nitrogen. Like (CO_2) and methane (CH_4), it is relevant as a gas with 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.
Nominal capacity	The nominal capacity of a generation, transmission or consumption installation is the maximum continuous capacity for which it is designed according the supply agreements.
Non-energy consumption	Those parts of certain energy sources that are not used for energy purposes. For example, oil is a raw material for the plastics industry.
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.
Photovoltaic systems (PV)	Direct conversion of solar radiation into electrical energy by means of semiconductors, often known as “solar cells”.
Physical energy content method	Since 1990, in the interests of international comparability, primary energy consumption in Germany has been calculated using the physical energy content method. In line with the procedure adopted by international organisations (IEA, EUROSTAT, ECE), it is assumed that electricity generation uses 33 percent of the energy content of the nuclear energy input, 100 percent of the hydro power / wind energy and photovoltaic energy, and 100 percent of imported electricity.
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, hydro power, geothermal energy and tidal energy). Primary energy is converted into a secondary stage in the energy series 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	Primary energy consumption is the total consumption of the primary energy sources occurring in nature. It is the sum of inventory changes and the balance of amounts received and supplied. It includes the energy needed for conversion and final consumption.
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.

Pumped-storage power plant	Hydroelectric power stations which use electrical energy to pump water from a low-level to a high-level reservoir at times of low demand for electricity. If needed, the potential energy stored in the water can be converted back into electrical energy by means of turbines and generators. Such power plants are used in particular to meet very short-term peak demand for electricity. A distinction is made between pumped-storage power plants with and without a natural inflow. Only the component due to the natural inflow is considered renewable and is taken into account in electricity supply accounting.
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 sources (RE)	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, in other words it is strictly speaking not 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 our 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, hydro power, ambient heat and wave energy.
Renewable Energy Sources Act (EEG)	The "Act on granting priority to renewable energy sources" (for short: Renewable Energy Sources Act – EEG) dating from 2000 regulates the regulates the grid operators' priority obligation to purchase electricity from renewable energies, the (declining) feed-in tariffs for the individual generation methods, and the procedure for allocating the resulting additional costs among all electricity customers. Amendments to the act entered into force in 2004, 2009 and – most recently – on 1 January 2012.
Repowering	Replacement of older power generation installations by new and more powerful installations on the same site. This plays an important role in the case of wind energy in particular.
Run-of-river hydro power plant	Installation for generating electrical energy using the power of flowing water (streams, rivers).
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 municipal gas. Enhancement to produce 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.
Sewage gas	Energy-rich gas formed in the digestion towers of sewage works. It is one of the biogases. Its main component is methane.
Smart grid	An intelligent power grid system that encompasses communicative networking and control of electricity generation units, storage facilities and other consumers in electricity grids.
Smart meter	"Intelligent" electricity meter which, unlike conventional meters, registers not only the quantity consumed, but also the time when it was consumed. This makes it possible to shift a household's electricity consumption into periods when the price of electricity is particularly low.
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 certain 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 fossil primary and secondary fuels by renewable energy sources.
Transmission losses	These losses occur during the transmission and transforming of electrical energy. Transmission losses increase as the square of the current transmitted. That is the reason why electricity is transformed to higher voltages for transmission over long distances.
Useful energy	The energy actually available to the consumer after the last conversion of the (final) energy in appliances and equipment. It does not include losses that occur due to transmission of electricity in power lines, residual quantities of liquid fuels left in tankers, or quantities lost through evaporation. Examples include the heat energy present in boiling water or heated rooms, the light energy radiated by a light bulb, the kinetic energy in a fast-moving car, or the potential energy present in raised loads. No reliable information is available on the scale of useful energy consumption, as there are virtually no data collection methods for this purpose.
Wind turbine	In the strict sense, installations 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 residual wood (sawdust, wood shavings, residual 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 around 5 kilowatt hour per kilogram.

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