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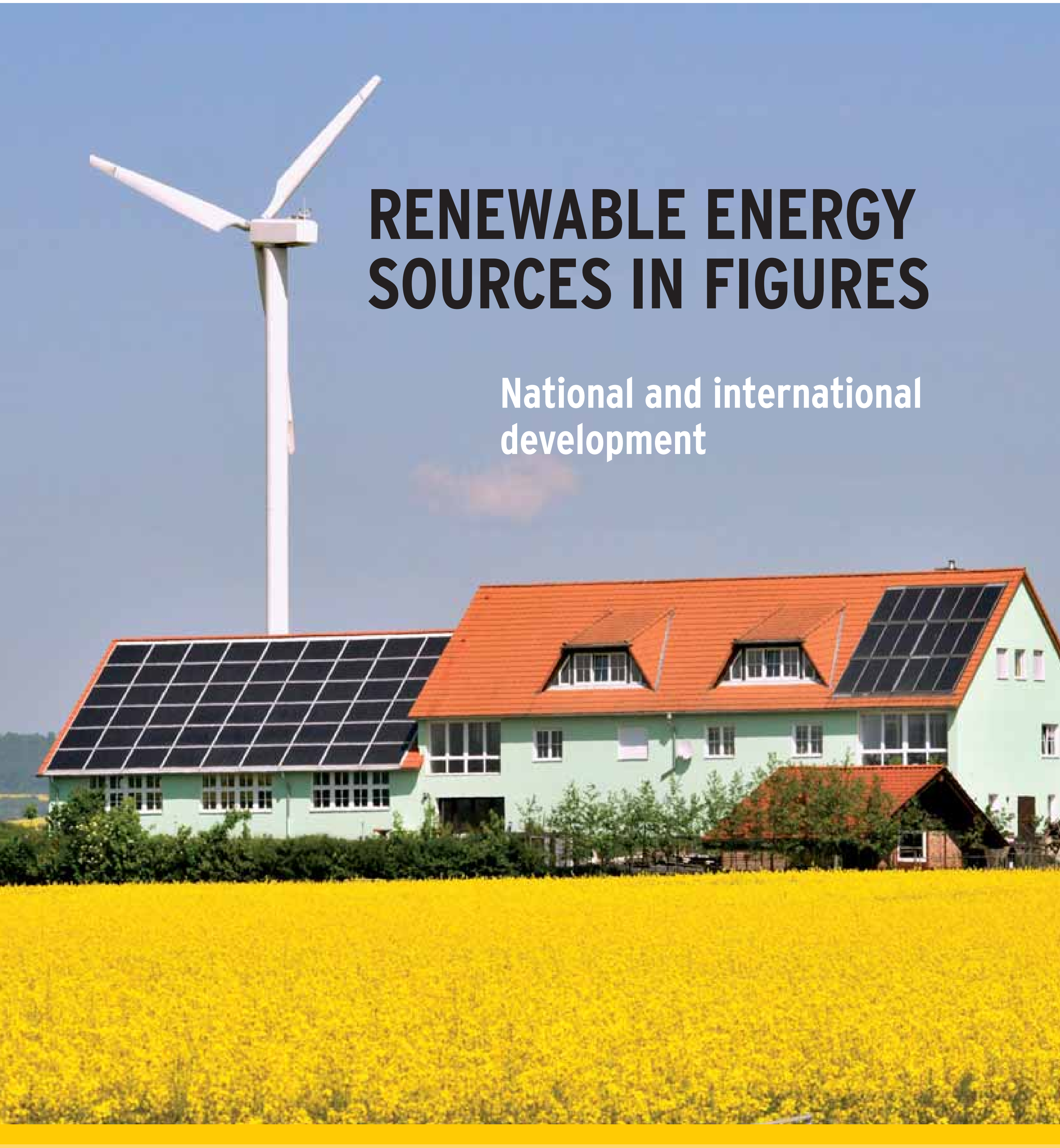

RENEWABLE ENERGY SOURCES IN FIGURES

National and international development

IMPRINT

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INTRODUCTION

The brochure "Renewable Energy Sources in Figures – National and International Development" has been published annually by the German Environment Ministry (BMU) since 2002, and contains information on the development of renewable energy sources in Germany, the European Union and worldwide.

In recent years, renewables have developed at a rapid rate, but the pace of expansion varies considerably between regions. Many of the world's countries have come to realise that the intensive use of renewable energy sources represents an important step towards protecting our climate, and a useful way of reducing our consumption of fossil resources and our growing dependency on imports of raw energy resources. The climate and energy problem is not a national issue but a global one, and is increasingly becoming a top priority for politicians. Drastically reducing our emissions of climate-damaging greenhouse gases is considered particularly important in this regard.

Thanks to its ambitious climate and energy programme, the German Government is making a national contribution to the European Union's joint climate protection targets, and thereby also contributing to the success of international climate negotiations. The German Government is guided by ambitious but realistic targets:

- Emissions of greenhouse gases are to be cut by 40 % by 2020 compared with 1990 levels; by the end of 2007, Germany had already achieved a reduction of -21.3 %.
- Energy productivity is to be increased by 3 % per annum. This means that by 2020, energy use will be twice as efficient as in 1990.
- Building on the continuous rise in renewables in recent years, their share is to be further significantly increased:
  - The proportion of gross electricity consumption attributable to renewables is to be increased from its current level of 15 percent to at least 30 percent by 2020, with plans for further continuous expansion thereafter.
  - The proportion of heating energy consumption attributable to renewables is to be increased from its current level of just under 8 percent to 14 percent by 2020.
  - Through the use of biofuels, greenhouse gas emissions are to be reduced by 7 percent by 2020 compared with the use of fossil fuels, corresponding to an energy share of around 12 percent.
  - In the long term (by 2050), the proportion of total energy consumption attributable to renewables in Germany is to be increased to around 50 percent.
- The share of electricity from cogeneration (CHP) is to be doubled to 25 percent by 2020.

Germany's targets for the expansion of renewable energy sources must be viewed within the context of the European Union's current targets, which aim to increase the share of total final energy consumption attributable to renewables to 20 percent by 2020. Germany has been allocated a share of 18 percent, almost double of the current level.

At present, the likelihood of achieving these targets in Germany looks very positive. With the new Renewable Energy Sources Act (EEG, 2009), the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG 2009), the promotion of renewables via targeted market incentive programmes, a wide range of initiatives in the research and development sector, plus a host of other mechanisms, the German Government and its legislative authorities have created the necessary requirements for future development in Germany. These instruments are accompanied by numerous activities at *Land* and local authority level, together with measures by various institutions, private individuals and companies.

Part one of this updated publication contains information on the development of renewable energy sources up until 2008, their environmental impacts, and the economic effects in Germany. It also provides an overview of the German Government's objectives, the mechanisms for achieving these targets, and information on the support of renewables and funding priorities in this sector. Parts two and three contain information on renewables in the European Union and at global level.

WORKING GROUP ON RENEWABLE ENERGIES – STATISTICS (AGEE-STAT)

In collaboration with the Federal Ministry of Economics and the Federal Agricultural Ministry, the German Environment Ministry has set up the Working Group on Renewable Energies – 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 have been incorporated into this brochure.

AGEE-Stat is an independent specialist body, which began operation in 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 Environmental Agency (UBA)
- the Federal Statistical Office (StBA)
- Fachagentur Nachwachsende Rohstoffe e.V. (Agency for Renewable Resources, FNR),
- Arbeitsgemeinschaft Energiebilanzen (Working Group on Energy Balances, AGEB), and
- Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (Centre for Solar Energy and Hydrogen Research, ZSW).

Prof. Dr. Staiß (ZSW Stuttgart) has been appointed Head of the Working Group on Renewable Energies – Statistics.

AGEE-Stat's activities focus primarily on renewable energy statistics. It has also been charged with

- creating a basis for the German Government's various national, EU-wide and international reporting obligations in the field of renewable energies, and
- carrying out general information and PR work on renewable energy data and development.

In order to improve the database and scientific calculation methods, AGEE-Stat is also involved in a range of research work. Its work is supported by workshops and consultations on selected topics.

Further information on AGEE-Stat and on renewable energies may be found on the BMU website: www.erneuerbare-energien.de/inhalt/3860.

PART I: RENEWABLE ENERGY SOURCES IN GERMANY: GUARANTEES FOR CLIMATE PROTECTION, SUSTAINABILITY AND SUPPLY RELIABILITY

How to achieve an intelligent energy supply, and ensure that it is used efficiently, is one of the central challenges facing us in the 21st century. In many regions of the world, energy demands are increasing at a rapid pace as industrialisation catches up. At the same time, industrialised countries are faced with the need to dramatically reduce their energy consumption. Only then can they succeed in ameliorating the most severe consequences of climate change and become less dependent on oil, gas, coal and uranium imports.

Alongside its important strategy of ensuring the economical use and efficient conversion of energy raw materials, the German Environment Ministry is also firmly committed to the use of renewable energy sources. In recent years, renewable energies have gained considerably in significance, particularly in the electricity market, but also in the heating and transport sectors. Accounting for just over 15 % of Germany's electricity supply in 2008, renewable energies have become an essential pillar of the energy industry.

Renewable energies contribute to a sustainable energy supply in a number of ways:

- They make a decisive contribution to climate protection, because their plants do not burn any fossil fuels – in 2008 they helped to avoid the emission of around 109 million tonnes of the climate gas CO_2.
- They diversify the range of raw materials, make us less dependent on fossil resources, and hence contribute to supply reliability, as well as helping to avert conflicts over raw materials (cf. also the BMU study "Die sicherheitspolitische Bedeutung erneuerbarer Energien" at www.erneuerbare-energien.de/inhalt/3860 under "Studies").
- In the medium term, renewables also protect us against cost increases associated with energy imports; such cost increases are inevitable for fossil and nuclear resources, and already evident in the case of oil.
- At the end of their useful life, plants for the use of renewable energy sources are easily dismantled and recycled. Unlike nuclear power plants, they do not cause residual radiation, nor do they leave a legacy of disused mines.
- Renewable energy sources are predominantly domestic energy sources which contribute to regional value-added and help to safeguard jobs. In 2008, a total turnover of around 29 billion Euros was generated in Germany with renewables; some 278,000 people were employed in this sector at the end of 2008.
- In poor countries, renewable energies can offer a way out of poverty, and in many cases, they also make it easier for large sections of the population to access energy, e.g. via rural electrification.

Objectives

The expansion of renewable energy sources in Germany has been an unprecedented success. Their share of final total final energy consumption has more than doubled since 2000, and now stands at 9.5 %. The German Government's target of generating 12.5 % of gross electricity consumption from renewables by the year 2010 had already been significantly exceeded by 2007.

The Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG) and the new version of the Renewable Energy Sources Act (EEG) entered into force on 1 January 2009. The latter is currently being supplemented by a series of ordinances designed to improve system integration of renewable electricity and ensure compliance with sustain-

ability criteria. The German Government's targets for 2020 have now been set: The share of electricity supply from renewable energy sources is to be increased to at least 30 %, and continuously increased thereafter. The contribution of renewables to heat supply is to be increased to 14 % by 2020. The sustainability strategy adopted in autumn 2008 also confirmed that 50 % of total final energy consumption is to be supplied from renewables by 2050. The Biomass Action Plan adopted by the Federal Cabinet in April aims to increase the proportion of biofuels to such an extent as to reduce greenhouse gases by 7 % by 2020 compared with the use of fossil fuels, corresponding to an energy share of around 12 %.

The European Council's resolutions of spring 2007 and the adoption of the new EU Directive on the promotion of the use of energy from renewable sources (2009/28/EC), which entered into force in late June 2009, have now set corresponding targets in an EU context: By the year 2020, 20 % of the European Union's total final energy consumption is to be met from renewable energy sources. A national target of 18 % has been prescribed for Germany.

Wind energy

With 20,287 installations and an installed capacity of 23,894 MW as per the end of 2008, wind energy has reasserted its dominant position among renewables in the electricity sector. In 2008, newly installed capacity remained constant against the previous year at 1,665 MW. At 40.4 TWh, the volume of electricity produced showed a further increase on 2007. In 2008, wind energy alone accounted for 6.6 % of total gross electricity consumption.
Under the new Renewable Energy Sources Act (EEG), from 2009 wind energy will benefit from increased fees and more attractive conditions for repowering (the replacement of older facilities with new, more powerful plants). We therefore expect newly installed capacity to continue to rise over the next few years. Additionally, the development of offshore wind energy will be a key factor in the growing significance of wind energy use.

Biomass

There has been a sharp upturn in the use of biomass as a climate-compatible, regional energy source for the production of electricity and heat, particularly since the improved framework conditions created by the 2004 Renewable Energy Sources Act (EEG) came into force. Additionally, in recent years, various alternative heating sources such as pellet heaters have become far more popular, primarily due to rising energy prices. Of all renewables, biomass has the advantage that it is available around the clock, to be used as and when needed. It is therefore an important contributor towards a reliable energy supply.
In 2008, electricity production from solid and liquid biomass, biogas, sewage gas and landfill gas and the biogenic portion of waste totalled 27 TWh, corresponding to 4.5 % of Germany's total gross electricity consumption. This further strengthened the ranking of biomass as the second-most important renewable after wind energy. In 2008, the contribution of biomass to heat supply increased to around 97 TWh, and maintained its dominant position among renewables in the heat sector at 94 %. Following a sharp increase in previous years, in 2008 the biofuels market reversed with a marked decrease in sales to around 3.7 million tonnes (2007: 4.6 mill. t). Sales of biodiesel and vegetable oil dropped sharply, while bioethanol experienced an increase. Overall, in 2008, biofuels covered 5.9 % of fuel demand.

Geothermal energy

The heat from the earth's core may be used to heat buildings and supply local district heating networks, as well as to generate electricity. While geothermal heating plants have been around for some time, in 2008 Germany's third geothermal plant in Unterhaching began producing electricity. Geothermal energy does not yet make a significant contribution to the generation of electricity, but over the next few years, further plants are expected to be built, particularly in southern Germany.

Hydropower

In recent years, hydropower capacity in Germany has increased slightly, partly as a result of plant modernisation. The electricity yield fluctuates according to the weather conditions. In 2008, 21.3 TWh of electricity was produced from hydropower, slightly more than in the same period of the previous year. Over the next few years, renovation work on several large plants is due to be completed, following the creation of new incentives under the 2004 Renewable Energy Sources Act (EEG).

Photovoltaic/solar thermal energy

The sharp increase in the generation of electricity from photovoltaic plants continued during 2008. At around 4.0 TWh, electricity production was around 29 % up on the previous year, accounting for 0.7 % of gross electricity consumption. In future, technical innovations and expanding markets will enable electricity from photovoltaic plants to become ever more cost-effective. Consequently, fees for solar power under the new EEG will drop off even more sharply than before, by between 8 and 10 % per annum.

In 2008, the construction of new solar collectors (solar thermal plants) for the heating of service water and room heating showed a significant increase against the previous year, prompted by high oil and gas prices. With more than 210,000 plants, there were some 1.9 million square metres of collector area installed in Germany at the end of 2008, almost double the amount of 2007. The expansion of solar thermal systems will continue to be favoured by expectations of persistent high energy prices, together with subsidies under the Federal Government's market incentive programme and the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG).

The German Government's targets at a glance:

- Greenhouse gas emissions are to be cut by 40 % by 2020 compared with 1990 levels. By the end of 2007 Germany had already achieved a reduction of – 21.3 %.
- Energy productivity is to be increased by 3 % per annum. This means that by 2020, energy use will be twice as efficient as in 1990.
- The proportion of renewable energies is to be continuously increased to account for
  - 18 % of final energy consumption by 2020, compared with around 10 % today;
  - At least 30 % of gross electricity consumption by 2020, compared with around 15 % at present, with continuous further expansion thereafter;
  - 14 % of heat energy demand by 2020, compared with just under 8 % today;
  - By 2020, the proportion of biofuels is to be increased to such an extent that greenhouse gas emissions will have been reduced by 7 % by 2020 compared with the use of fossil fuels, corresponding to an approximate energy share of 12 %;
  - 50 % of energy consumption by 2050.
- The share of electricity production derived from cogeneration (CHP) is to be doubled to 25 % by 2020.

Further cornerstones of the energy transformation and climate protection

As well as increasing the use of renewable energy sources, the Federal Government consistently exploits the potential for the rational, economical use of energy and improving energy efficiency. Pivotal to this policy are the ecological tax reform of 1999, together with a range of other measures that have already been implemented, such as the Energy Saving Ordinance, the Combined Heat and Power Act, and a series of energy consumption labelling measures. Emissions trading for plants with a combustion heat capacity of 20 MW and above was further developed in 2007, to allow German industry to attain its long-term climate protection targets even more cost-effectively and efficiently than before. Additionally, in 2007 and 2008 the German Government adopted a whole range of further measures as part of its integrated energy and climate programme (IKEP), the vast majority of which have since been implemented.

The revised Atomic Energy Act (AtG) of 22 April 2002 transposed the phase-out of nuclear power into German law. Under this Act, existing nuclear power plants will be decommissioned once they have generated the volume of electricity specified for each individual plant. Two reactors have already been decommissioned under the terms of the Act, and the last nuclear power plant is expected to be shut down in around 14 years' time.
Protecting the global climate, conserving valuable resources and ensuring sustainable global development – these are the main challenges facing us in the 21st century. The restructuring of our energy system is a vital precondition for achieving these goals.

In particular, this includes phasing out nuclear power, gradually reducing the use of fossil fuels, energy saving, energy efficiency, and the continuous expansion of renewable energies.

RENEWABLE ENERGY SOURCES IN GERMANY: THE MOST IMPORTANT DEVELOPMENTS IN 2008 AT A GLANCE

Renewable energy sources as a share of energy supply in Germany

- 9.5 % of total final energy consumption (electricity, heat, fuel; 2007: 9.8 %)
- 15.1 % of gross electricity consumption (2007: 14.2 %)
- 7.4 % of final energy consumption for heat (2007: 7.6 %)
- 5.9 % of fuel consumption (2007: 7.2 %)
- 7.0 % of primary energy consumption (2007: 6.9 %) (according to the physical energy content method; or 9.2 % if calculated according to the substitution method)

Wind energy makes the greatest contribution

Following a gross increase in installed capacity of 1,665 MW, a total of 23,894 MW was installed as per the end of 2008. In 2008 around 40.4 TWh of electricity was produced.
(1 TWh = 1 billion kWh)

Bioenergy still gaining ground

In the electricity market, expansion is speeding ahead: More than 20.5 TWh was produced from solid, liquid and gaseous biomass in 2008 (the total figure including biogenic waste, landfill gas and sewage gas was 27.1 TWh); more than 3.7 million tonnes of biofuels were consumed; the number of pellet heaters has increased to 105,000 [DEPV 49].

Hydropower stagnating

Installed capacity remained more or less constant; 21.3 TWh of electricity was produced.

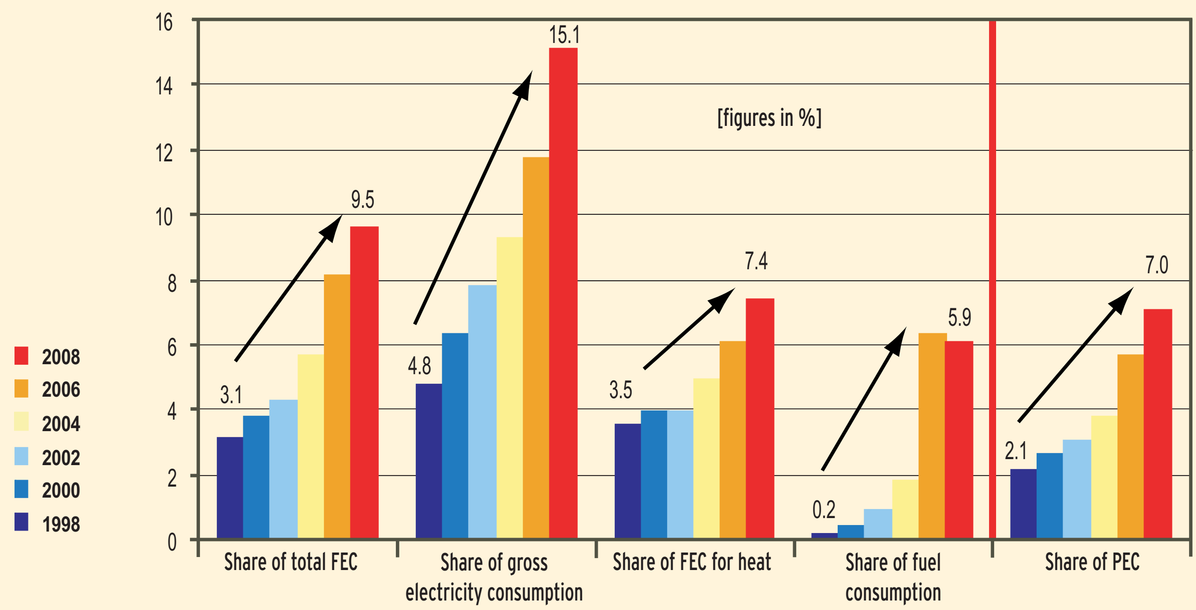
World leader in solar power use

With an additional 1,500 MW of capacity built, Germany is the world champion of photovoltaics, with around 4 TWh of electricity produced.
The installation of new solar thermal collector area has remained at a high level of around 1.9 million m²; the total installed area as at the end of 2008 was 11 million m².

Geothermal energy on track

Electricity production by Germany's three geothermal power plants totalled 0.018 TWh in 2008; sales of heat pumps increased by a factor of 1.4 to around 62,450 systems [BWP 26].

Renewable energy sources as a share of energy supply in Germany



FEC Final energy consumption
PEC Primary energy consumption, calculated according to the physical energy content method

Sources: BMU based on AGEE-Stat and other sources, see following tables

CONTRIBUTION OF RENEWABLE ENERGY SOURCES TO ENERGY SUPPLY IN GERMANY, 2008

		Final energy	Primary energy equivalent 1)		Share of final energy consumption		Share of total primary energy consumption 14)	
			physical energy content method	substitution method			physical energy content method	substitution method
		[GWh]	[PJ]	[PJ]		[%]	[%]	[%]
Electricity generation	Hydropower 2)	21,300	76.7	189.0	Share of electricity consumption 10)	3.5	0.5	1.3
	Wind energy	40,400	145.4	356.8		6.6	1.0	2.5
	Photovoltaics	4,000	14.4	33.9		0.7	0.1	0.2
	Biogenic solid fuels	10,949	95.6	96.8		1.8	0.7	0.7
	Biogenic liquid fuels	1,509	13.2	13.2		0.2	0.1	0.1
	Biogas	8,050	70.3	70.2		1.3	0.5	0.5
	Sewage gas	1,002	8.8	8.7		0.2	0.1	0.1
	Landfil gas	1,008	8.8	8.8		0.2	0.1	0.1
	Biogenic share of waste 3)	4,543	39.7	40.2		0.7	0.3	0.3
	Geothermal energy 4)	18	0.1	0.2		0.003	0.005	0.001
	Total	**92,779**	**473.5**	**817.6**		**15.1**	**3.4**	**5.7**
Heat generation	Biogenic solid fuels (households)	57,778	208.0		Share of FEC for heat 11)	4.1	1.5	1.4
	Biogenic solid fuels (industry) 5)	16,800	60.5			1.2	0.4	0.4
	Biogenic solid fuels (CHP and HP) 6)	6,255	22.5			0.4	0.16	0.16
	Biogenic liquid fuels 7)	6,189	22.3			0.4	0.16	0.16
	Biogenic gaseous fuels 8)	5,066	18.2			0.4	0.13	0.13
	Biogenic share of waste 3)	5,020	18.1			0.4	0.13	0.13
	Solar thermal energy	4,131	14.9			0.3	0.11	0.10
	Deep geothermal energy	163	0.6			0.01	0.004	0.004
	Near-surface geothermal energy 9)	2,353	8.5			0.2	0.06	0.06
	Total	**103,755**	**373.5**			**7.4**	**2.7**	**2.6**
Fuel	Biodiesel	27,806	100.1		Share of fuel consumption 12)	4.5	0.7	0.7
	Vegetable oil	4,194	15.1			0.7	0.1	0.1
	Bioethanol	4,694	16.9			0.8	0.1	0.1
	Total	**36,694**	**132.1**			**5.9**	**0.9**	**0.9**
Total		**233,228**	**979.1**	**1,323.3**	**FEC 13)**	**9.5**	**7.0**	**9.2**

Note:
Figures used throughout this brochure are provisional.

Abbreviations:
RES Renewable energy sources
FEC Final energy consumption
PEC Primary energy consumption

The valid method currently used for calculating the primary energy equivalent of electricity generation from renewable energy sources is the physical energy content method. The substitution method, which for example is used in the calculation of avoided emissions by renewable energies and the use of fuels, is additionally outlined below.
On the generation of electricity from photovoltaic energy and on the supply of heat from solar thermal energy, cf. Appendix, paragraph 6.

Deviations in the totals are due to rounding; PEC (primary energy consumption): 14,003 PJ, as at spring 2009

1) For an explanation of the methods used to determine primary energy equivalent, please refer to the Appendix, para. 5; in the case of heat and fuel, final energy is equated with primary energy for the purposes of this calculation.
2) In the case of pumped-storage power plants, only electricity generated from natural inflow
3) Biogenic portion estimated at 50 %
4) Third geothermal power plant began operation at the end of 2008; geothermal input calculated with an assumed utilisation rate of 10 %.
5) Industry = Operations involved in mining, the extraction of stones and soil, and the manufacturing industry, Article 8 of the Energy Statistics Act
6) According to Articles 3 and 5 of the Energy Statistics Act
7) Heat from CHP plants powered by vegetable oil (just under 1.1 TWh, estimated according to source [88]), from the paper industry (spent sulphite liquor) and other industry collated by the Federal Statistical Office
8) Estimated, partly according to Source [88]; includes figure for the direct use of sewage gas
9) Geothermal energy including other ambient heat
10) Based on a gross electricity consumption in 2008 of 615.1 TWh
11) Final energy consumption for room heating, hot water and other process heat 172.3 million tonnes of hard coal equivalent or 5,050 PJ in 2008 (estimate by ZSW).
12) Based on a fuel consumption in 2008 of 2,228 PJ
13) Based on a final energy consumption of 8,828 PJ in 2008.
14) With a substitution factor (for electricity from biomass) of 8,733 kJ/kWh, cf. Appendix, para. 5.

Sources: BMU based on AGEE-Stat and ZSW [3]; BSW [10]; ZfS [19]; AGEB [1], [15], [18]; StBA [5]; Klobasa et al. [41]; IE [70]; IE et al, [88]; BDEW [71]; BAFA [83]; FNR [7]

RENEWABLE ENERGY SOURCES AS A SHARE OF ENERGY SUPPLY IN GERMANY, 1998 TO 2008

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Renewables as a share of final energy consumption (FEC)						**[%]**					
Electricity generation (in relation to total gross electricity consumption)	4.8	5.5	6.3	6.7	7.8	8.1	9.5	10.4	11.7	14.2	15.1
Heat supply (in relation to total heat supply)	3.5	3.5	3.9	3.8	3.9	4.6	4.9	5.4	6.1	7.6	7.4
Fuel consumtion [1] (in relation to total fuel consumption)	0.2	0.2	0.4	0.6	0.9	1.4	1.8	3.8	6.3	7.2	5.9
Renewable as a share of total FEC	**3.1**	**3.3**	**3.8**	**3.8**	**4.3**	**4.9**	**5.5**	**6.6**	**8.1**	**9.8**	**9.5**
Renewable as a share of total primary energy consumption (PEC)											
Electricity generation (in relation to total PEC)	0.8	0.9	1.1	1.1	1.4	1.5	1.6	2.1	2.5	3.2	3.4
Heat supply (in relation to total PEC)	1.3	1.3	1.4	1.4	1.5	1.8	1.9	2.0	2.3	2.6	2.7
Fuel consumption (in relation to total PEC)	0.03	0.03	0.06	0.1	0.1	0.2	0.3	0.6	1.0	1.2	0.9
Renewable as a share of total PEC [2]	**2.1**	**2.2**	**2.6**	**2.7**	**3.0**	**3.5**	**3.9**	**4.7**	**5.7**	**6.9**	**7.0**

1) Until 2002, the reference variable used was fuel consumption in road traffic; from 2003, the reference variable is the total consumption of engine fuels, excluding fuel in air traffic
2) According to the physical energy content method, cf. Appendix, para. 5

Sources: BMU based on AGEE-Stat and the preceding and following tables, and according to VDEW [17], [47], [74]; ‚BDEW [100], [101]

Development in the shares of primary and final energy consumption attributable to renewables in Germany since 1998

PEC according to physical energy content method

Sources: See table above

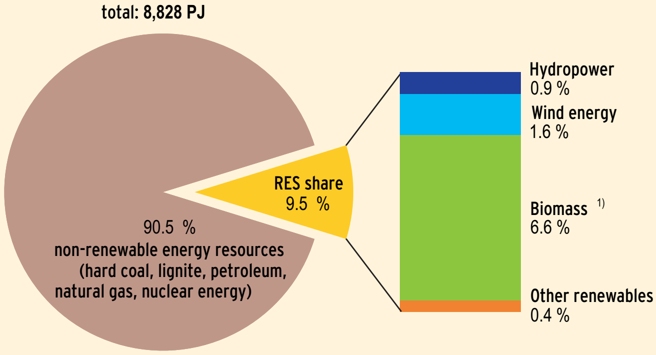
FINAL ENERGY CONSUMPTION IN GERMANY, 2008 – SHARES OF RENEWABLE ENERGY SOURCES

Final energy supply from renewables: approx. 233 TWh (840 PJ)
(9.5 % share of total final energy consumption)

1) Solid, liquid, gaseous biomass, biogenic portion of waste, landfill and sewage gas, and biogenic fuels

Sources: BMU on the basis of AGEE-Stat, ZSW [3]; according to AGEB [15]

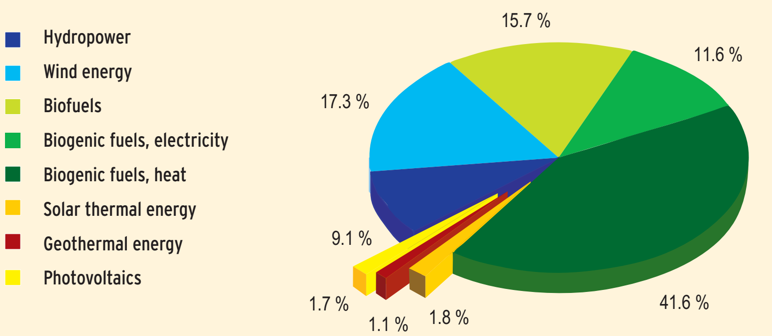
Shares of renewables among total final energy consumption in Germany, 2008



Total biomass [1)] supplies just under 70 % of all final energy from renewable sources.

Biomass (primarily wood) accounts for just under 94 % of heat generation from renewable energy sources.

Structure of final energy supply from renewable energy sources in Germany, 2008

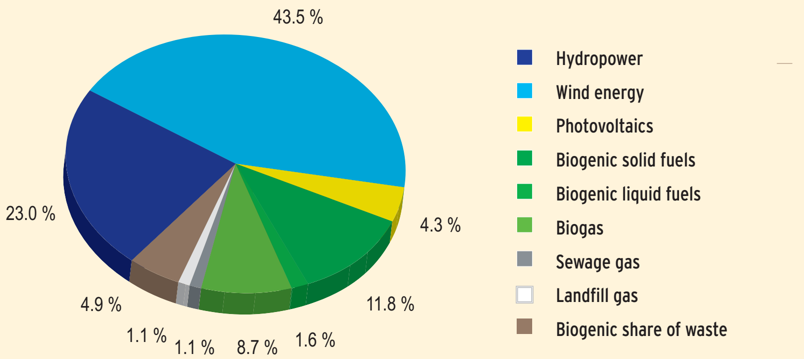


1) Biogenic solid fuels, biogenic liquid and gaseous fuels, biogenic portion of waste, biogas, sewage and landfill gas, and biofuels

Sources: BMU based on AGEE-Stat and other sources, see table on page 12

STRUCTURE OF ELECTRICITY SUPPLY FROM RENEWABLE ENERGY SOURCES IN GERMANY, 2008

Structure of energy supply from renewable energy sources in Germany, 2008



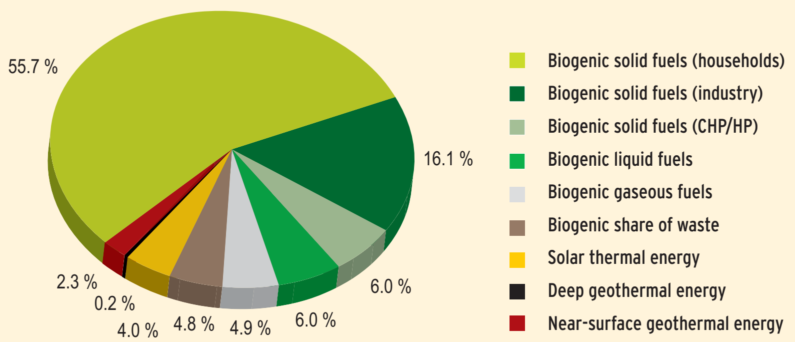
Geothermal electricity generation not shown, due to the negligible quantities of electricity produced

Electricity generation from renewables: approx. 92.8 TWh
(15.1 % share of total electricity consumption)

For electricity generation from renewable energy sources, apart from biomass (22.1 %), the most significant sources are wind energy with 43.5 %, and hydropower with 23.0 %. Biomass including sewage gas, landfill gas and biogenic portion of waste: 29.2 %.

Sources: BMU based on AGEE-Stat and other sources, see table on page 12

Structure of heat supply from renewable energy sources in Germany, 2008

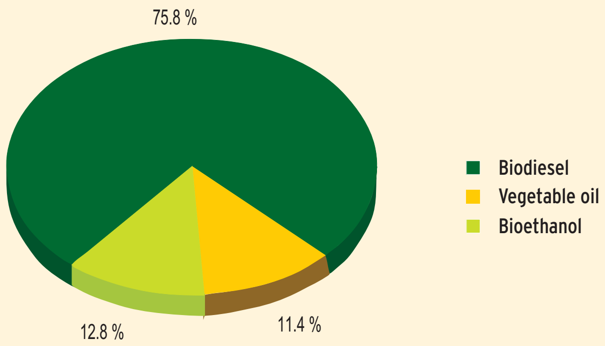


CHP/HP = Cogeneration and heating plants

Heat supply from renewables: approx. 103.8 TWh
(7.4 % share of total heat consumption)

Sources: BMU based on AGEE-Stat and other sources, see table on page 12

Structure of fuel supply from renewable energy sources in Germany, 2008



Biogenic fuels: approx. 36.7 TWh
(5.9 % share of total fuel consumption)

Biofuel volumes 2008:
Biodiesel: 2,695,000 tonnes, 3,066 million litres;
Vegetable oil: 401,000 tonnes, 436 million litres;
Bioethanol: 626,000 tonnes, 800 million litres
The volume sold has decreased against the previous year.

Sources: BMU based on AGEE-Stat and other sources, see table on page 12

DEVELOPMENT OF ENERGY SUPPLY FROM RENEWABLE ENERGY SOURCES IN GERMANY, 1990 TO 2008

Electricity generation (final energy) in Germany

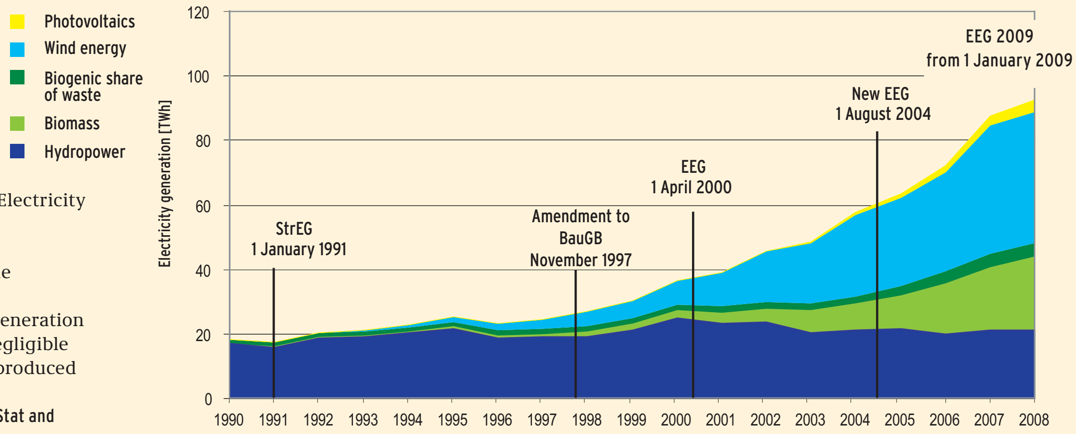
	Hydro-power 1)	Wind-energy	Biomass 2)	Biogenic share of waste 3)	Photo-voltaics	Geothermal energy	Total electricity generation	Share of gross electricity consumption
	[GWh]	[GWh]	[GWh]	[GWh]	[GWh]	[GWh]	[GWh]	[%]
1990	17,000	40	222	1,200	1	0	18,463	3.4
1991	15,900	140	250	1,200	2	0	17,492	3.2
1992	18,600	230	295	1,250	3	0	20,378	3.8
1993	19,000	670	370	1,200	6	0	21,246	4.0
1994	20,200	940	570	1,300	8	0	23,018	4.3
1995	21,600	1,800	670	1,350	11	0	25,431	4.7
1996	18,800	2,200	853	1,350	16	0	23,219	4.2
1997	19,000	3,000	1,079	1,400	26	0	24,505	4.5
1998	19,000	4,489	1,642	1,750	32	0	26,913	4.8
1999	21,300	5,528	1,791	1,850	42	0	30,511	5.5
2000	24,936	7,550	2,279	1,850	64	0	36,679	6.3
2001	23,383	10,509	3,206	1,859	116	0	39,073	6.7
2002	23,824	15,786	4,017	1,945	188	0	45,760	7.8
2003	20,350	18,859	6,970	2,162	313	0	48,654	8.1
2004	21,000	25,509	8,347	2,116	557	0.2	57,529	9.5
2005	21,524	27,229	10,495	3,039	1,282	0.2	63,569	10.4
2006	20,042	30,710	15,593	3,675	2,220	0.4	72,240	11.7
2007	21,249	39,713	19,438	4,130	3,075	0.4	87,604	14.2
2008	21,300	40,400	22,518	4,543	4,000	18.0	92,779	15.1

The energy supply from hydropower, wind energy and solar energy is subject to natural fluctuations, which can affect the total annual energy yield on both a short-term and seasonal basis.
On the generation of electricity from photovoltaic energy, see Appendix, para. 6.

1) In the case of pumped-storage power plants, electricity generated from natural inflow only
2) Until 1998, only feed-in to the general supply grid
3) Share of biogenic waste estimated at 50 %

Sources: BMU based on AGEE-Stat and ZSW [3]; EnBW [12]; Fichtner [36], BWE [16]; StBA [5]; BMELV [75]; IE [8], [13], [20], [70]; VDN [9]; AGEB [2], [18]; FNR [7]; SFV [28]; BSW [10]; ZfS [19]; Erdwärme-Kraft [79]; DEWI [62], [67], [76], [77], [78], [103]; geo x GmbH [66]; BDEW [71]; Solarthemen [45]; dbfz [44]

Development of electricity generation from renewable energies in Germany since 1990



StrEG Act on the Sale of Electricity to the Grid

BauGB Construction Code

Geothermal electricity generation not shown, due to the negligible quantities of electricity produced

Sources: BMU based on AGEE-Stat and other sources, see table above

Installed capacity for electricity generation from renewable energy sources in Germany since 1990

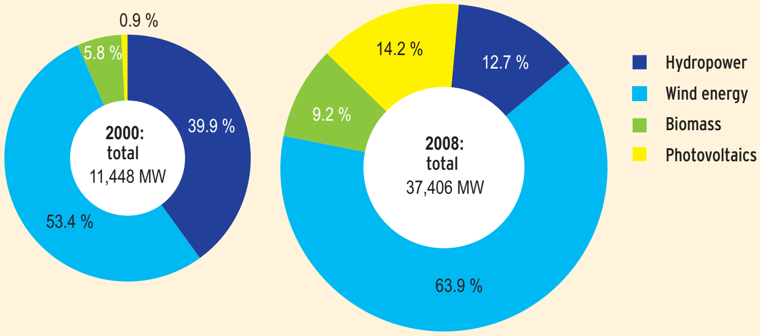
	Hydro-power	Wind energy	Biomass	Photovoltaics	Geothermal energy	Total capacity
	[MW]	[MW]	[MW]	[MW_p]	[MW]	[MW]
1990	4,403	56	190	2	0	4,651
1991	4,403	98	N/A	3	0	4,504
1992	4,374	167	227	6	0	4,774
1993	4,520	310	N/A	9	0	4,839
1994	4,529	605	276	12	0	5,422
1995	4,521	1,094	N/A	16	0	5,631
1996	4,563	1,547	358	24	0	6,492
1997	4,578	2,082	400	36	0	7,096
1998	4,601	2,875	409	45	0	7,930
1999	4,547	4,444	604	58	0	9,653
2000	4,572	6,112	664	100	0	11,448
2001	4,600	8,754	790	178	0	14,322
2002	4,620	11,965	952	258	0	17,795
2003	4,640	14,609	1,137	408	0	20,794
2004	4,660	16,629	1,550	1,018	0.2	23,857
2005	4,680	18,428	2,192	1,881	0.2	27,181
2006	4,700	20,622	2,740	2,711	0.2	30,773
2007	4,720	22,247	3,140	3,811	3.2	33,921
2008	4,740	23,895	3,453	5,311	6.6	37,406

The figures on installed capacity refer to the year-end status in each case, cumulative; data for thermal waste treatment plants not included.

N/A = Not available

Sources: BMU based on AGEE-Stat and other sources, see page 16

Shares of total installed capacity of renewable energy sources in Germany, 2000 and 2008



Since the Renewable Energy Sources Act (EEG) entered into force in 2000, the total installed capacity for the generation of electricity from renewable energy sources has more than tripled.

Geothermal electricity generation capacity in comparison with other renewable technologies remains marginal, and is therefore not shown.

Sources: BMU based on AGEE-Stat and other sources, see page 16

Heat supply (final energy) from renewable energy sources in Germany since 1990

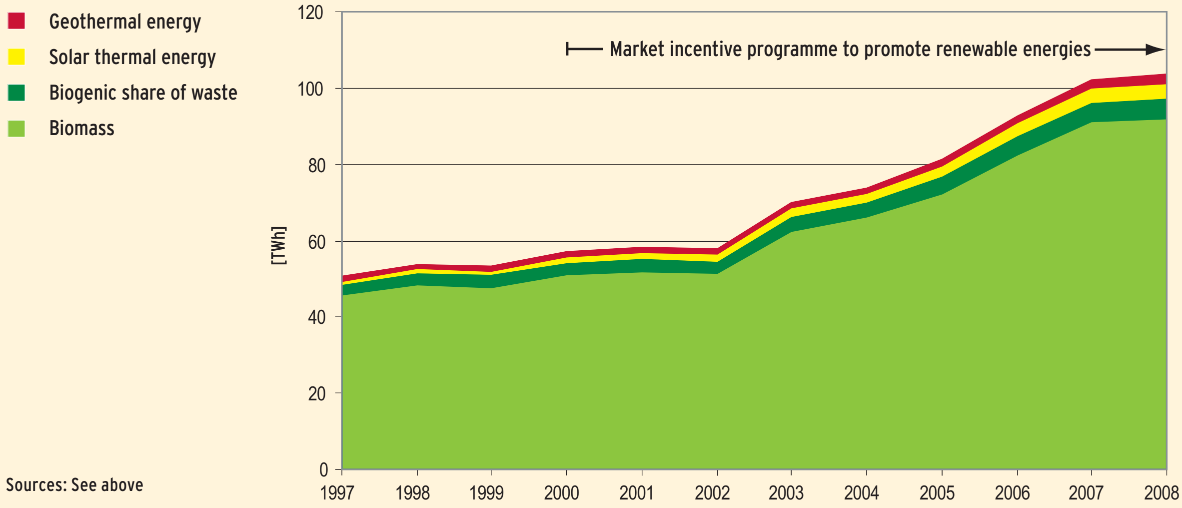
	Biomass [1]	biogenic share of waste [2]	Solar thermal energy	Geothermal energy	Total heat generation	Share of heat consumption
	[GWh]	[GWh]	[GWh]	[GWh]	[GWh]	[%]
1990	N/A	N/A	127	N/A	N/A	N/A
1991	N/A	N/A	164	N/A	N/A	N/A
1992	N/A	N/A	215	N/A	N/A	N/A
1993	N/A	N/A	273	N/A	N/A	N/A
1994	N/A	N/A	348	N/A	N/A	N/A
1995	N/A	N/A	431	1,425	N/A	N/A
1996	N/A	N/A	540	1,383	N/A	N/A
1997	45,646	2,900	680	1,335	50,561	N/A
1998	48,625	2,988	837	1,384	53,834	3.5
1999	47,811	3,140	1,020	1,429	53,400	3.5
2000	51,036	3,278	1,255	1,433	57,002	3.9
2001	52,043	3,283	1,581	1,447	58,354	3.8
2002	51,302	3,324	1,878	1,483	57,987	3.9
2003	62,555	3,806	2,137	1,532	70,030	4.6
2004	66,251	3,694	2,437	1,558	73,940	4.9
2005	72,190	4,692	2,771	1,601	81,254	5.4
2006	82,558	4,911	3,211	1,934	92,614	6.1
2007	91,355	4,783	3,636	2,299	102,072	7.6
2008	92,088	5,020	4,131	2,516	103,755	7.4

1) In contrast to previous years, from 2003 onwards figures are according to Articles 3, 5 (cogeneration and heating plants) and Article 8 (industry) of the 2003 Energy Statistics Act and direct use of sewage gas
2) Biogenic waste share in waste incineration plants estimated at 50 %

N/A = Not available

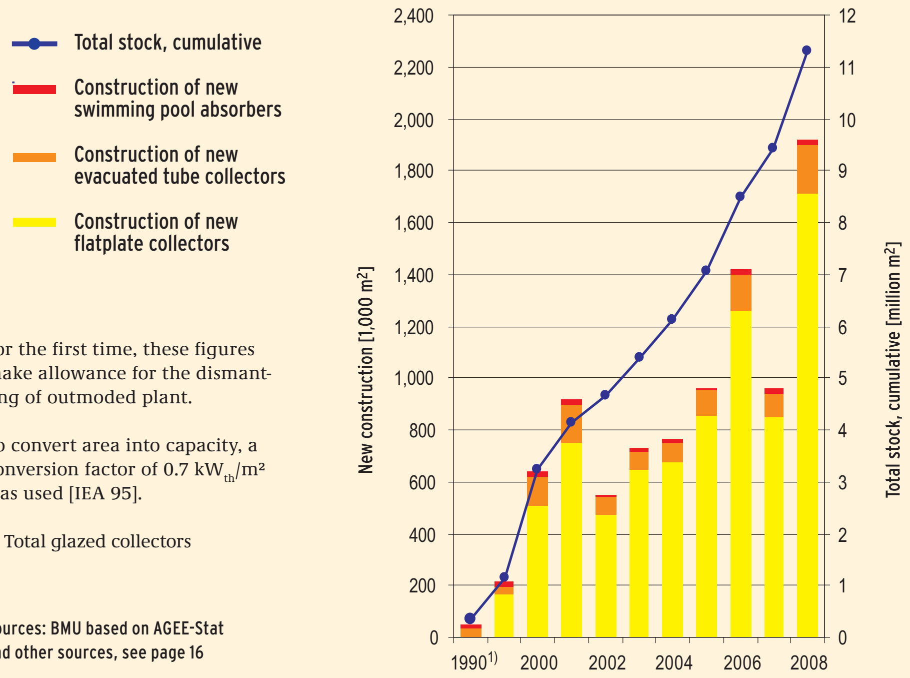
Sources: BMU based on AGEE-Stat and other sources on page 12 and VDEW [17], [47], [74]; BDEW [100], [101]

Development of heat supply from renewable sources in Germany since 1997



Sources: See above

Development in the installation of new solar collectors in Germany since 1990



For the first time, these figures make allowance for the dismantling of outmoded plant.

To convert area into capacity, a conversion factor of 0.7 kW_{th}/m^2 was used [IEA 95].

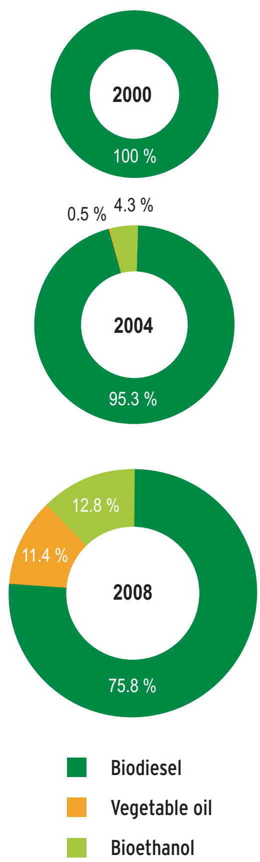
1) Total glazed collectors

Sources: BMU based on AGEE-Stat and other sources, see page 16

	Solar thermal energy	
	Cum. area [1,000 m^2]	Cum. capacity [MW]
1990	340	238
1991	468	328
1992	585	409
1993	751	526
1994	943	660
1995	1,159	811
1996	1,448	1,013
1997	1,806	1,264
1998	2,171	1,520
1999	2,601	1,821
2000	3,237	2,266
2001	4,136	2,895
2002	4,667	3,267
2003	5,374	3,762
2004	6,125	4,288
2005	7,074	4,952
2006	8,474	5,932
2007	9,419	6,593
2008	11,312	7,919

Fuel supply (final energy) from renewable energy sources in Germany since 1990

	Biodiesel	Vegetable oil	Bioethanol	Total biofuels	Share of fuel consumption
	[GWh]	[GWh]	[GWh]	[GWh]	[%]
1990	0	0	0	0	0.0
1991	2	0	0	2	0.0
1992	52	0	0	52	0.01
1993	103	0	0	103	0.02
1994	258	0	0	258	0.04
1995	310	0	0	310	0.05
1996	517	0	0	517	0.1
1997	827	0	0	827	0.1
1998	1,033	0	0	1,033	0.2
1999	1,343	0	0	1,343	0.2
2000	2,583	0	0	2,583	0.4
2001	3,617	0	0	3,617	0.6
2002	5,683	0	0	5,683	0.9
2003	8,267	52	0	8,319	1.4
2004	10,850	52	484	11,386	1.8
2005	18,600	2,047	1,936	22,583	3.8
2006 1)	29,444	7,417	3,556	40,417	6.3
2007	33,673	8,066	3,412	45,151	7.2
2008 2)	27,806	4,194	4,694	36,694	5.9



1) The volume of biodiesel for 2006 also includes vegetable oil, because biodiesel and vegetable oil statistics were collected jointly until August 2006

2) For 2008, this volume corresponds to: Biodiesel: 2,695,000 tonnes; Vegetable oil: 401,000 tonnes; Bioethanol: 626,000 tonnes

Sources: BMU based on AGEE-Stat and other sources, see page 12, and BMU/BMELV [40]; BMVBS [57]; BAFA [83]

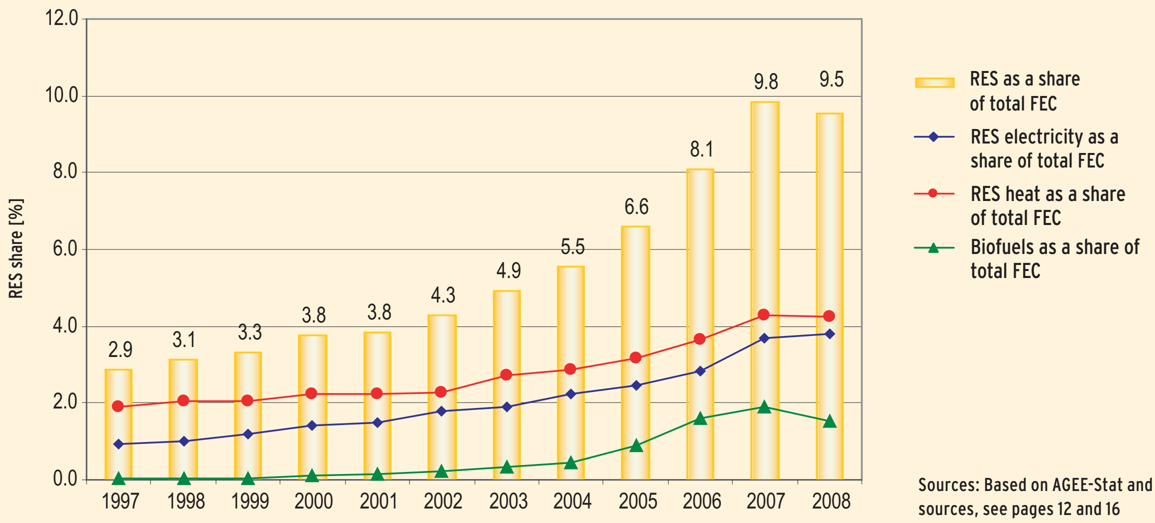
Total energy supply and shares of renewable energies in Germany since 1990

	Total final energy con-sumption (FEC)	Total RES final energy supply	Share of total FEC	RES electricity as a share of total FEC	RES heat as a share of total FEC	Biofuels as a share of total FEC	Share of total primary energy cons. (PEC)
	[PJ]	[GWh]	[%]	[%]	[%]	[%]	[%]
1990	9,472	N/A	N/A	0.7	N/A	0.0	N/A
1991	9,366	N/A	N/A	0.7	N/A	0.0	N/A
1992	9,127	N/A	N/A	0.8	N/A	0.0	N/A
1993	9,234	N/A	N/A	0.8	N/A	0.0	N/A
1994	9,110	N/A	N/A	0,.9	N/A	0.0	N/A
1995	9,322	N/A	N/A	1.0	N/A	0.0	N/A
1996	9,686	N/A	N/A	0.9	N/A	0.0	N/A
1997	9,535	75,908	2.9	0.9	1.9	0.0	2.0
1998	9,458	81,800	3.1	1.0	2.0	0.0	2.1
1999	9,300	85,271	3.3	1.2	2.1	0.1	2.2
2000	9,235	96,288	3.8	1.4	2.2	0.1	2.6
2001	9,455	101,075	3.8	1.5	2.2	0.1	2.7
2002	9,226	109,471	4.3	1.8	2.3	0.2	3.0
2003	9,284	127,049	4.9	1.9	2.7	0.3	3.5
2004	9,322	142,905	5.5	2.2	2.9	0.4	3.9
2005	9,240	167,463	6.6	2.5	3.2	0.9	4.7
2006	9,149	196,498	8.1	2.8	3.6	1.6	5.7
2007	8,585	234,828	9.8	3.7	4.3	1.9	6.9
2008	8,828	233,228	9.5	3.8	4.2	1.5	7.0

Primary energy consumption (PEC) calculated according to the physical energy content method; N/A = Not available

Sources: BMU based on AGEE-Stat and other sources, see pages 12 and 16

Development of renewable energy sources (RES) as a share of total final energy consumption (FEC) in Germany since 1997



Sources: Based on AGEE-Stat and other sources, see pages 12 and 16

EMISSIONS AVOIDED VIA THE USE OF RENEWABLE ENERGY SOURCES IN GERMANY, 2008

Introduction

The emissions avoided via the use of renewable energy sources are calculated on the basis of a net balance which makes allowance both for the emissions avoided from the use of fossil energy sources and for the emissions resulting from the supply of renewable energy. The following emission balances for the use of renewable energy sources in the electricity, heat and transport sectors in 2008 have undergone a number of major methodological changes compared with previous years. In particular, this includes the consistent consideration of energy supply pre-chains, updated substitution methods in the electricity and heat sector, and a modified allocation method for biofuels. For this reason, comparability with previous years' figures is very limited.

Emissions avoided via the use of renewable energy sources in the electricity sector

		RES electricity generation: total: 92,779 GWh	
Greenhouse gas/ air pollutant		Avoidance factor [kg/GWh]	Avoided emissions [1.000 t]
Greenhouse-effect 1)	CO_2	772,211	71,645
	CH_4	1,851.3	171.8
	N_2O	-8.4	-0.8
	CO_2 equivalent	**808,662**	**75,027**
Acidification 2)	SO_2	416.3	38.6
	NO_x	52.8	4.9
	SO_2 equivalent	**457.5**	**42.4**
Ozone 3) Dust 4)	CO	-87.9	-8.2
	NMVOC	-2.5	-0.2
	Dust	-45.4	-4.2

Sources: UBA [110] based on AGEE-Stat and Klobasa et al. [41]; UBA [24]; Öko-Institut [22]; Ecoinvent [111]; Vogt et al. [112]; Ciroth [113]

The avoidance factor is the quotient of avoided emissions from energy supply from renewables (in kg) and electricity generation from renewables (in GWh). This equates to an average saving of greenhouse gases and air pollutants per GWh generated from renewables.

1) Other greenhouse gases (SF_6, PFC, HFC) have been disregarded
2) Other air pollutants with acidification potential (NH_3, HCl, HF) have been disregarded
3) NMVOC and CO are important precursor substances for ground-level ozone which makes a significant contribution to so-called "summer smog".
4) Here, dust includes the total emissions of airborne particles of all sizes.

These calculations are based on the "Report on CO_2 reduction through the use of renewable energy sources in 2006 and 2007" (cf. Appendix, para. 1). For further details on the methodology of these calculations, please refer to the Appendix, para. 1.

Hydropower, wind energy and solar energy, together with geothermal energy and biomass, are all used in the production of electricity from renewable energy sources. Fossil fuels, on which Germany's electricity supply is currently still based, are being replaced accordingly. In this way, the generation of electricity from renewables makes a major contribution to the avoidance of greenhouse gases and acidifying air pollutants in Germany.

The balances make allowance for directly avoided emissions from fossil power plants, as well as avoided environmental pollution from the supply chains for fossil energy production, which may be many times higher than the emissions associated with the supply of renewables. In this connection, it is particularly worth mentioning the high methane (CH_4) emissions from the supply of hard coal and natural gas.

Emissions avoided via the use of renewable energy sources in the heating sector

The avoidance factor is the quotient of avoided emissions from energy supply from renewables (in kg) and heat generation from renewables (in GWh). This equates to an average saving of greenhouse gases and air pollutants per GWh generated from renewables.

1) Other greenhouse gases (SF_6, PFC, HFC) have been disregarded
2) Other air pollutants with acidification potential (NH_3, HCl, HF) have been disregarded
3) NMVOC and CO are important precursor substances for ground-level ozone which makes a significant contribution to so-called “summer smog”
4) Here, dust includes the total emissions of airborne particles of all sizes

For further details on the methodology of these calculations, please refer to the Appendix, para. 2.

Sources: UBA [110] based on AGEE-Stat and Frondel et al. [114]; UBA [24]; Öko-Institut [22]; Ecoinvent [111]; Vogt et al. [112]; Frick et al. [115]; Ciroth [113]; AGEB [85], [116]

		RES heat generation: total: 103,755 GWh	
Greenhouse gas/ air pollutant		Avoidance factor [kg/GWh]	Advoided emissions [1,000 t]
Greenhouse effect [1]	CO_2	280,101	29,060
	CH_4	323.7	33.6
	N_2O	-3.6	-0.4
	CO_2-equivalent	**285,641**	**29,635**
Acidifi-cation [2]	SO_2	207.8	21.6
	NO_X	-99.4	-10.3
	SO_2-equivalent	**149.9**	**15.6**
Ozone [3] Dust [4]	CO	-5,682.1	-589.5
	NMVOC	-304.3	-31.6
	Dust	-232.4	-24.1

Apart from the direct use of solar energy and ambient heat, renewable energy for room heating and hot water in private households is derived primarily from the CO_2-neutral combustion of biomass. This only releases the same amount of CO_2 as the plant has previously absorbed for growth.

The supply of heat from renewables therefore makes a major contribution to the avoidance of greenhouse gas emissions. This climate protection effect is derived, firstly, by avoiding the release of carbon that is fixed in the fossil fuels oil, natural gas, hard coal and lignite, and secondly, by avoiding environmental pollution (e.g. methane emissions) during the extraction, processing and transportation of such energy sources.

The combustion of biomass, particularly in older firing installations such as tile stoves and fireplaces, releases higher quantities of air pollutants compared with fossil heat supply. This is especially true of volatile organic compounds and carbon monoxide that contribute to summer smog, as well as dust emissions of all particle sizes.

However, the use of modern boilers and furnaces with flue gas purification, coupled with responsible conduct on the part of users, can help to significantly reduce environmental impacts.

Emissions avoided via the use of renewable energy sources in the transport sector

Greenhouse gas/ air pollutant		Biogenic fuels: total: 36,694 GWh – Avoidance factor [kg/GWh]	Biogenic fuels: total: 36,694 GWh – Avoided emissions [1,000 t]
Greenhouse-effect [1]	CO_2 [2]	226,978	8,329
	CO_2-equivalent	**144,767**	**5,312**

1) Among greenhouse gas emissions, only CO_2, CH_4 and N_2O have been taken into account; other greenhouse gases (SF_6, PFC, HFC) have been disregarded.
2) The avoided CO_2 emissions were derived on the basis of avoided CO_2 equivalents.

The avoidance factor is the quotient of avoided emissions from energy supply from renewables (in kg) and fuel generation from renewables (in GWh). This equates to an average saving of greenhouse gases and air pollutants per GWh generated from renewables. It makes allowance for prechains and different biomasses, and is based on an allocation to main products and by-products based on the lower net calorific value.

The greenhouse gas balance is dependent on many different parameters, including the biomass used, the processes, the chosen reference systems, and the allocation method. The figures calculated therefore include a certain degree of uncertainty. For further details on the methodology of these calculations, please refer to the Appendix, para. 3.

Basis for calculation of the avoidance factor [kg/GWh]

	Biodiesel	Vegetable oil	Bioethanol
CO_2	214,149	273,359	261,534
CO_2-equivalent	136,584	174,348	166,806

Sources: UBA [110] based on AGEE-Stat and EP [92]; BR [98]; BMU [56]; BDBe [90]; UFOP [87], [108]; TFZ [109]

The supply and use of biofuels produces emissions associated with the cultivation and harvesting of the biomass, its processing, its combustion in the motor, as well as – to a lesser degree – its transportation. With regard to cultivation, particular mention should be made of fertilisation, which is responsible for climate-relevant laughing gas (N_2O) and ammonia (NH_3) emissions. The consequence of NH_3 emissions is that the sum total of acidifying emissions is higher when using biofuels than with conventional fuels. During the manufacture of biofuels, moreover, the fossil process energy requirements and auxiliary materials used (such as methanol of fossil origin) must also be taken into account.

Considering the sum total of greenhouse gases, the level of emissions depends heavily on the raw material basis, and linked to this, the origins of the biofuels and the corresponding emission factors. At present, the highest specific greenhouse gas reductions are achieved via the use of vegetable oils, followed by bioethanol and biodiesel.

Direct and indirect land use changes due to the cultivation of biofuels may also cause considerable greenhouse gas emissions. To date, such effects have been disregarded, since methodological approaches for calculating land use changes are only just being developed.

Total CO_2 avoidance via the use of renewable energy sources in Germany, 2008

The contribution of renewable energy sources to climate protection is clearly greater than its contribution to energy supply. In 2008, for example, 109 million tonnes of CO_2 were avoided through the use of renewable energies. This means that without their use, total CO_2 emissions (approx. 748 million tonnes) would have been around 15 % higher.

By contrast, the contribution of renewables to primary energy consumption is only around 7 %. This is due, firstly, to the method used to calculate primary energy consumption (physical energy content method, cf. Appendix, para. 5).

Secondly, at present, renewable energies in the electricity sector are only used to substitute fossil energy sources, leading to high specific greenhouse gas avoidance factors.

In 2008, electricity generation remunerated under the Renewable Energy Sources Act (EEG) alone led to an emission reduction of approximately 53 million tonnes of CO_2.

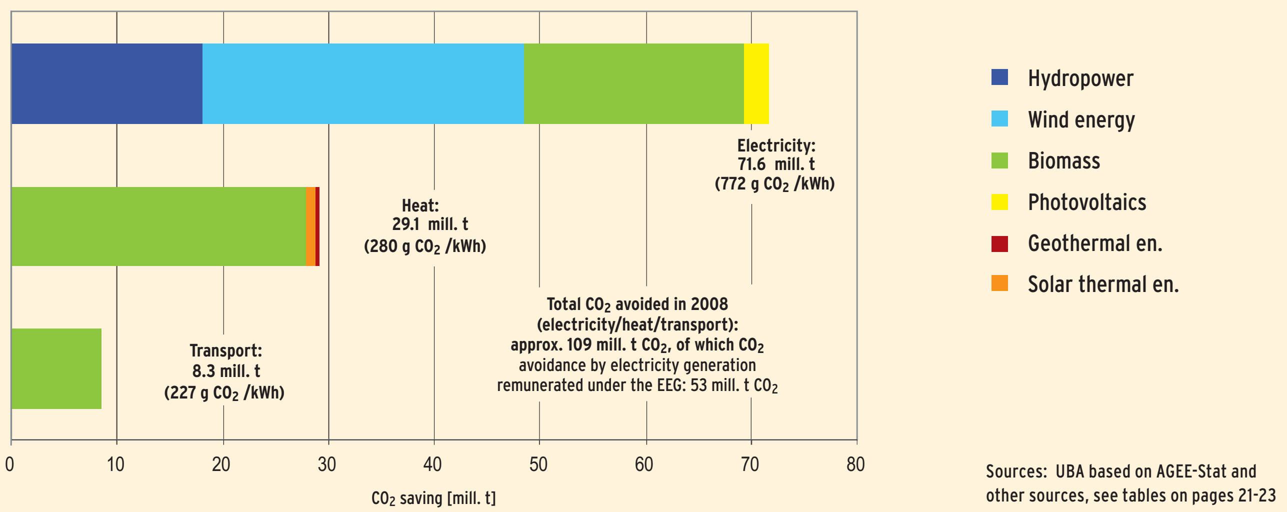
	Avoidance factor	Avoided emissions	Share
	[g CO_2/kWh]	[1,000 t]	[%]
Electricity			
Hydropower	851	18,131	25.3
Wind energy	753	30,435	42.5
Photovoltaics	591	2,365	3.3
Biogenic solid fuels	819	8,970	12.5
Biogenic liquid fuels	570	860	1.2
Biogas	688	5,536	7.7
Sewage gas	780	781	1.1
Landfill gas	784	786	1.1
Biogenic share of waste	829	3,767	5.3
Geothermal energy	835	15	0.02
Total electricity	–	**71,645**	**100**
Heat			
Biogenic solid fuels (households)	299	17,295	59.5
Biogenic solid fuels (industry)	273	4,586	15.8
Biogenic solid fuels (CHP/HP)	284	1,774	6.1
Biogenic liquid fuels	250	1,549	5.3
Biogenic gaseous fuels	265	1,256	4.3
Biogenic share of waste	289	1,452	5.0
Solar thermal energy	218	900	3.1
Deep geothermal energy[1)]	219	36	0.1
Near-surface geothermal energy [2)]	91	213	0.7
Total Heat	–	**29,060**	**100**
Transport			
Biodiesel [1)]	214	5,955	71.5
Vegetable oil [1)]	273	1,146	13.8
Bioethanol [1)]	262	1,228	14.7
Total transport	–	**8,329**	**100**
Total (electricity/heat/transport)		**109,007**	

CHP/HP Cogeneration plants/heating plants

1) The avoided CO_2 emissions were derived on the basis of avoided CO_2 equivalents.
2) Including other ambient heat

Sources: UBA based on AGEE-Stat and other sources, see tables on pages 21-23

Total CO_2 avoidance via the use of renewable energy sources in Germany, 2008



Sources: UBA based on AGEE-Stat and other sources, see tables on pages 21-23

DEVELOPMENT OF ENERGY-RELATED EMISSIONS IN GERMANY, 1990 TO 2008

	CO_2	CH_4	N_2O	CO_2-equivalent [1]	SO_2	NO_X [2]	NH_3	SO_2- equivalent [3]	CO	NMVOC	Dust [4]
	[mill. t]	[1,000 t]	[1,000 t]	[mill. t]	[1,000 t]	[1,000 t]	[1,000 t]	[1,000 t]	[1,000 t]	[1,000 t]	[1,000 t]
1990	948	1,536	24	988	5,146	2,710	15	7,061	11,480	2,190	1,339
1991	915	1,446	24	953	3,833	2,499	16	5,603	9,314	1,699	725
1992	870	1,307	23	905	3,119	2,348	17	4,785	8,019	1,474	454
1993	862	1,338	23	897	2,781	2,245	18	4,378	7,243	1,218	304
1994	843	1,201	23	875	2,317	2,108	18	3,819	6,267	945	191
1995	839	1,154	23	870	1,650	1,999	19	3,076	6,063	845	127
1996	866	1,126	23	896	1,386	1,916	20	2,756	5,704	754	118
1997	830	1,109	22	860	1,141	1,835	20	2,455	5,529	690	115
1998	824	995	22	851	898	1,745	20	2,150	5,146	621	103
1999	800	1,065	22	829	715	1,712	20	1,943	4,798	546	98
2000	798	1,004	21	826	523	1,607	19	1,677	4,472	456	91
2001	820	928	22	847	528	1,536	19	1,633	4,234	425	90
2002	806	887	21	831	488	1,448	19	1,531	3,945	379	85
2003	808	795	21	831	465	1,374	18	1,455	3,736	337	81
2004	797	703	21	818	437	1,306	18	1,380	3,503	309	77
2005	772	656	20	792	424	1,227	17	1,310	3,241	279	74
2006	784	612	21	803	424	1,188	17	1,283	3,218	267	73
2007	755	564	21	774	400	1,120	16	1,210	3,168	252	69
2008	748 *)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

As at spring 2009; figures include diffuse emissions from the extraction, conversion and distribution of fuels
*) Provisional figure
N/A = Not available

1) Includes CO_2, CH_4 and N_2O
2) Calculated as NO_2
3) Includes SO_2, NO_X and NH_3
4) Excluding abrasion from tyres and brake pads

On the significance and calculation of CO_2 and SO_2 equivalents, cf. Appendix, para. 4.

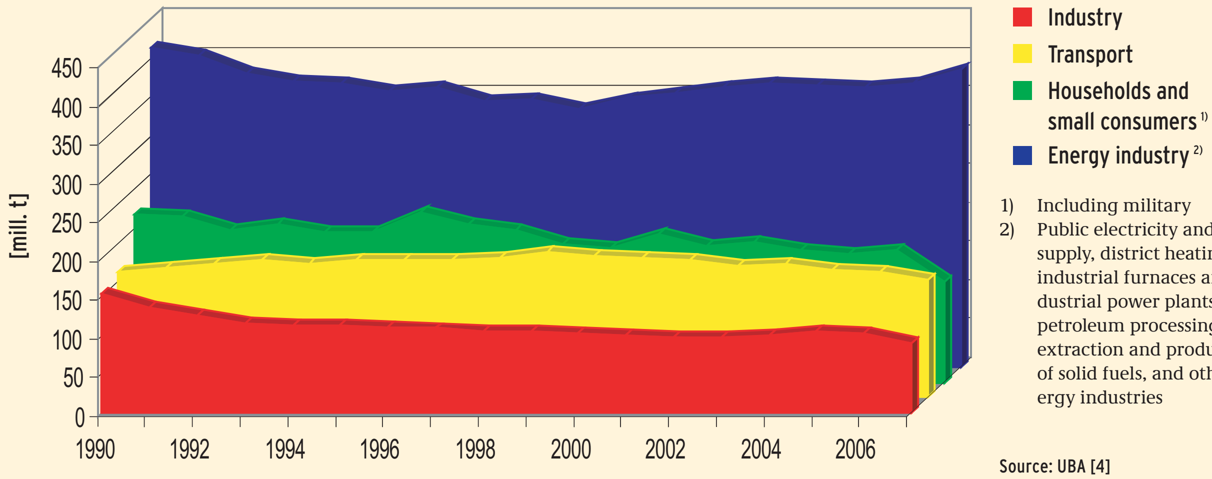
Source: UBA [4]

At the end of the year 2008, total energy-related CO_2 emissions were around 200 million tonnes lower than in 1990, corresponding to a 21 % reduction in emissions.

By 2007, total energy-related emissions of greenhouse gases had been reduced by just under 22 %.

Emissions of energy-related air pollutants have also been significantly reduced since 1990.

Development of energy-related CO_2 emissions in Germany since 1990



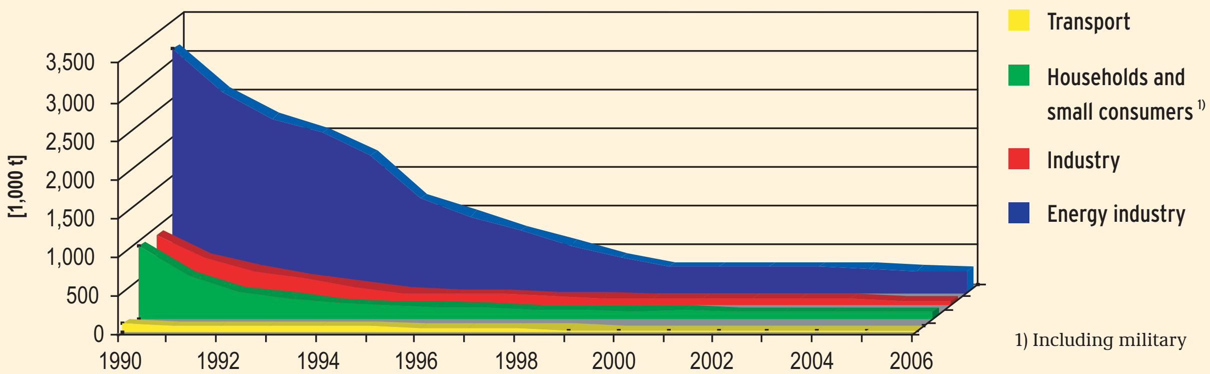
1) Including military
2) Public electricity and heat supply, district heating, and industrial furnaces and industrial power plants for petroleum processing, the extraction and production of solid fuels, and other energy industries

Source: UBA [4]

A sectoral analysis of the development of energy-related CO_2 emissions during the period 1990 to 2007 indicates that the energy industry, as the main emitter, was able to reduce energy-related CO_2 emissions by around 7 % over this period. In the transport sector, too, energy-related CO_2 emissions were reduced by 7 % between 1990 and the end of 2007.

In 2007, households and small consumers, together with industry, achieved reductions in energy-related CO_2 emissions of 38 % and 42 % respectively compared with 1990.

Development of energy-related SO_2 emissions in Germany since 1990



1) Including military

Source: UBA [4]

Total energy-related emissions of sulphur dioxide (SO_2) were reduced by 92 % between 1990 and 2007. As illustrated by the above graph, the bulk of this reduction was achieved by the year 2000.

ENERGY-RELATED EMISSIONS IN GERMANY ACCORDING TO SOURCE GROUPS, 2007

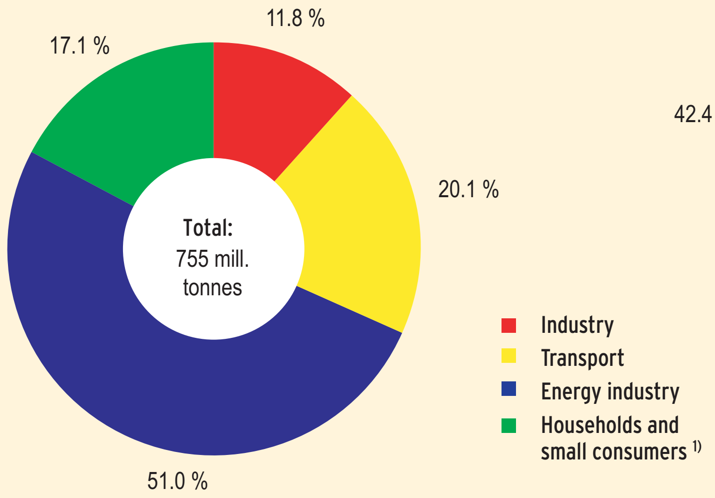
		Energy industry [1]	Household/ small consumers [2]	Transport [3]	Industry [4]	Total
CO_2	[mill. t]	385.5	128.8	151.9	89.1	755.3
CH_4	[1,000 t]	6.5	29.3	7.2	5.5	48.5
N_2O	[1,000 t]	13.10	1.1	3.7	2.7	20.6
CO_2-equivalent [5]	[mill. t]	389.5	129.8	153.1	90.0	762.5
SO_2	[1,000 t]	282.5	53.9	1.5	44.8	382.8
NO_x [6]	[1,000 t]	295.8	127.6	628.6	68.3	1,120.3
SO_2-equivalent [7]	[1,000 t]	494.3	146.8	456.5	94.6	1,192.1
CO	[1,000 t]	143.1	896.9	1,410.3	709.4	3,159.6
NMVOC	[1,000 t]	8.8	53.3	136.3	2.9	201.4
Dust	[1,000 t]	12.4	31.2	52.3	1.8	97.7

As at spring 2009; figures exclude diffuse emissions from the extraction, conversion and distribution of fuels.

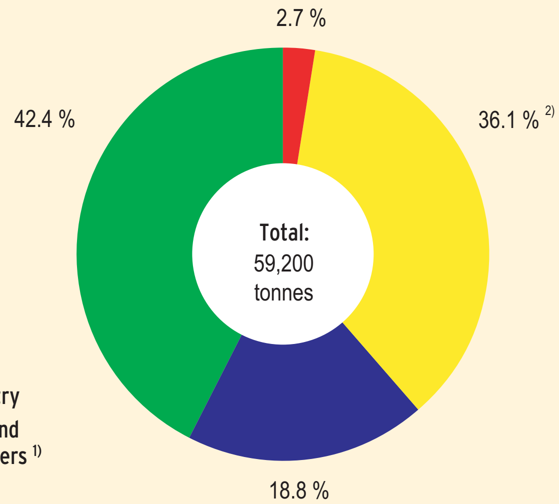
1) Public electricity and heat supply, district heating plants, industrial furnaces and industrial power plants for petroleum processing, the extraction and production of solid fuels and other energy industries
2) Private households, commerce, trade, services and military, plus agricultural and forestry traffic and military land and air traffic
3) Including rail traffic, national aviation, coastal and inland shipping
4) Manufacturing industry; excluding process-related emissions
5) Includes CO_2, CH_4 and N_2O
6) Calculated as NO_2
7) Includes SO_2, NO_X and NH_3

Source: UBA [4]

Source group shares of energy-related CO_2 emissions in Germany, 2007



Source group shares of energy-related particulate matter emissions in Germany, 2007



1) Including military
2) Excluding abrasion from tyres and brake pads.

Only includes particulate matter emissions for particle sizes up to 10 micrometres (PM_{10}) in accordance with the European Air Quality Directive (1999/30/EC), which has been in force in Germany since 1 January 2005.

Source: UBA [4]

FOSSIL FUELS SAVED VIA THE USE OF RENEWABLE ENERGY SOURCES IN GERMANY, 2008

Savings of fossil fuels are calculated analogously to the emissions balance, cf. also Appendix, para. 7.

1) To convert the primary energy saved, the following calorific values calculated by AGEB in 2006 were used: Lignite 9,013 kJ/kg, lignite briquettes 1 9,647 kJ/kg, pulverised coal 22,039 kJ/kg; hard coal 30,705 kJ/kg, hard coal coke 28,650 kJ/kg, natural gas 31,736 kJ/m³, light fuel oil 35,739 kJ/litre, diesel fuel 35.871 kJ/litre, petrol 32,439 kJ/litre.
2) Including approx. 15.9 million tonnes lignite, approx. 0.2 million tonnes lignite briquettes and approx. 0.4 million tonnes pulverised coal.
3) Including approx. 17.3 million tonnes hard coal and approx. 0.1 million tonnes hard coal coke.

	Lignite	Hard coal	Natural gas	Petroleum / fuel oil	Diesel fuel	Petrol	Total
	Primary energy [TWh]						
Elecricity	35.8	140.3	54.9	2.2	-	-	233.2
Heat	7.6	7.7	55.0	39.0	-	-	109.4
Transport	-	-	-	-	23.0	3.9	26.9
Total	43.4	148.1	109.9	41.2	23.0	3.9	369.5
	Primary energy [PJ]						
Total	156.2	533.1	395.6	148.4	82.9	14.0	1,330.2
Corresponding to 1):	16.5 mill. t 2)	17.4 mill. t 3)	12,465 mill. m^3	4,153 mill. litres	2,312 mill. litres	431 mill. litres	

Sources: UBA [110] based on AGEE-Stat and Klobasa et al. [41], Frondel et al. [114]; Öko-Institut [22]; Ecoinvent [111]; Vogt et al. [112]; Frick et al. [115] and other sources, cf. tables on pages 21-23

The table gives a detailed insight into the saving of fossil fuels via the use of renewable energies in 2008. As a large proportion of the fossil, i.e. non-renewable, fuels in Germany is imported, these savings also lead to a direct reduction in German energy imports.

Development in the saving of fossil fuels via the use of renewable energies in Germany, 2007 and 2008

	Elecricity	Heat	Transport	Total
	[TWh]			
2007	218.7	106.4	34.0	359.1
2008	233.2	109.4	26.9	369.5

Growing levels of primary energy savings, in conjunction with a significant hike in import prices for primary energy carriers, mean a disproportionately high increase in financial savings. (calculation based on the so-called substitution method – see Appendix, para. 5).

Development in the costs saved on energy imports in Germany, 2007 and 2008 1)

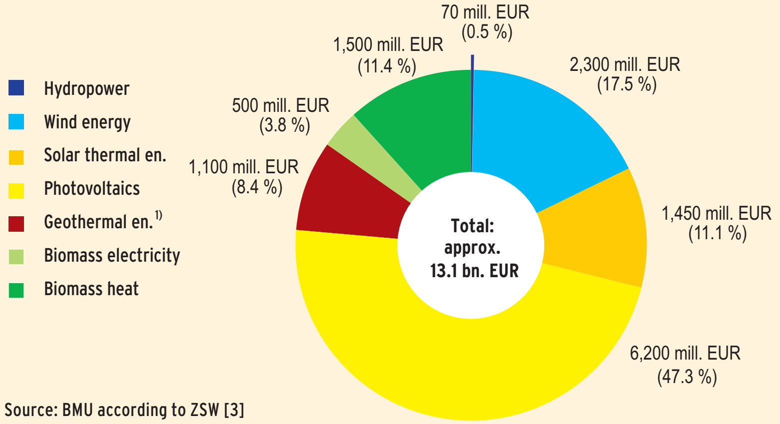
1) Excluding imported lignite for heating purposes (briquettes). Import shares of petroleum and natural gas according to [BMWi]. Import share for steam coal 100 %, because fixed purchase agreements for German hard coal do not permit any reductions. Consequently, steam coal savings lead to a reduction in hard coal imports. The overall import share of hard coal is more than 60 %. Import prices according to [BAFA].

	Elecricity	Heat	Transport	Total
	[billion EUR]			
2007	0.9	2.6	1.1	4.5
2008	2.7	2.9	0.6	6.2

Sources: BAFA [6]; BMWi [84]; IfnE [48]

TURNOVER FROM RENEWABLE ENERGY SOURCES IN GERMANY, 2008

Turnover from the construction of plants for the use of renewable energy sources in Germany, 2008

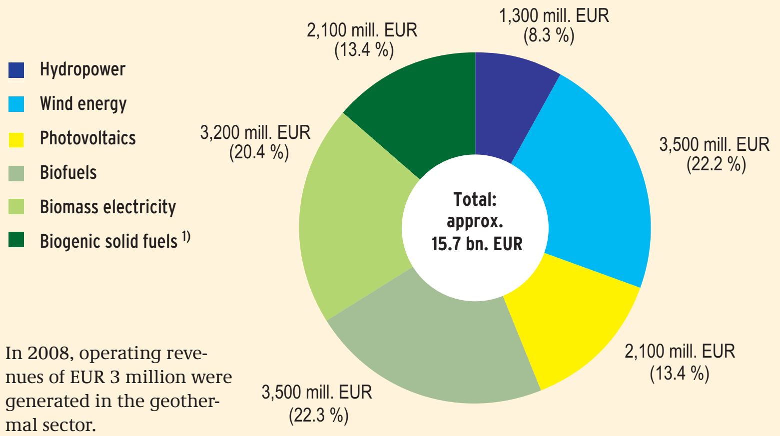


Source: BMU according to ZSW [3]

This primarily concerns the construction of new plants and, to a lesser extent, the expansion or upgrading of existing plants, such as the reactivation of old hydropower plants.

1) Large plants and heat pumps

Turnover from the operation of plants for the use of renewable energy sources in Germany, 2008



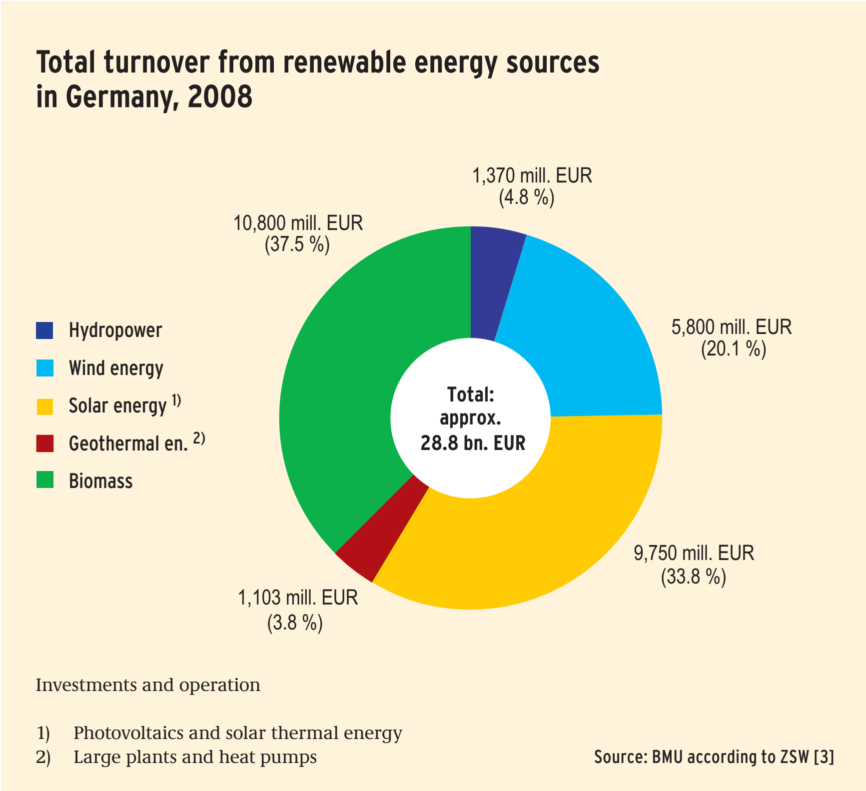
In 2008, operating revenues of EUR 3 million were generated in the geothermal sector.

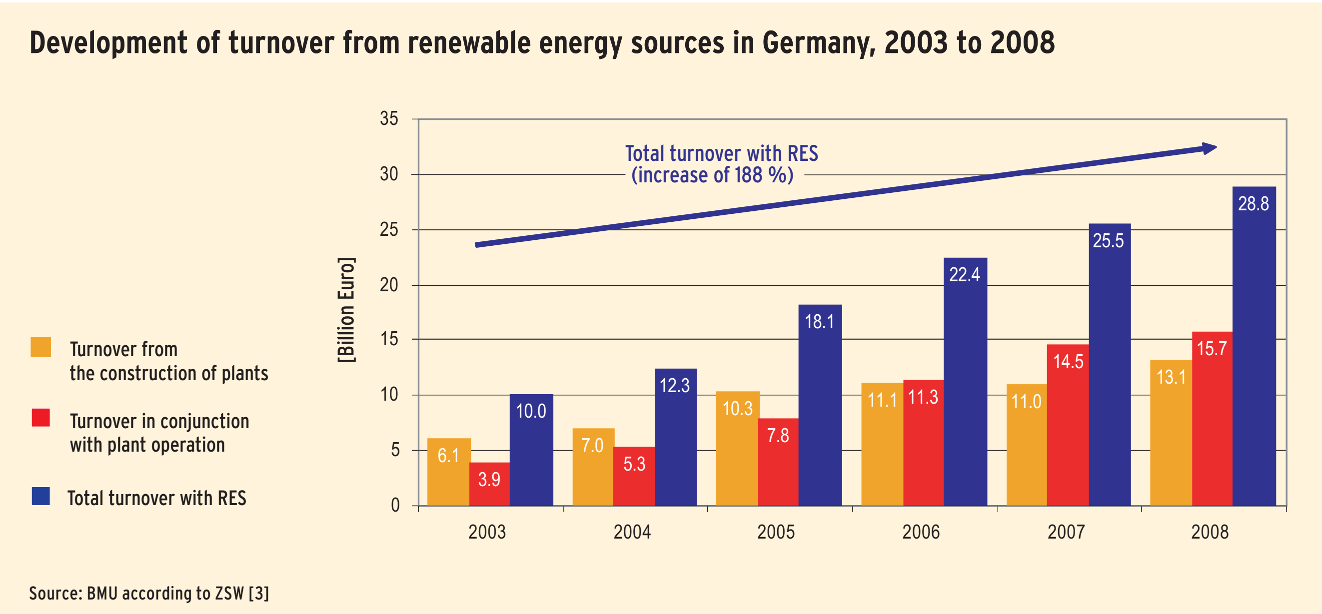
Source: BMU according to ZSW [3]

In the case of electricity generation, turnover is generated from the feed-in fees payable under the Renewable Energy Sources Act, or from the price attainable on the open electricity market, and in the case of fuel, from the sale of biofuels. In the case of heat generation, only the sale of fuels (generally wood) contributes to turnover, since in the majority of cases, the heat produced is not sold, but used internally.

1) Only fuels used exclusively to supply heat.

For explanations, refer to Appendix, para. 8.





In recent years, renewable energies have developed into a significant economic factor. Between 2003 and 2008, total turnover with renewable energy sources increased from around 10 billion Euros to around 28.8 billion Euros, which translates into an increase of 188 % in relation to the year 2003. The level of total turnover in 2008 (28.8 billion Euros) therefore exceeds the tax revenues of the state of Baden-Wuerttemberg for the first time in 2008 (around 28 billion Euros) [102].

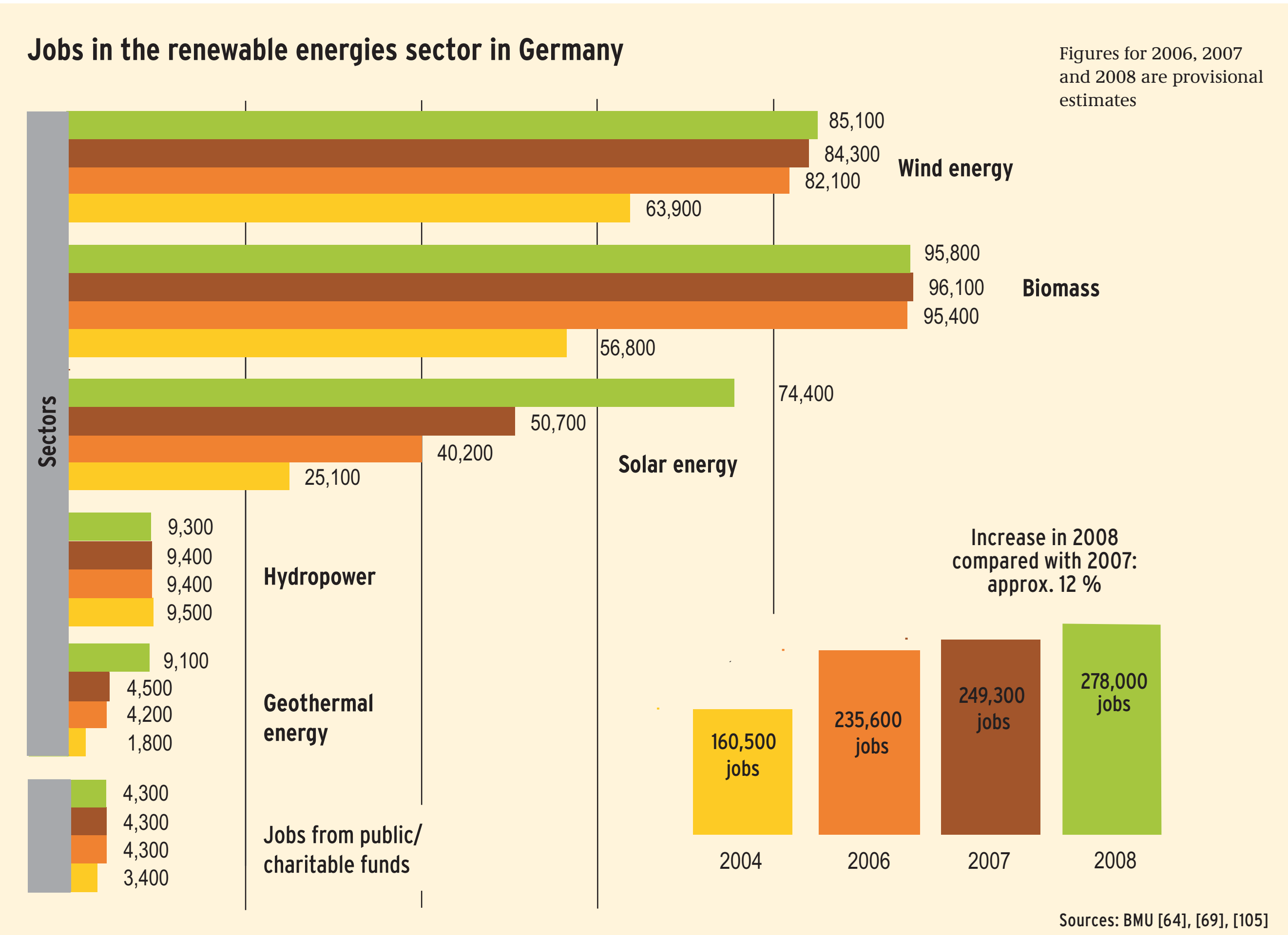
JOBS IN THE RENEWABLE ENERGIES SECTOR IN GERMANY

Renewable energies are a job creator for Germany. Last year, once again, their continuous expansion helped to create or secure numerous jobs.

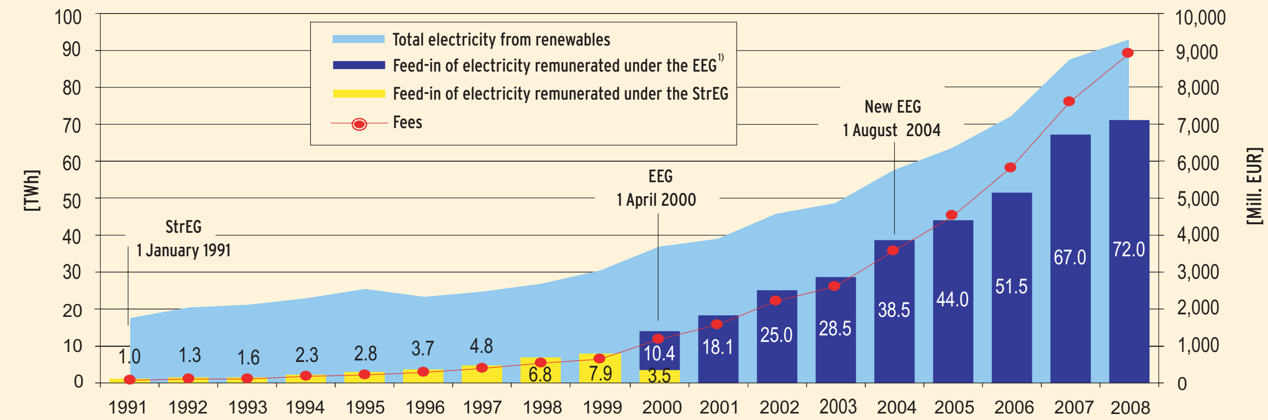
According to the interim results of an on-going research project by the BMU [105], it is estimated that nearly 280,000 jobs in Germany were attributable to the renewable energies sector in 2008. This translates into an increase of around 75 % compared with 2004 (approximately 160,000 jobs). The number of jobs was up by around 12 % on the previous year.

In calculating the above figures, data relating to investments in renewable energy plants, their operation, turnover and related outlay such as the required supply of biomass was taken into account. In this way, the researchers arrived at a figure of just under 280,000 jobs for the year 2008, around two-thirds of which are attributable to the effects of the Renewable Energy Sources Act. This is supplemented by jobs associated with public and charitable funding to promote renewables, including public sector employees. A further BMU research project [64] updated the figures calculated for the year 2006 (4,300 jobs).

According to this study, the positive trend looks set to continue over the next few years, suggesting a potential total of around 400,000 employees in the renewables sector by 2020 [64], [69], [105]. Key influencing factors for future development include Germany's future attractiveness as a production location in conjunction with the positioning of German companies in the world market for renewable energies, which is expected to experience sharp growth despite the current financial and economic crisis. In this regard, a further BMU research project is currently underway, which will once again examine in detail the possible negative employment effects of expanding renewable energies. To date, the so-called net balance of renewables in Germany has been clearly positive [64].



FEED-IN AND FEES UNDER THE ACT ON THE SALE OF ELECTRICITY TO THE GRID (STREG) AND THE RENEWABLE ENERGY SOURCES ACT (EEG) SINCE 1991



Figures for 2008 are provisional

1) Private and public feed-in

Sources: VDEW [55]; VDN [9]; BDEW [11]; ZSW [3]

Structure of electricity volumes remunerated under the EEG since 2000

		2000 1)	2001	2002	2003	2004	2005	2006	2007	2008 7)
Total end consumption	**[GWh]**	**344,663**	**464,286**	**465,346**	**478,101**	**487,627**	**491,177**	**495,203**	**495,041**	**495,000**
Privileged end consumption 2)	[GWh]	-	-	-	5,847	36,865	63,474	70,161	72,050	75,900
Total remunerated EEG electricity 3)	**[GWh]**	**10,391.0**	**18,145.4**	**24,969.9**	**28,417.1**	**38,511.2**	**43,966.6**	**51,545.2**	**67,010.0**	**71,978.0**
Hydropower, gases 4)	[GWh]	4,114.0	6,088.3	6,579.3	5,907.7	4,616.1	4,952.6	4,923.9	5,546.8	5,300.0
Gases 4)	[GWh]					2,588.6	3,135.6	2,789.2	2,751.1	2,700.0
Biomass	[GWh]	586.0	1,471.7	2,442.0	3,483.6	5,241.0	7,366.5	10,901.6	15,923.9	19,560.0
Geothermal energy	[GWh]	-	-	-	-	0.2	0.2	0.4	0.4	18.0
Wind energy	[GWh]	5,662.0	10,509.2	15,786.2	18,712.5	25,508.8	27,229.4	30,709.9	39,713.1	40,400.0
Solar irradiation energy	[GWh]	29.0	76.2	162.4	313.3	556.5	1,282.3	2,220.3	3,074.7	4,000.0
EEG quota 5)	**[%]**	**3.01**	**3.91**	**5.37**	**6.02**	**8.48**	**10.0**	**12.01**	**15.68**	**17.00**
Average fee	**[ct/kWh]**	**8.50**	**8.69**	**8.91**	**9.161**	**9.29**	**9.995**	**10.875**	**11.36**	**12.0**
Total fee 6)	**[bn. EUR]**	**0.88**	**1.58**	**2.23**	**2.61**	**3.61**	**4.50**	**5.81**	**7.61**	**8.95**
Non-remunerated EEG electricity	[GWh]	26,288.0	20,927.6	20,790.1	20,236.9	19,017.8	19,602.6	20,694.9	20,594.1	20,801.0
Total EEG electricity	**[GWh]**	**36,679.0**	**39,073.0**	**45,760.0**	**48,654.0**	**57,529.0**	**63,569.2**	**72,240.1**	**87,604.1**	**92,779.0**

1) Short year: 01/04 – 31/12/2000
2) Privileged end consumption since July 2003 under the special compensation provision (Articles 11 and 16 of the EEG)
3) Does not include post-corrections by the VDN (2002 to 2006) because the additional feed-ins for previous years according to auditors' certificates cannot be allocated to energy sources
4) Landfill, sewage and pit gas listed separately for the first time in 2004
5) Quota of non-privileged end consumption
6) Overall fees excluding avoided grid utilisation fees. The fees shown here differ significantly from the differential costs (see following pages), but are slightly below the total fees paid out.
7) Provisional; figures have been amended compared with the BDEW medium-term forecast 2000 to 2014, as at 22 April 2008

Sources: VDN [9]; BDEW [11]; ZSW [3]

COST TO ELECTRICITY CONSUMERS

From a business viewpoint [1], electricity from renewable energy sources which is eligible for remuneration under the EEG is still more expensive than that from conventional energy sources. To date, the resultant total costs have generally been calculated according to the following basic formula:

EEG apportionment = EEG quota x (EEG average fee – avoided electricity purchase price)

The EEG fees paid to plant operators are published by 30 September of the following year by the Bundesverband Energie- und Wasserwirtschaft e.V. (BDEW e.V., German Energy and Water Association) in an audited annual account. Until that date, only forecasts are available. The electricity purchase costs avoided as a result of EEG feed-in can only be approximated, since these are trade secrets and there is no general database available. As the assumptions made may vary, published figures on EEG cost levels can vary significantly.

Based on BMU research projects [73, 94], it would seem plausible to estimate the (commercial) value of conventionally generated electricity that is substituted by the EEG feed-in at 5.7 cents per kWh in 2008. With an EEG electricity volume of around 72 TWh in 2008 and an average fee of 12 cents per kWh, this leads to additional costs (differential costs) of around 4.5 billion Euros. The additional costs are therefore significantly lower than the remuneration paid to the operators of EEG electricity generation plants in 2008 of 9 billion Euros.

Making allowance for a special provision in the EEG for particularly electricity-intensive companies [2], this produces an average nationwide EEG apportionment of 1.1 cents per kWh for all electricity consumers without privileges, which includes private households. This equates to just under 5 % of the costs for one kilowatt hour of household electricity in 2008 (an average of approx. 21.6 cents/kWh). Depending on the market situation and the market behaviour of electricity suppliers, however, the actual EEG apportionment invoiced may vary. In 2008, the cost of the EEG to an average household with an electricity consumption of 3,500 kWh per annum was around 3.10 Euros per month. Despite the further increase in the feed-in of electricity from renewable sources, the EEG cost share will only increase at a below-average rate over the next few years.

In conjunction with the significant rise in EEG electricity, recent estimates for the current year 2009 suggest that there will be no increase in EEG differential costs, and consequently, no increase in the EEG apportionment. More reliable figures in this connection will not become available until early 2010.

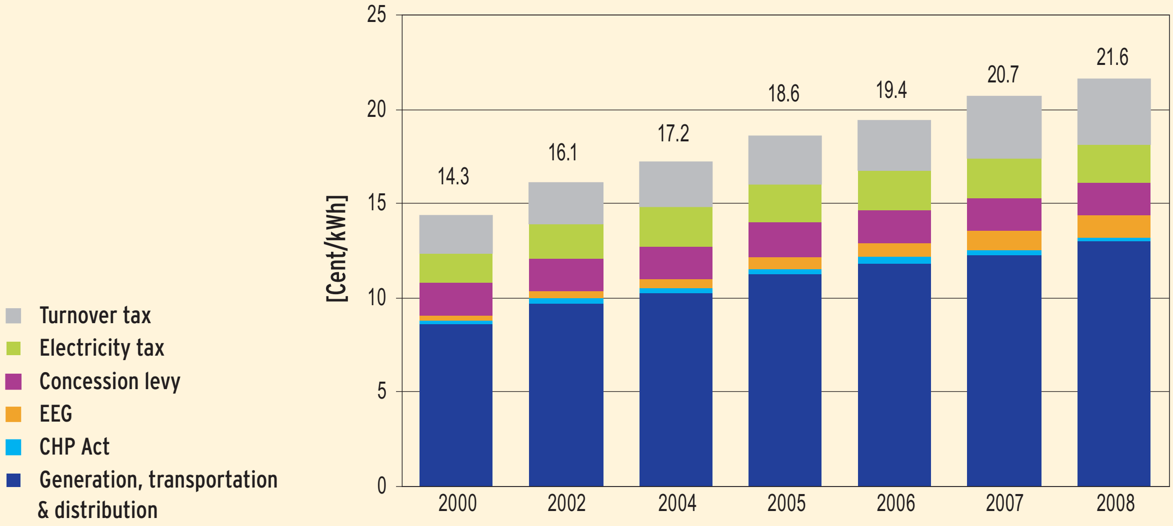
Development of EEG differential costs and specific EEG apportionment

	EEG costs	EEG apport.
Year	[bn. EUR]	[Cent/kWh]
2000	1.0	0.2
2001	1.2	0.3
2002	1.8	0.4
2003	1.9	0.4
2004	2.5	0.6
2005	2.8	0.6
2006	3.3	0.8
2007	4.3	1.0
2008	4.5	1.1

Based on 2008 prices

1) A macro-economic analysis gives a different picture; cf. in this respect page 36.
2) In 2009, this allows around 500 particularly electricity-intensive companies in the manufacturing industry and railways to purchase EEG electricity at significantly reduced prices, based on an EEG apportionment (differential costs) of just 0.05 ct/kWh. As a result, the EEG costs of all other electricity customers are increased by just under 20 %.

Cost shares for one kilowatt hour (kWh) of electricity for household customers in Germany



Turnover tax	2.0	2.2	2.4	2.6	2.7	3.3	3.4
Electricity tax	1.5	1.8	2.0	2.0	2.0	2.0	2.0
Concession levy	1.8	1.8	1.8	1.8	1.8	1.8	1.8
EEG	0.2	0.3	0.4	0.6	0.8	1.0	1.1
CHP Act	0.2	0.3	0.3	0.3	0.3	0.3	0.2
Generation, transportation & distribution	8.6	9.7	10.2	11.2	11.8	12.2	13.0
Total	**14.3**	**16.1**	**17.2**	**18.6**	**19.4**	**20.7**	**21.6**

EEG: Renewable Energy Sources Act
CHP Act: Combined Heat and Power (Cogeneration) Act

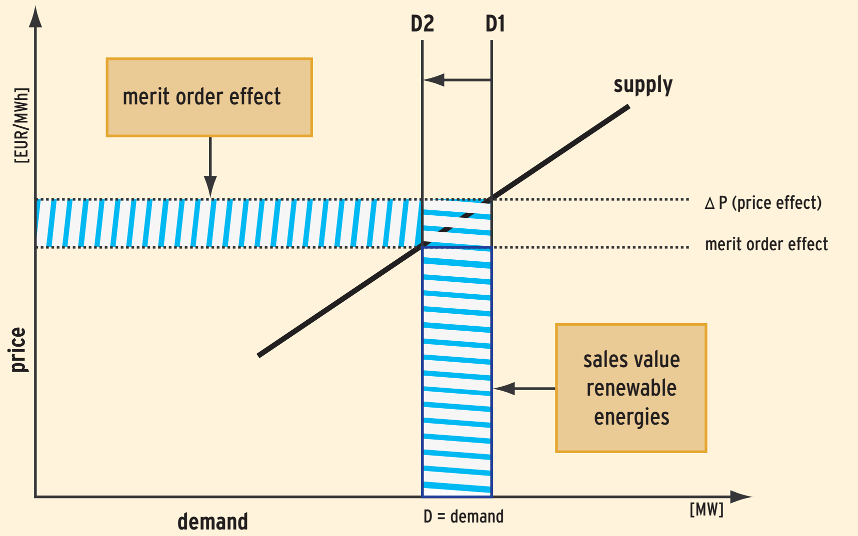
Source: BMU [43]

EFFECTS OF RENEWABLE ENERGIES ON ELECTRICITY PRICES

When assessing the economic effects of the promotion of renewable energy sources by the EEG, as well as considering the market value of the EEG electricity, it is also necessary to take into account the impacts of electricity generation from renewable energies on wholesale electricity market prices. The fact that priority is given to the feed-in of renewables will, in the short term, lead to a lowering of electricity prices on the wholesale market. A scientific study commissioned by the BMU [86] analysed the impacts of EEG electricity generation on wholesale prices up until 2006. This calculation is currently being reviewed and updated.

The market price of electricity is determined by the most expensive power station still needed to satisfy the demand for electricity (merit order). Because priority is given to EEG feed-in, demand for conventional electricity is reduced. In accordance with the merit order, therefore, the most expensive power plants are no longer needed to meet demand, and the market price falls accordingly. This effect is known as the merit order effect. The illustration below provides a diagrammatic overview.

Representation of the merit order effect



Note: The model is calibrated against the market prices for the year in question, which means that comparability between the results for different years is limited. With the time series given below, it is important to bear in mind that in 2006, the feed-in price of CO_2 for lignite power plants were reduced slightly, while fuel prices followed with a time lag.

Source: BMU [86]

Scientific studies commissioned by the BMU, prepared on the basis of a detailed electricity market model (PowerACE) and confirmed by an expert discussion, suggest that over the past three years, the merit order effect has reduced the cost of electricity purchased via the spot market by between 2.5 and 7.8 Euros/MWh (see table below) [42], [80], [86]. Hence, the merit order effect reduces the purchasing costs to electricity suppliers, which in turn tends to lower electricity prices.

	Simulated EEG electr. generation	Average price reduction	Volume merit order effect	Specific effect	Average EEG feed-in fee
Year	[TWh]	[EUR/MWh]	[bn. EUR]	[EUR/MWh_{EEG}]	[EUR/MWh_{EEG}]
2004	41.5	2.50	1.65	40	92.9
2005	45.5	4.25	2.78	61	99.5
2006	52.2	7.83	4.98	95	109.0

Source: Sensfuß [89]

MACROECONOMIC EXTERNAL COSTS

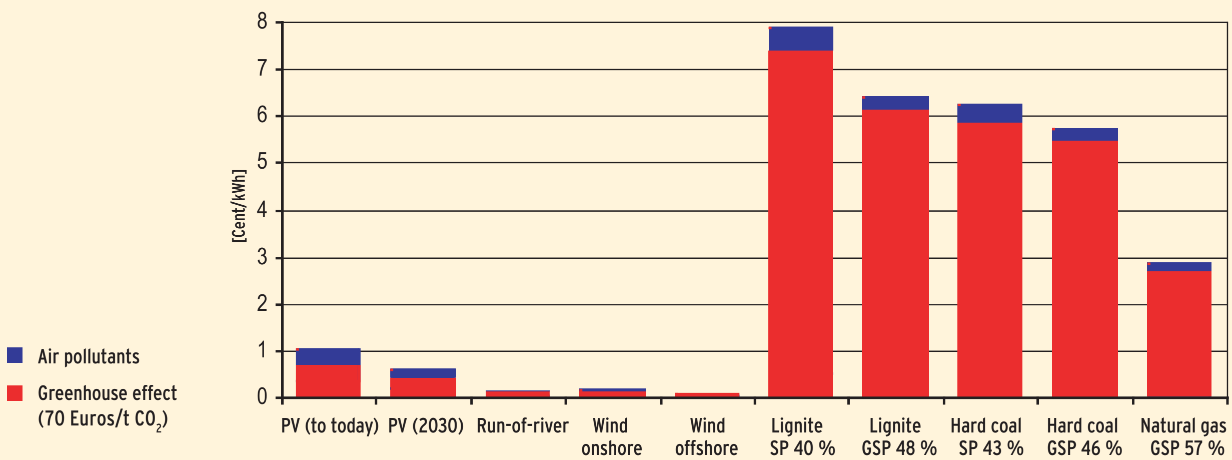
The costs of the EEG derived from the figures on the previous pages are not in themselves sufficient for a comprehensive economic evaluation of renewable energy sources, because as microeconomic dimensions, they do not reflect the fact that conventional electricity generation still causes significantly more environmental damage than electricity from renewable energy sources, despite the major environmental progress made in recent decades. These so-called external costs are not yet incorporated into the electricity prices as required by the polluter pays principle.

According to a scientific study carried out on behalf of the BMU [39], greenhouse gas emissions play a key role: The current best estimate of the cost of climate damage arising from such emissions is around 70 Euros/t CO_2. Part of this is already taken into account in the electricity price via emissions trading. In addition, health and material damage caused by air pollutants are important, together with, to a lesser extent, agricultural revenue losses. External costs for electricity generated from hard coal and lignite – even allowing for modern technology – amount to 6 to 8 cents/kWh. For modern gas and steam plants, the external costs are still approximately 3 cents/kWh[1]).

By contrast, electricity generation from renewable energies causes comparatively minor external costs (generally less than 0.5 cents/kWh; only photovoltaics at present still cost around 1 cent/kWh). The construction and disposal of the plants are included in these calculations[1]).

1) Further external effects of electricity generation from fossil fuels (impairment of biodiversity, ecosystems and supply reliability, as well as geopolitical risks) cannot be quantified, due to the lack of reliable data. As such, the aforementioned variables are only a fraction of the actual external costs currently anticipated.

External costs of electricity generation for various options in Germany



PV Photovoltaics
SP Steam power plant
GSP Gas and steam power plant

Source: BMU [39]

Based on the scientifically proven assumption that the electricity generated from renewable energies at present fully displaces electricity generated from fossil fuels, in 2007 the external costs avoided in the electricity sector thanks to renewables can be estimated at a minimum of 3.9 billion Euros (electricity remunerated and not remunerated under the EEG) respectively 2.9 billion Euros (only remunerated under the EEG) [48]. This is therefore in a comparable range to the EEG differential costs over the same period (4.5 billion Euros, see page 33 “Costs to electricity consumers”). Renewable energies also boast a host of other strategic and economic advantages.

OVERVIEW OF THE COSTS AND BENEFICIAL EFFECTS OF THE RENEWABLE ENERGY SOURCES ACT (EEG)

On the preceding pages, we have explained in detail that while the Renewable Energy Sources Act (EEG) incurs costs, it also brings substantial macroeconomic benefits. The following overview summarises the key variables:

Costs of the EEG

From a microeconomic viewpoint, electricity from renewable energy sources is still more expensive than that produced by conventional means. Because the utility companies are obliged under the EEG to purchase electricity from renewable sources, this incurs higher procurement costs. In 2008, these costs totalled around 4.5 billion Euros (cf. page 33).

The Bundesnetzagentur (Federal Network Agency) approved some 0.6 billion Euros [72][1)] for the additional balancing and compensatory energy requirements, as well as transaction costs to transmission grid operators, necessitated by renewable energies.

Benefits

The beneficial effects of the EEG include, firstly, a very positive influence on innovation, turnover and value-added in Germany, coupled with the creation of new jobs. In 2008, around two-thirds of the 280,000 or so jobs in the renewable energies sector were attributed to the EEG (cf. page 31).

EEG-related savings on imports of hard coal and natural gas should also be viewed in the same light. In 2008, including biomass imports, these totalled some 2.7 billion Euros (cf. page 28).

By avoiding externalities, a relevant macroeconomic benefit of 2.9 billion Euros in total (electricity remunerated under the EEG) is also attributable to the EEG in 2008 (page 36).

Finally, on page 35, we explained in greater detail that the cost of electricity purchased via the spot market was around 7.8 Euros/MWh lower in 2006, thanks to the additional electricity supply available from renewable energy sources. In relation to total trade on the spot market, this amounts to around 700 million Euros. If this effect is extrapolated to the electricity demand as a whole, it equates to around 5 billion Euros. Hence, the merit order effect of renewable energy sources exerts downward pressure on electricity prices, which may in turn impact end-user prices.

Calculations for subsequent years are due to become available shortly.

Summary

The above overview of the possible cost and benefit effects of the EEG does not claim to be exhaustive. Given the varying effect levels and the interactions between them, these figures cannot be balanced out. Nevertheless, the significant beneficial effects associated with the EEG clearly show that an economic assessment of the EEG based purely on microeconomic cost variables (as is often implemented) falls well short of the mark.

1) For the most part, possible EEG-related grid expansion costs will not come into play until the future, and have therefore been disregarded here. Current estimates [85] suggest that the expansion of offshore and onshore networks could cost around 4 billion Euros in total; the long depreciation periods mean that the additional costs incurred would total just under 400 million Euros per annum.

PROMOTING RENEWABLE ENERGY SOURCES

The German Government supports renewable energy sources through research and development, and offers a wide range of measures to encourage market development.
The Renewable Energy Sources Act is of pivotal importance to the electricity market, while biofuels benefit from compulsory admixture under the Biofuels Quotas Act, as well as petroleum tax concessions in selected application areas.

The market incentive programme to support measures for the use of renewable energies is one of the German Government's key mechanisms for promoting renewable energies in the heating market.

In the buildings sector, the Reconstruction Loan Corporation (KfW) offers a range of attractive financing schemes. These also include the use of renewable energy sources and the conversion of heating systems. Investment loans are still available for photovoltaic plants ("KfW renewable energies programme – Standard"), for the construction of new energy-saving homes ("Energy-efficient construction"), and for home modernisation measures ("Housing modernisation") (for further information, please see: www.kfw-foerderbank.de/EN_Home/index.gsp/).

In addition, anyone interested in taking advantage of a comprehensive energy consultation for older properties is eligible to apply for a grant towards the cost of this service ("Local consultations to save energy" scheme, www.bafa.de/bafa/en/energy/index.html).

Support at national level is supplemented by a wide range of measures in the various Federal Länder and local authorities. An overview of the measures available may be found under the nationwide "Klima sucht Schutz" (Climate Seeks Protection) campaign at http://www.klima-sucht-schutz.de/3351.html, which also contains a wealth of useful information on energy-saving in the home.

In cooperation with the BINE information service (www.bine.info), the German Environment Ministry has published a detailed brochure outlining all the support available at EU, national, state and local level, as well as from the power utilities (www.bmu.de/english/climate/aktuell/3821.php).
A comprehensive support database (www.foerderdatenbank.de) is also provided by the Federal Ministry of Economics and Technology.

The Market Incentive Programme

The Market Incentive Programme (MIP) to promote measures for the use of renewable energies constitutes the "support" pillar of the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG), which entered into force at the beginning of 2009. The "Support" pillar of the EEWärmeG obligates owners of newly constructed buildings to meet a proportion of their energy requirements for heating (including hot water supply) and cooling from renewable energies ("the obligation to use renewables").

Under Article 13 of the EEWärmeG, between 2009 and 2012, funding of up to 500 million Euros per annum will be provided under the MIP for the utilisation of renewable energies for heat generation. It is hoped that this will help to significantly accelerate the expansion of renewable energies in the heating market.

The MIP primarily supports investments to construct facilities for the generation of heat from renewable energy sources.

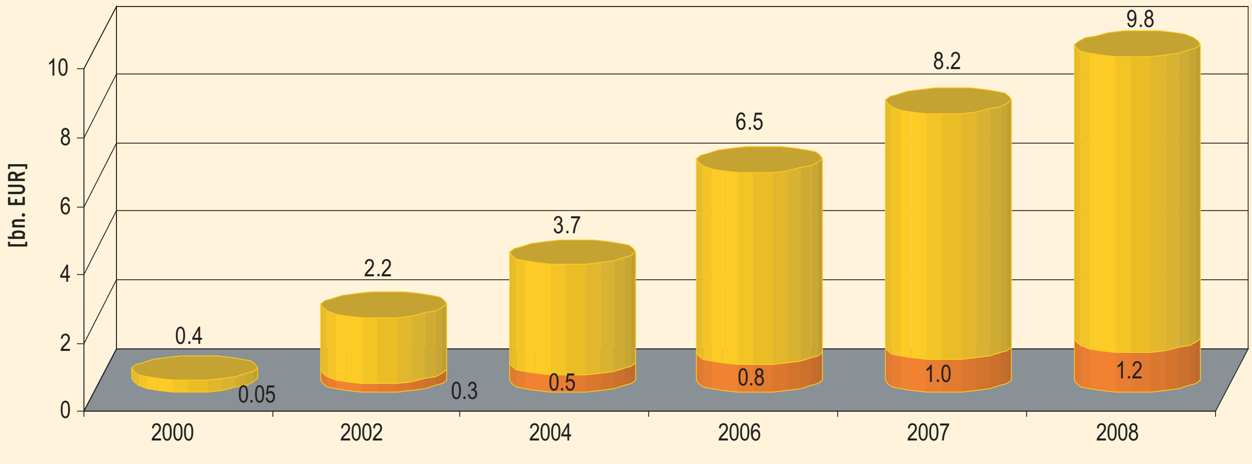
The support available is divided into two parts: Investment cost subsidies via the Federal Office of Economics and Export Control (BAFA) for smaller facilities, mainly for private investors, and interest-reduced loans with repayment subsidies under the KfW "Renewable Energies – Premium" programme for larger facilities, generally for commercial investors.
Details of the support available are set out in the relevant guidelines.
The new support guidelines dated 20 February 2009 entered into force on 1 March 2009. These guidelines essentially implement the provisions of the EEWärmeG, which entered into force on 1 January 2009.

For owners of new buildings who are obligated under the EEWärmeG to utilise renewable energy sources, the basic rates of support for investment cost subsidies are generally reduced by a fixed amount of 25 %, to make allowance for the vested interest of owners of new houses in meeting their usage obligation, but also for the fact that the use of renewable energies in new-builds is considerably less labour- and cost-intensive.

For the KfW Renewable Energies – Premium programme, no amendments were made to the support rates for systems in new buildings.

From the programme's launch up until February 2009, over 780,000 solar thermal collectors and over 170,000 small biomass boilers had received grants under this programme. The investments supported by this scheme total some 6.2 billion Euros for solar collectors and 2.7 billion Euros for small biomass plants. Between early 2008 and February 2009, grants were awarded for 24,000 efficient heat pumps, triggering an investment volume of 409 million Euros.

Funding and investment volume (cumulative) triggered by the market incentive programme since 2000



As at January 2009

Source: BMU – KI III 2

Under the Market Incentive Programme, during the period from 2000 to January 2009, the KfW-Förderbank (KfW Renewable Energies – Premium programme) granted more than 3,900 loans with a volume of around 970 million Euros e.g. for large-scale biomass combustion plants, systems for the use of deep geothermal energy, biogas plants, district heating networks and innovative technologies (large heat accumulators, crude biogas pipelines, and plants for the processing and infeed of biogas).

Overall, from its inception until the end of 2008, some 950,000 projects with a funding volume of around 1.2 billion Euros were supported under the MIP. The volume of investments triggered as a result of this totals some 10 billion Euros.

Since 2008, the programme has been continued with a new focus. Bonuses and innovation grants are now being offered in addition to basic funding as additional incentives for exceptionally efficient or innovative applications.

In the residential buildings sector, the main emphasis is on subsidising solar panel installations for hot water, and combined hot water supply and heating support, as well as biomass heaters.

There are also plans to step up the funding of commercial investments under the KfW Renewable Energies – Premium programme. As well as plants for the use of solid biomass in the capacity range from 100 kW and large solar panel installations and district heating networks, in future, support will also be available for particularly innovative technologies in the form of an innovations grant. Support for large heat accumulators, plants for processing biogas to natural gas quality, and biogas pipelines was also introduced in 2008. In future, deep geothermal energy plants will be eligible for up to four separate grants. It is hoped that this will reduce the specific investment risks and high initial investment costs of deep geothermal plants.

Funding queries may be addressed to the German Environment Ministry's "climate hotline" (tel. +49 (0)180 200 4 200, calls charged at 6 cents per call from a German landline). Information on the grants available under the Market Incentive Programme is available from the Federal Office of Economics and Export Control (BAFA), telephone +49 (0)6196 908625 (www.bafa.de/bafa/en/energy/index.html). Questions regarding eligibility for reduced-rate loans for commercial or municipal applicants within the context of the Market Incentive Programme will be answered by the Reconstruction Loan Corporation (KfW) information centre, telephone +49 (0)1801 335577 (www.kfw-foerderbank.de/EN_Home/index.jsp).

BAFA	KfW
Grants	Interest-reduced loans and partial debt relief
Biomass plants up to 100 kW	Biomasse plants from 100 kW (incl. CHP)
Solar thermal plants	Solar thermal plants from 40 m^2
Efficient heat pumps	District heating networks
Plus bonus and innovation grants	Geothermal plants
	Heat accumulators
	Crude biogas pipelines and plants for the processing and feed-in of biogas into the natural gas network

BIOFUELS

Around 30 % of the total energy consumption in Germany is attributable to the transport sector. By the year 2000, fossil resources (in the form of petroleum) were used almost exclusively to meet the fuel demand, the bulk of which were imported. In order to make Germany less dependent on energy imports for the transport sector and on price developments in the raw materials markets, as well as contributing to climate protection, a series of statutory framework conditions have been put in place to make market entry easier for biofuels.

On the basis of the Biofuels Quotas Act (Biostoffquotengesetz) adopted by the Bundestag (Lower House of Parliament) in October 2006, since 2007, degressive tax concessions have been available to pure biofuels outside of the quota, while admixtures to fossil fuels are supported via the biofuels quota. In future, support will be made dependent upon whether production of the biomass used verifiably meets certain requirements vis-à-vis the sustainable management of agricultural land and the conservation of natural habitats. In concrete terms, this means that biofuels cannot be offset against the quota unless a reduction in greenhouse gases can be proven over its entire lifecycle compared with fossil fuels. The energy share of total fuel consumption in Germany attributable to biofuels totalled 5.9 % by the end of 2008, already exceeding the EU target for 2010 of 5.75 %.

In April 2009, the European Council and the European Parliament finally adopted the Directive on the promotion of the use of energy from renewable sources (cf. also page 48). Under this Directive, a binding minimum share of 10 % renewable energies in the transport sector by the year 2020 and the introduction of sustainability standards will become mandatory.

Overview of biofuels

Biofuel [1]	Feedstock	Production process
Vegetable oil	Oil crops[2]	Cold pressing/extraction
Biodiesel		
from energy crops	Oil crops [2]	Cold pressing/extraction & transesterfication
from biogenic waste	Waste/fat	Transesterfication
Bioethanol[3]	Sugar beet, grains	Fermentation und hydrolysis

Source: ZSW [3]

Biofuels are usually referred to as second-generation if the manufacturing process facilitates the use of the entire plant and a high level of greenhouse gas reduction is achieved. Compared with the production of first-generation biofuels, this leads to increased efficiencies and yields. Second-generation biofuels include BTL (Biomass-To-Liquids) and bioethanol from lignocellulose, for example.

1) First-generation biofuels only
2) Generally rapeseed
3) Bioethanol can either be added directly to petrol or processed into ETBE (ethyl tertiary butyl ether).

RESEARCH AND DEVELOPMENT OF TECHNOLOGIES FOR THE USE OF RENEWABLE ENERGY SOURCES

Research and development projects on renewable energy sources are eligible for support under the Federal Government's Energy Research Programme. Investments in renewable energies help to conserve scarce resources, reduce our dependency on energy imports, and protect the climate and environment. Technical innovations help to reduce the cost of regeneratively produced electricity. The German Environment Ministry (BMU) is responsible for application-oriented project funding in the field of renewable energy sources.

The BMU funds research and development in the field of renewable energies, also with a view to job market-related policies and promoting Germany's attractiveness as an industrial location. Research funding strengthens the leading international position and competitiveness of German companies and research institutions, helping to create jobs in a growing world market.

Aims and focal points of research support

The superordinate aims of research support are:

- To further increase the use of renewables
- To strengthen the international competitiveness of German companies and research institutions.
- To create and expand future-safe jobs.

In order to achieve these goals, the BMU has set the following priorities:

- To continuously reduce the cost of the production and use of renewable energies.
- To optimise energy systems overall, e.g. by improving the integration of renewable energy sources and system-based approaches.
- To ensure that renewables are developed and expanded in an eco- and nature-friendly manner, e.g. with resource-conserving production methods.
- To ensure the rapid transfer of technology from research to market.
- To promote cross-sectoral research (economic issues, jobs, system studies etc.) [68].

In 2008, a total of 168 new projects with a total volume of more than 150 million Euros were approved by the BMU in the fields of photovoltaics, geothermal energy, wind energy, low-temperature solar thermal energy, solar thermal power plants, ocean energy, and international cooperation, as well as overall strategy and overarching issues. This represented a significant increase on the previous year's volume of new project approvals (2007: approx. 100 million Euros).

In 2008, the lion's share of newly approved funding went to photovoltaics and wind energy. There is a particularly pressing need for research and development work in the field of photovoltaics, because the EEG fee rates show the highest degression in these areas, and it is vital that suitable cost reductions are achieved. In addition, there is still a huge potential for innovation in this field. Ultimately, it is a matter of safeguarding Germany's leading international position in photovoltaics research, and improving the competitiveness of German companies in a rapidly expanding global market. In the area of wind energy research, the biggest challenges are in the offshore sector. Under the RAVE research initiative, the BMU is supporting extensive research projects linked to Germany's first offshore test field "alpha ventus".

High-level support is also given to research in other areas. All renewable energy sources are vital if we are to meet the German Government's ambitious expansion targets. In 2007 and 2008, the extraction of geothermal energy took a major step forwards in Germany, with the generation of electricity and heat at the geothermal power plants in Landau (Pfalz) and Unterhaching (Bavaria). Additionally, an online geological atlas was also completed in 2008. This will help to significantly reduce the risks associated with geothermal drillings in future.

With the growing expansion of renewable energy sources, and given the age structure of the grids and power plants, optimisation of the energy supply systems is an increasingly important issue. In 2008, the BMU established a new support priority in recognition of this fact. The aim is to create innovative energy systems with a high proportion of renewables. Electromobility also plays a role in this connection.

The BMU attaches great importance to the transparency of its research funding. In-depth information can be found in the 2008 annual report, the free newsletter, and the regularly updated overview of on-going research projects.
Link: www.erneuerbare-energien.de/inhalt/42606/

Newly approved and on-going projects by the BMU

	Newly approved projects								
	2006			2007			2008		
	[Number]	[1,000 EUR]	[Share in %]	[Number]	[1,000 EUR]	[Share in %]	[Number]	[1,000 EUR]	[Share in %]
Photovoltaics	39	43,367	43.9	49	41,653	40.8	38	39,735	26.3
Wind energy	29	16,083	16.3	52	34,713	34.0	32	40,097	26.6
Geothermal en.	11	23,718	24.0	17	8,051	7.9	18	16,381	10.9
Low-temp. solar thermal energy	13	5,058	5.1	20	7,505	7.3	20	10,129	6.7
Solar thermal power plants	16	6,875	7.0	18	5,851	5.7	15	8,217	5.4
System integration	-	-	-	-	-	-	26	28,184	18.7
Other	10	3,716	3.8	21	4,391	4.3	20	8,070	5.4
Total	**118**	**98,818**	**100.0**	**177**	**102,164**	**100.0**	**169**	**150,813**	**100.0**

	On-going projects 2008		Completed projects 2008	
	[Number]	[1,000 EUR]	[Number]	[1,000 EUR]
Photovoltaics	133	150,530	27	28,563
Wind energy	125 [1)]	102,414	37 [1)]	22,230
Geotherm. energy	48	46,327	16	12,454
Low-temp. solar thermal energy	60	29,294	14	5,481
Solar thermal power plants	41	24,786	11	5,085
System integration	26	28,184		
Other	51	28,811	11	4,811
Total	**484**	**410,346**	**116**	**78,624**

1) Including 10 individual projects under the 250 MW wind programme

Sources: BMU [81], [106]

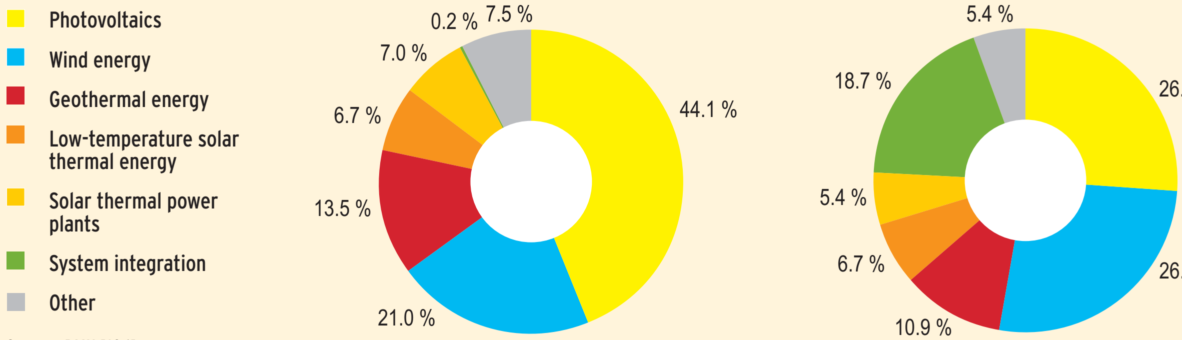
Expenditure from BMU research funding

	Expenditure (1,000 EUR)					
	2005	2006	2007	2008	Average 2005 - 2008	Average share in %
Photovoltaics	41,961	37,609	32,108	39,939	37,904	44.1
Wind energy	16,885	9,765	15,741	29,908	18,075	21.0
Geothermal energy	10,667	13,985	14,443	7,415	11,628	13.5
Low-temp. solar thermal energy	4,920	6,612	5,676	5,736	5,736	6.7
Solar thermal power plants	5,154	5,906	5,935	7,078	6,018	7.0
System integration	-	-	-	822	206	0.2
Other	6,229	6,490	6,437	6,460	6,404	7.5
Total	**85,816**	**80,367**	**80,340**	**97,358**	**85,970**	**100.0**

Source: BMU [106]

Average share of expenditure (2005-2008) total: Approx. 86 mill. EUR

Sector shares of newly approved funding volume, 2007 total: Approx. 151 mill. EUR



Sourec: BMU [106]

LONG-TERM, SUSTAINABLE UTILISATION POTENTIAL OF RENEWABLE ENERGY SOURCES FOR ELECTRICITY, HEAT AND FUEL PRODUCTION IN GERMANY

	Utilisation	Potential		Comments
	2008	Yield	Capacity	
Electricity generation	[TWh]	[TWh/a]	[MW]	
Hydropower [1]	21.3	25	5,200	Run-of-river plants and natural inflow to reservoirs
Wind energy				
onshore	40.4	100	45,000	
offshore	-	135	35,000	
Biomass [2]	27.1	50	10,000	Generation partly in combined heat/power generation
Photovoltaics	4.0	105	115,000 [3]	Only suitable roof, facade and human settlement areas
Geothermal energy	0.02	150	25,000	Bandwidth 66–290 TWh depending on heat utilisation requirements (combined heat/power)
Total	**92.8**	**565**		
Share in relation to gross electricity consumption, 2008	**15.1 %**	**91.9 %**		
Heat generation	[TWh]	[TWh/a]		
Biomass	97.1	150		Incl. useful heat from combined heat/power generation
Geothermal energy	2.5	330		Only energy supply from hydrothermal sources
Solar thermal energy	4.1	300		Only suitable roof and human settlement areas
Total	**103.8**	**780**		
Share in relation to final energy consumption for heat, 2008 [4]	**7.4 %**	**55.6 %**		
Fuels	[TWh]	[TWh/a]		
Biomass	36.7	155		
Total	**36.7**	**155**		
Share in relation to fuel consumption, 2008	**5.9 %**	**25.0 %**		
Share in relation to final energy consumption, 2008	**9.5 %**	**61.2 %**		The percentile share of renewables rises to around 60 % if final energy consumption is reduced versus 2008 levels (improvement in energy efficiency)

Energy imports of renewable energy sources are not included in these figures.

1) Excluding ocean energy
2) Including biogenic waste
3) Capacity figure relates to the modular capacity (MW_p); the corresponding AC capacity is 106,000 MW
4) Room heat, hot water and other process heat

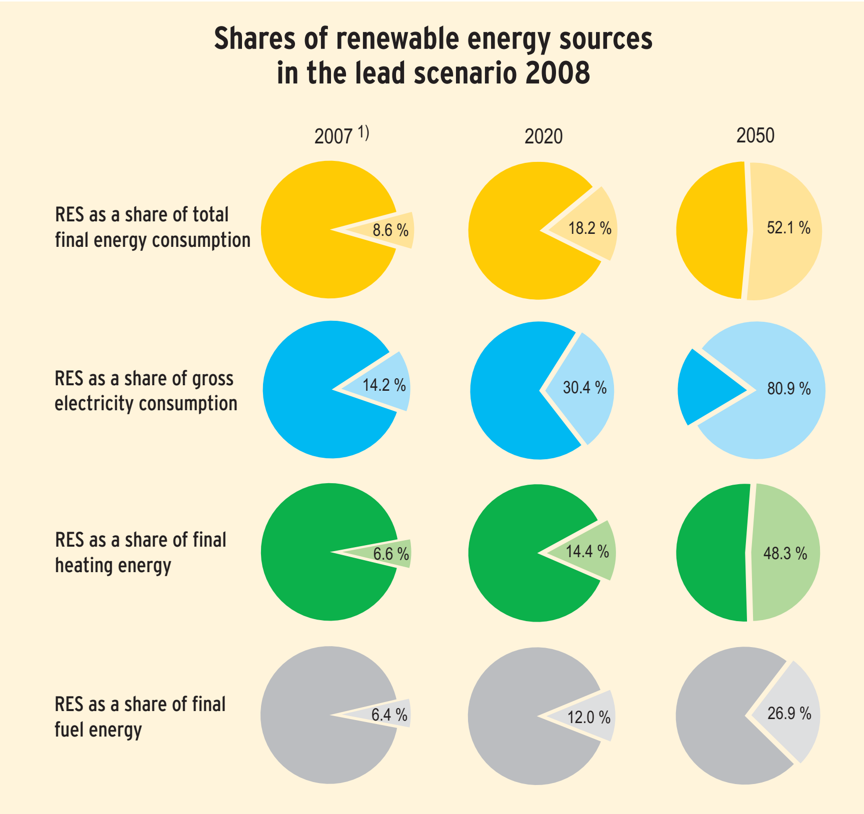
Sources: BMU [27]; Arbeitsgemeinschaft: WI, DLR, IFEU [38]; ZSW [3]

As there are varying assumptions regarding the availability of suitable locations, the technical characteristics of the utilising technologies, plus various other factors, the results of potential estimates may differ considerably.

The guideline values given here make particular allowance for the requirements of nature and landscape conservation, and hence represent the lower limit of the technically feasible potential.

The energetic use of biomass indicates a high level of flexibility. Depending on requirements, therefore, the percentages allocated to the areas of electricity, heat and fuel supply may vary. This is particularly applicable to the cultivation of energy crops (based here on a cultivation area of 4.5 million hectares).

SCENARIO FOR AN INTENSIFIED EXPANSION OF RENEWABLE ENERGIES IN GERMANY

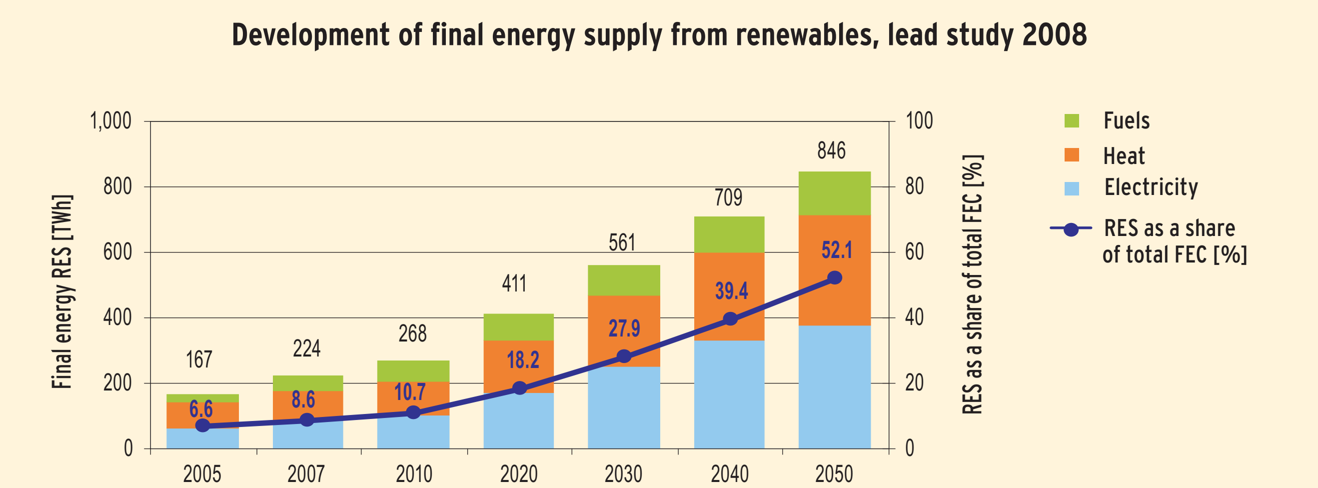


The “Leitstudie 2008” (Lead Study 2008) [27][1)] published by the BMU includes a lead scenario and five other scenarios illustrating the probable range of future development of renewable energy sources and the corresponding energy supply up until 2050.

Thanks to the continuous expansion of renewable energies coupled with significant improvements in efficiency under the lead study 2008, the proportion of total final energy consumption attributable to renewables could rise to around 18 % by 2020, with the cogeneration share rising to just under 21 %. Around 30 % of gross electricity consumption could be of renewable origin. By 2050, renewables could account for around half of total final energy consumption, i.e. including electricity, heat and mobility.

1) The lead scenario 2008 was based on the data status for June 2008

Source: BMU [27]



Source: BMU [27]

Thanks to the expansion of renewables under the new lead scenario, an annual investment volume of around 12 billion Euros$_{2005}$ will be continuously maintained. This will strengthen our chances of maintaining technological leadership in many renewable energy technologies, and continuing to effectively develop our export markets. After 2020, annual investments will rise to more than 15 billion Euros$_{2005}$ per annum.

The various scenarios showed that further efficiency achievements with regard to the expansion of renewables above and beyond the lead scenario 2008 are also possible.

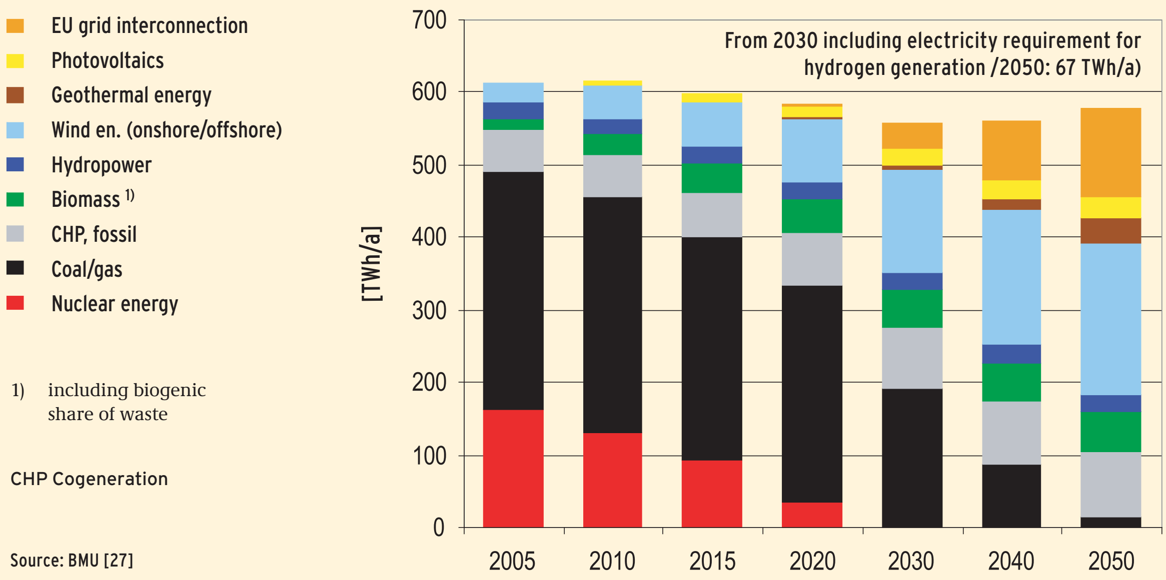
Expansion of renewable energy sources and increase in energy efficiency – potential contributions to CO_2 reduction by the year 2020 according to action areas, lead study 2008

The structural changes in the energy supply structure under the lead scenario 2008 lead to a 36 % reduction in CO_2 emissions by 2020 compared with 1990, and a reduction of almost 80 % by 2050.

Action area / package of measures	Contribution to CO_2 reduction in 2020
Expansion of RES in the electricity sector	70 - 80 mill. t CO_2/a
Efficiency gains in heat supply and use, particulary in the buildings sector	70 - 80 mill. t CO_2/a
Expansion of CHP in conjunction with efficientcy gains in electricity consumption	60 mill. t CO_2/a
Expansion of RES in the heating sector	20 - 25 mill. t CO_2/a
Efficiency gains in transport	20 - 25 mill. t CO_2/a
RES in the transport sector (biofuels and electromobility)	20 - 25 mill. t CO_2/a

Source: BMU [27]

Gross electricity generation, lead study 2008



1) including biogenic share of waste

CHP Cogeneration

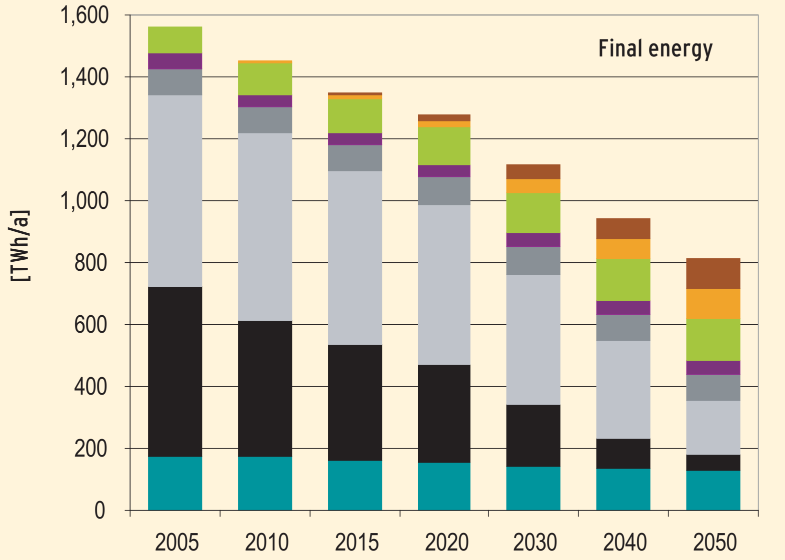
Source: BMU [27]

Under the 2008 lead scenario, the contribution of renewable energies to electricity supply will rise to just under 180 TWh/a by 2020, corresponding to 30 % of gross electricity consumption. By 2030, 50 % of gross electricity consumption will be met from renewables.

By 2020, renewable energy plants with a total capacity of 70 GW will be installed, twice the level of 2007.

This figure will rise to around 100 GWh by 2030. The new renewable energy plants installed since 2000 will produce more electricity each year than is lost due to the phasing-out of nuclear power.

Energy used for heating, lead study 2008



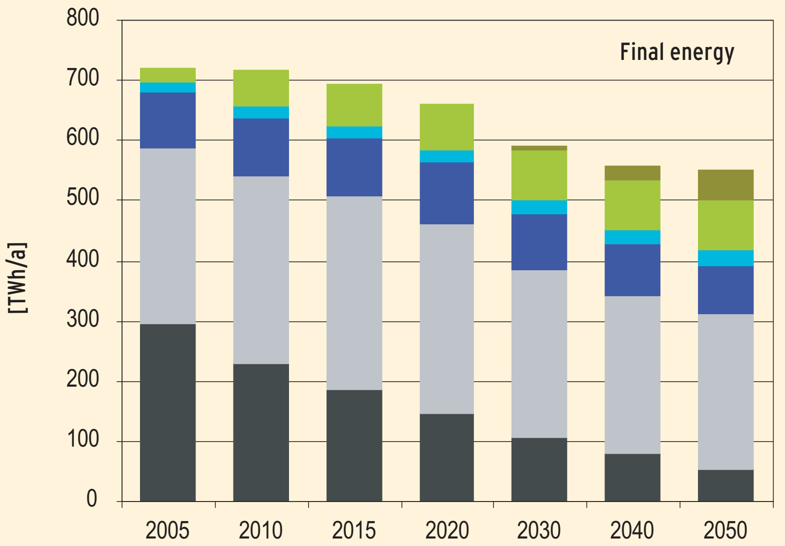
According to the physical energy content method

CHP cogeneration
HP heat pumps

Source: BMU [27]

Under the lead scenario, the demand for heat will fall by 18 % of its current level by 2020, and 50 % by 2050. The contribution of renewables to heat supply will rise to 14 % by 2020. By 2050, half of the remaining demand for heating energy can be met from renewable energies. By 2050, only 25 percent of the current level of fossil energy sources will be needed.

Fuel supply, lead study 2008



According to the physical energy content method

Source: BMU [27]

By the year 2020, biogenic fuels will account for 12 % total fuel consumption in energy terms of (and around 15 % of consumption by road traffic). The attainable long-term share of fuel consumption from sustainable biofuels is 17 % (20 %).

PART II: RENEWABLE ENERGY SOURCES IN THE EUROPEAN UNION

The Directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources, which entered into force in June 2009, formulates ambitious targets: 20 % of final energy consumption from renewable energy sources, and at least 10 % of renewable energies in the transport sector by 2020

To date, there have been two instruments at EU level to promote renewables: The EU Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market, and the Biofuels Directive. A key element of the former, which entered into force in 2001, was to increase the share of electricity produced from renewable energy sources from 14 % in 1997 to 21 % by 2010 in the EU-25. The Biofuels Directive sets a target of 5.75 % of fuel consumption from biofuels by 2010. Both of these instruments, which expire in 2011, are being replaced by a new EU Directive on the promotion of the use of energy from renewable sources covering the sectors of electricity, transport and heating/cooling (EU Directive 2009/28/EC).

This new Directive on the promotion of energy from renewable sources is part of the European climate and energy package, in respect of which the European Council achieved a political breakthrough in December 2008 after a year of negotiations. The Directive (2009/28/EC) has been published in the Official Journal of the European Community and entered into force. The new Directive on the promotion of energy from renewable sources will implement the pioneering resolutions adopted at the Spring Summit of heads of state and government (European Council) on 9 March 2007. Under Germany's Presidency, the European Council resolved to increase the proportion of total energy consumption in the EU attributable to renewables from around 8.5 % in 2005 to a binding level of 20 % by 2020. This target is to be met through the adoption of binding national targets for the share of energy consumption from renewables, and implemented within the context of national action plans specifying how the targets are to be distributed among the relevant sectors. For biofuels, the parties resolved a binding minimum target of 10 % of total petrol and diesel consumption for all Member States by the year 2020, together with the introduction of sustainability standards.

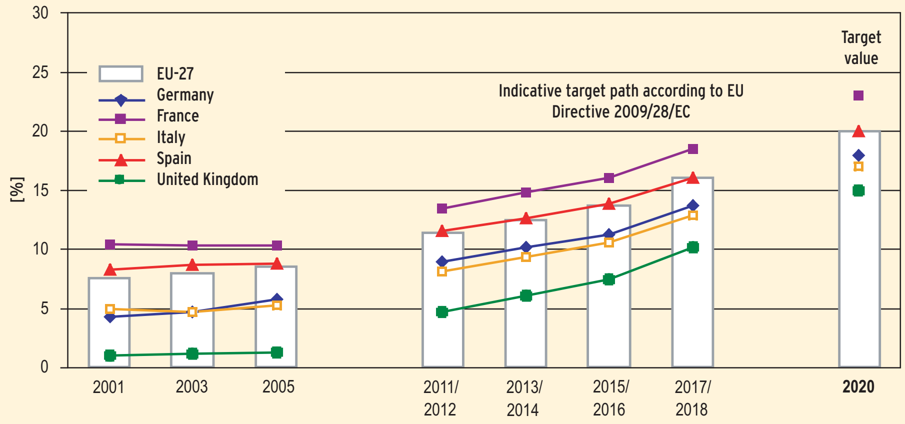
The Directive specifies differentiated overall national targets for the Member States specifying the proportion of final energy consumption attributable to renewables, which will be based on the respective starting figures for 2005 and the respective available national potential. The 2020 national targets for the EU Member States range between 10 % for Malta and 49 % for Sweden. For Germany, a national target of 18 % has been set. In derogation of the European Council's resolutions of 9 March 2007, the Directive does not envisage a separate target for biofuels, but instead prescribes a uniform target of at least 10 % of energy consumption in the transport sector from renewables. This means that in addition to biofuels, for example, electricity from renewable energies that is used to power electric cars can also be included in this figure.

With respect to national target achievement, the Directive is based primarily on national promotion mechanisms. The Member States have the choice of formulating their own promotion system in order to maximize achievement of their potential. Additionally, the Directive introduces flexible cooperation mechanisms, giving Member States the opportunity to cooperate on meeting their targets where necessary. These cooperation mechanisms include the statistical transfer of surplus quantities of renewables, joint projects to promote renewable energy sources, and the (partial) merging of the national promotion systems of two Member States.

The Directive envisages that the Member States should adopt national action plans to achieve their targets, and should report regularly to the Commission on the progress achieved. It also stipulates that priority grid access should be granted to electricity from renewable energy sources, and for the first time defines sustainability requirements on the production of biomass for energy use. The sustainability criteria only apply to biofuels and liquid bioenergy carriers initially, but the Directive also states that by the end of 2009, the European Commission must submit a report outlining proposals adapting these criteria to gaseous and solid bioenergy.

For the first time, this new Directive introduces a comprehensive EU regulation covering all aspects of renewable energy sources: Electricity, heating/cooling and transportation. This creates a reliable legal framework for the required investments, and therefore lays the foundations for the continued successful expansion of renewables over the forthcoming decade.

Share of renewable energies in final energy consumption in selected EU countries

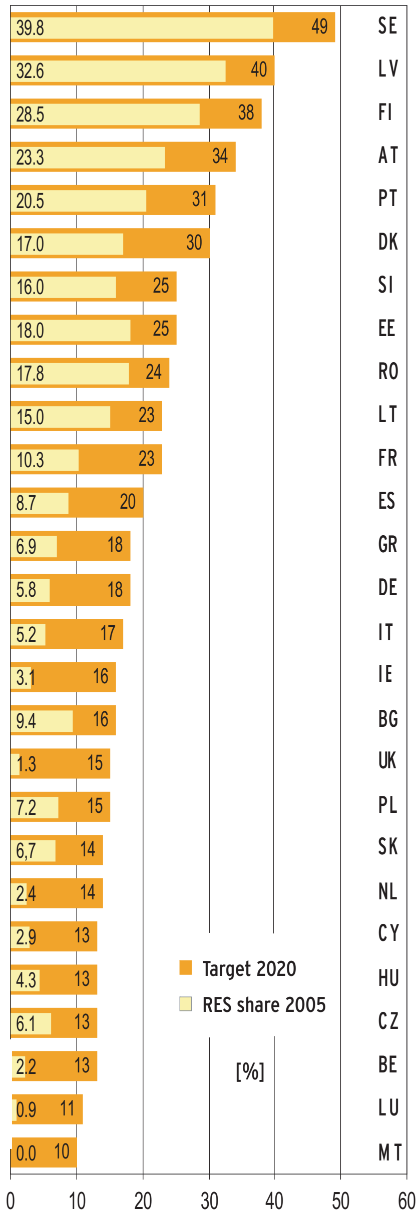


We have selected the 5 EU Member States with the highest final energy consumption

The new EU Directive 2009/28/EC sets out an indicative target path for the share of final energy consumption attributable to renewables. The Member States are required to take suitable measures to ensure that their share of energy from renewable sources meets the national guidelines of the target path as a minimum requirement.

Sources: according to EC [92], Eurostat [91]

	Share of RES in total FEC 2005 [%]	Target value [1] 2020
Belgium	2.2	13 %
Bulgaria	9.4	16 %
Denmark	17.0	30 %
Germany	5.8	18 %
Estonia	18.0	25 %
Finland	28.5	38 %
Frande	10.3	23 %
Greece	6.9	18 %
Ireland	3.1	16 %
Italy	5.2	17 %
Latvia	32.6	40 %
Lithuania	15.0	23 %
Luxembourg	0.9	11 %
Malta	0.0	10 %
Netherlands	2.4	14 %
Austria	23.3	34 %
Poland	7.2	15 %
Portugal	20.5	31 %
Romania	17.8	24 %
Sweden	39.8	49 %
Slovakia	6.7	14 %
Slovenia	16.0	25 %
Spain	8.7	20 %
Czech. Republic	6.1	13 %
Hungary	4.3	13 %
United Kingdom	1.3	15 %
Cyprus	2.9	13 %
EU-27	**8.5**	**20 %**



General remarks

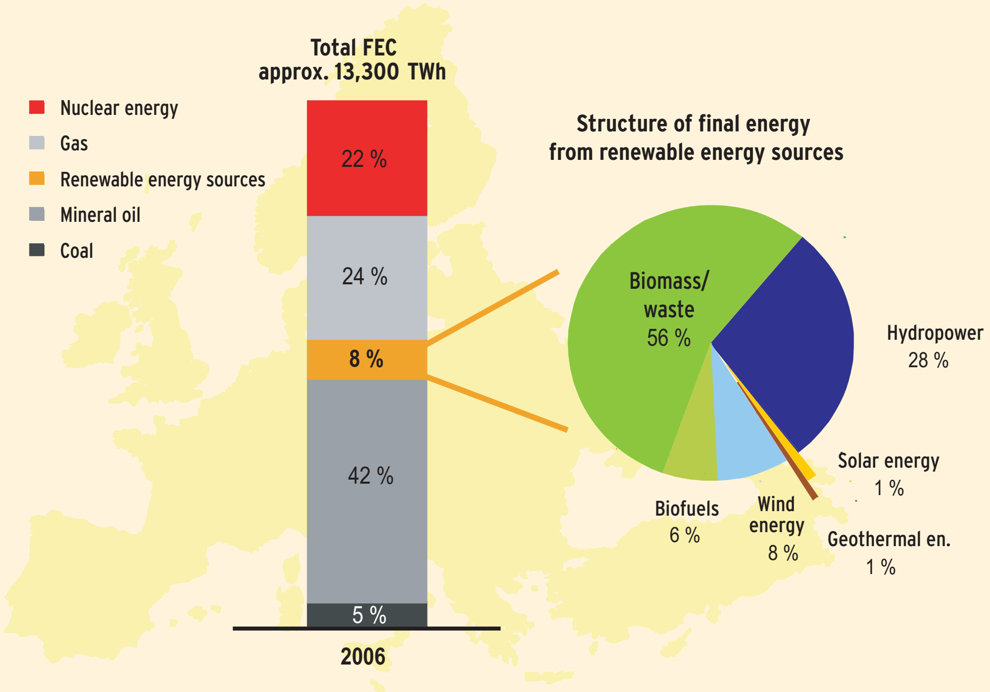
In 2004, the EU-15 was enlarged by 10 new countries to form the EU-25. A further two Member States acceded in 2007, and the EU is now comprised of 27 Member States (EU-27) (cf. also Appendix, para. 9).
The texts and time series contained in this brochure include the new Member States from the year of their accession.

The data on renewable energy supply and use in Germany contained in European and international statistics sometimes deviates from the figures found in German sources. As well as different data origins, this is also partially attributable to different calculation methods (calculated according to the physical energy content method; cf. also Appendix para. 5 and 11).
In the section on "Europe", the data for Germany has been taken from the international statistics for consistency purposes. Generally speaking, however, the detailed information contained in the national sources on the preceding pages is more reliable.

1) RES shares 2005 and overall national targets for the share of final energy consumption from renewables in accordance with EU Directive 2009/28/EC

Sources: EC [92], Eurostat [91]

Structure of final energy consumption in the EU

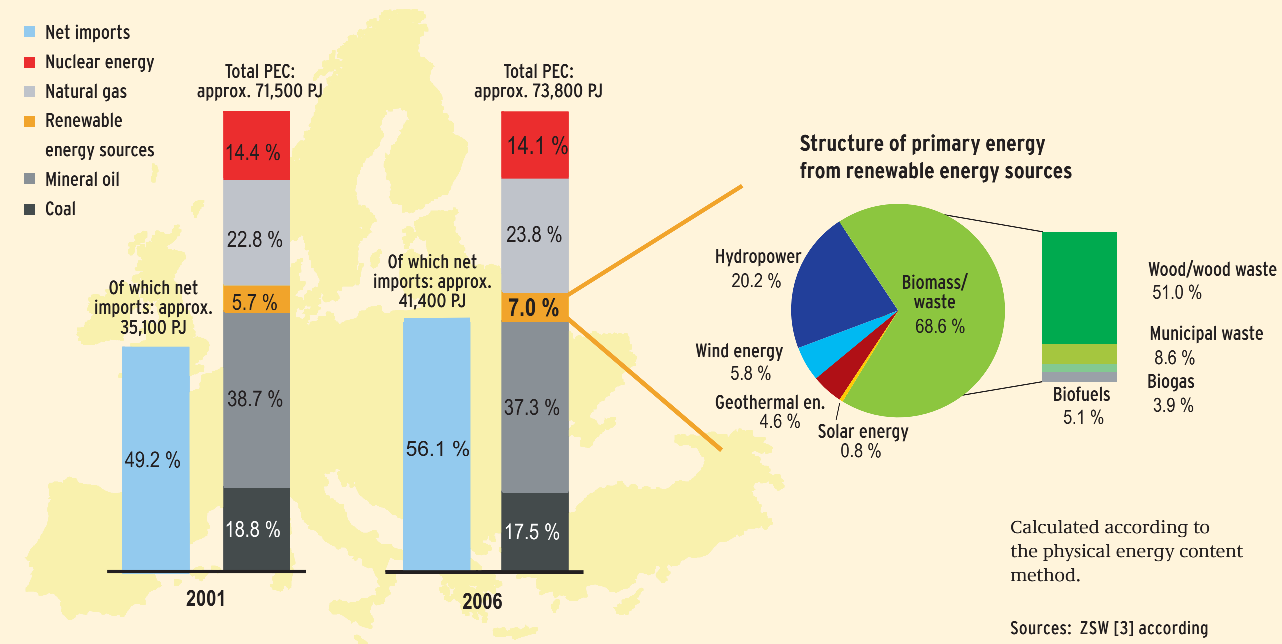


The new EU Directive on the promotion of energy from renewable sources focuses primarily on the share of total final energy consumption attributable to renewables. Until now, statistics concerning final energy consumption have focussed on the shares attributable to the various different sectors. The diagram opposite shows a breakdown into different energy carriers, calculated on the basis of various statistics compiled by Eurostat. As such, the shares given are only intended to indicate the dimensions of the different energy carriers.

Calculated according to the physical energy content method.

Sources: ZSW [3] according to Eurostat [34]

Structure of primary energy consumption in the EU



Calculated according to the physical energy content method.

Sources: ZSW [3] according to Eurostat [32]

USE OF RENEWABLE ENERGY SOURCES IN THE EU

	2007					2008		
	Biomass 1)	Hydropower 2)	Wind-energy	Geoth. energy 3)	Total	Solar thermal energy 4), 5)		Photovoltaics 5)
	Final energy [TWh]					[1,000 m²]	[MW_{th}]	[kW_p]
Belgium	11.8	0.4	0.52	0.01	12.7	280	196	71,191
Denmark	17.7	0.0	7.17	-	24.9	431	302	3,210
Germany	151.1	20.9	39.50	2.14	213.6	11,317	7,922	5,351,000
Finland	62.3	14.2	0.19	-	76.7	25	18	5,679
France	135.0	58.7	4.05	1.51	199.3	1,701	1,191	91,155
Greece	12.9	2.6	1.85	0.16	17.5	3,870	2,709	18,500
Ireland	2.5	0.7	1.88	0.02	5.1	79	55	400
Italy	28.9	32.8	4.03	8.05	73.8	1,616	1,131	317,500
Luxembourg	0.7	0.1	0.06	-	0.9	11	8	24,414
Netherlands	14.1	0.1	3.44	-	17.7	704	493	54,900
Austria	39.1	36.0	2.02	0.07	77.2	3,964	2,775	30,201
Portugal	33.5	10.1	4.04	0.32	48.0	390	273	67,952
Sweden	72.5	66.2	1.43	-	140.1	388	272	7,942
Spain	51.8	27.8	27.05	0.09	106.7	1,463	1,024	3,404,762
U. Kingdom	21.3	5.1	5.27	0.01	31.7	387	271	21,590
EU-15	**655.3**	**275.6**	**102.51**	**12.39**	**1,045.8**	**26,627**	**18,639**	**9,470,396**
Estonia	5.7	-	0.07	-	5.8	2	1	20
Latvia	11.7	2.7	0.05	-	14.5	7	5	6
Lithuania	6.8	0.4	0.07	-	7.3	4	3	55
Malta	-	-	-	-	-	36	26	238
Poland	49.9	2.4	0.47	0.12	52.8	366	256	1,638
Slovakia	5.8	4.5	0.01	0.02	10.3	92	64	66
Slovenia	5.0	3.3	-	-	8.3	135	94	2,145
Czech. Republic	20.1	2.1	0.13	-	22.4	414	290	54,290
Hungary	10.5	0.2	0.11	0.94	11.8	57	40	450
Cyprus	0.2	-	-	-	0.2	665	466	2,089
EU-25	**771.1**	**291.1**	**103.41**	**13.47**	**1,179.1**	**28,405**	**19,883**	**9,531,393**
Bulgaria	7.9	2.9	0.06	0.38	11.2	62	43	1,407
Romania	37.9	16.0	0.01	0.30	54.2	80	56	450
EU-27	**816.9**	**310.0**	**103.48**	**14.16**	**1,259.2 6)**	**28,547**	**19,983**	**9,533,250**

This overview represents the current status of available statistics (see sources). This data may deviate from national statistics, partly as a result of different methodology.

All figures are provisional; deviations in the totals are due to rounding up or down.

1) Generation of electricity and heat from solid biomass, biogas and the biogenic portion of waste as well as biofuels; the transformation sector has been disregarded
2) Gross generation; in the case of pumped-storage power plants, generation from natural inflow only
3) Heat and electricity generation; electricity generation in Italy with 5.6 TWh, Portugal 0.2 TWh and Austria 0.002 TWh (France 0.08 TWh in departements overseas not included). In Germany, geothermal electricity was produced for the first time in 2004
4) Glazed and unglazed collectors; conversion factor 0.7 kW_{th}/m^2
5) Including installations in departements overseas.
6) Total includes 10.9 TWh from solar thermal energy and 3.8 TWh from photovoltaics

Sources:
Biomass: Eurostat [34]
Hydropower: Eurostat [34]
Wind energy: Observ'ER [46]
Geothermal energy: Eurostat [34]
Solar thermal energy: Observ'ER [35]
Photovoltaics: Observ'ER [82]

In a global context, the EU plays an important role with regard to the use of renewable energy sources. Particularly worth mentioning in this regard is the contribution of the so-called "new" renewable technologies (solar, wind and ocean energy). In 2008, the EU photovoltaics sector showed an impressive development. In comparison with the preceding year, newly built capacities increased by around 152 % (2007: 1.8 GW_p; 2008: 4.6 GW_p). This equates to 80 % of global new photovoltaics constructions (estimated 5.8 GW_p). At the end of 2008, photovoltaics capacities in the EU totalled around 9.5 GW_p (2007: approx. 4.9 GW_p) [82]. In the wind sector, the EU is the world leader, with a global share of 54 % as per the end of 2008, boasting around 65 GW (2007: around 56.5 GW) of installed wind energy capacity.

The International Energy Agency estimates the installed global solar collector area for 2007 at 154 GW_{th}, of which the EU accounts for around 11 % with 16.8 GW_{th}. The contribution of ocean energy to energy supply in the EU, and indeed globally, remains minimal, although this sector is believed to offer considerable potential. IEA Ocean Energy Systems estimates the global potential of ocean energy technologies for electricity generation at more than 80,000 TWh/a [99].

EXPANSION OF ELECTRICITY GENERATION FROM RENEWABLE ENERGY SOURCES IN THE INTERNAL EUROPEAN ELECTRICITY MARKET

Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market entered into force in October 2001. The Community is aiming to increase the proportion of renewable sources in electricity generation from 14 % in 1997 to 22 % by 2010 in the EU-15 and 21 % in the EU-25.

The progress report by the European Commission (COM (2009) 192) on "Renewable Energy Sources" dated 28 April 2009 [1)] states that Commission analyses indicate that Europe will fall short of its 21 % target by 2010 in the electricity sector unless considerable further efforts are made in the various Member States. According to this report, Germany and Hungary have already met their targets for 2010. The renewable share of total electricity generation in the EU increased by almost 1.5 percentage points between 2004 and 2006. Overall, apart from Germany, five other EU Member States managed to increase their share by more than 2 percentage points between 2004 and 2006, thus making a significant contribution to the development of the EU's overall targets for electricity generated from renewable energy sources. The growth was primarily attributable to an increase in the use of solid biomass and wind energy.
Despite the progress made, growth rates remain low. In most Member States, all sectors still face significant obstacles to growth.
The 7th EU Framework Research Programme gave clear priority to energy efficiency and renewable energy sources in the section on non-nuclear research funding.
In its green paper "A European strategy for sustainable, competitive and secure energy", published in March 2005, the EU Commission highlights the contribution made by wind energy, solar energy, biomass, hydropower and geothermal energy, as domestic energy sources, towards ensuring a secure electricity supply, especially in the light of a growing EU-wide dependency on imports. The green paper underscores the importance of renewable energies for the economy and Europe's technological leadership in this sector, with reference to around 300,000 jobs in the EU linked to renewables. The road map presented on 10 January 2007 outlined the Commission's plans for the future expansion of renewables in Europe. The new Directive adopted within the context of the European climate and energy package represents an important milestone en route to this objective (cf. also page 48).

1) Article 3, paragraph 4 of Directive 2001/77/EC requires the Commission to publish a report every two years evaluating the progress made by Member States towards meeting their national guideline targets in the renewable energies sector.

Supply of electricity from renewable energy sources in the EU

	RES electricity [%]						Target value 2010
	1997	2000	2002	2004	2006	2007	
			[%]				[%]
Belgium	1.0	1.5	1.8	2.1	3.9	4.2	6.0
Denmark	8.9	16.7	19.9	27.1	26.0	29.0	29.0
Germany	4.3	6.5	8.1	9.5	12.0	15.1	12.5
Finland	25.3	28.5	23.7	28.3	24.0	26.0	31.5
France	15.2	15.1	13.7	12.9	12.5	13.3	21.0
Greece	8.6	7.7	6.2	9.5	12.1	6.8	20.1
Ireland	3.8	4.9	5.4	5.1	8.5	9.3	13.2
Italy	16.0	16.0	14.3	15.9	14.5	13.7	25.0
Luxembourg	2.0	2.9	2.8	3.2	3.4	3.7	5.7
Netherlands	3.5	3.9	3.6	5.7	7.9	7.6	9.0
Austria	67.5	72.4	66.1	58.7	56.6	59.8	78.1
Portugal	38.3	29.4	20.8	24.4	29.4	30.1	39.0
Sweden	49.1	55.4	46.9	46.1	48.2	52.1	60.0
Spain	19.7	15.7	13.8	18.5	17.7	20.0	29.4
U. Kingdom	1.9	2.7	2.9	3.7	4.6	5.1	10.0
EU-15	**13.8**	**14.6**	**13.5**	**14.7**	**15.3**	**16.6**	**22.0**
Estonia	0.1	0.3	0.5	0.7	1.4	1.5	5.1
Latvia	46.7	47.7	39.3	47.1	37.7	36.4	49.3
Lithuania	2.6	3.4	3.2	3.5	3.6	4.6	7.0
Malta	0.0	0.0	0.0	0.0	0.0	0.0	5.0
Poland	1.7	2.0	2.1	2.9	3.5	3.5	7.5
Slovakia	14.5	16.9	19.2	14.4	16.6	16.6	31.0
Slovenia	26.9	31.7	25.4	29.1	24.4	22.1	33.6
Czech. Republic	3.5	3.6	4.6	4.0	4.9	4.7	8.0
Hungary	0.8	0.7	0.7	2.3	3.7	4.6	3.6
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0	6.0
EU-25	**12.8**	**13.7**	**12.7**	**13.7**	**14.3**	**15.5**	**21.0**
Bulgaria	7.0	7.4	6.0	8.9	11.2	7.5	11.0
Romania	30.5	28.8	30.8	29.9	31.4	26.9	33.0
EU-27	**13.1**	**13.8**	**12.9**	**13.9**	**14.6**	**15.6**	**21.0**

This overview represents the current status of available statistics (see sources). This data may deviate from national statistics, partly as a result of different methodologies.

Sources: Eurostat [34]

SUPPLY OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES IN THE EU

	1990	1997	2000	2001	2002	2003	2004	2005	2006	2007 [1]
	[TWh]									
Biomass [2]	17.0	28.0	39.6	41.0	47.2	56.2	68.8	79.9	89.8	101.8
Hydropower [3]	260.3	297.8	321.5	339.7	280.8	277.4	303.6	282.4	286.4	310.0
Windenergy	0.8	7.3	22.2	27.0	35.6	44.2	58.8	70.5	81.9	103.5
Geothermal en.	3.2	4.0	4.8	4.6	4.8	5.4	5.5	5.4	5.6	5.8
Photovoltaics	0.0	0.0	0.1	0.2	0.3	0.5	0.7	1.5	2.5	3.8
Total	**281.4**	**337.1**	**388.2**	**412.5**	**368.7**	**383.7**	**437.5**	**439.6**	**466.3**	**524.8**
RES share of gross elec. consump. [%]	**12.9**	**13.8**	**14.7**	**15.2**	**13.5**	**13.7**	**13.7**	**13.6**	**14.3**	**15.6**

New EU Member States are included from the year of their accession, i.e. EU-25 from 2004 and EU-27 from 2007.

1) Provisional figures
2) Including municipal waste and biogas
3) In the case of pumped-storage power plants, generation from natural inflow only

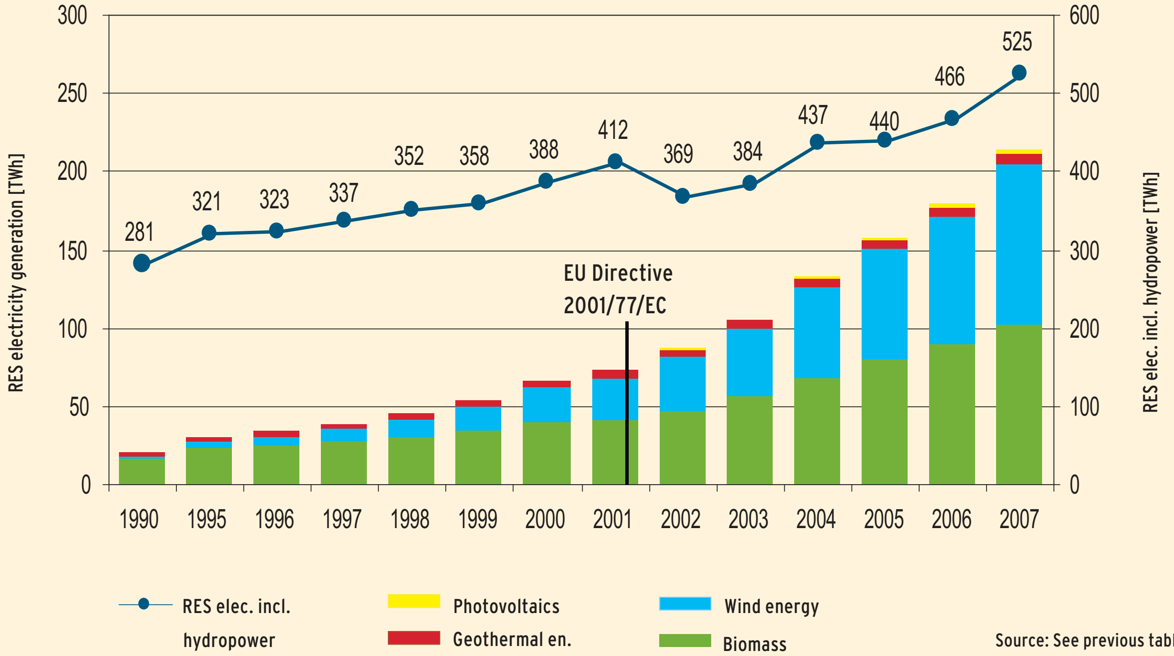
This overview represents the current status of available statistics (see sources). This data may deviate from national statistics, partly as a result of different methodologies.

Sources: Eurostat [34]; Observ'ER [46]; ZSW [3]

Since the entry into force of the EU electricity directive (cf. also page 52), the generation of electricity from renewable energy sources in the EU has increased by an average of 4.1 % p.a. to around 525 TWh in 2007. Based on the available data, the contribution of renewables to total electricity supply may be estimated at 15.6 % for the year 2007. Considering the development in renewable electricity supply excluding hydropower, the absolute contribution of renewables over this period has almost tripled, or increased by an average of just under 20 % per annum. In 2007, electricity generation from renewables increased by around 60 TWh. Assuming an average electricity consumption for a specimen household of 3,500 kWh/a, this is equivalent to an additional renewable electricity supply of more than 16 million households in the European Union.

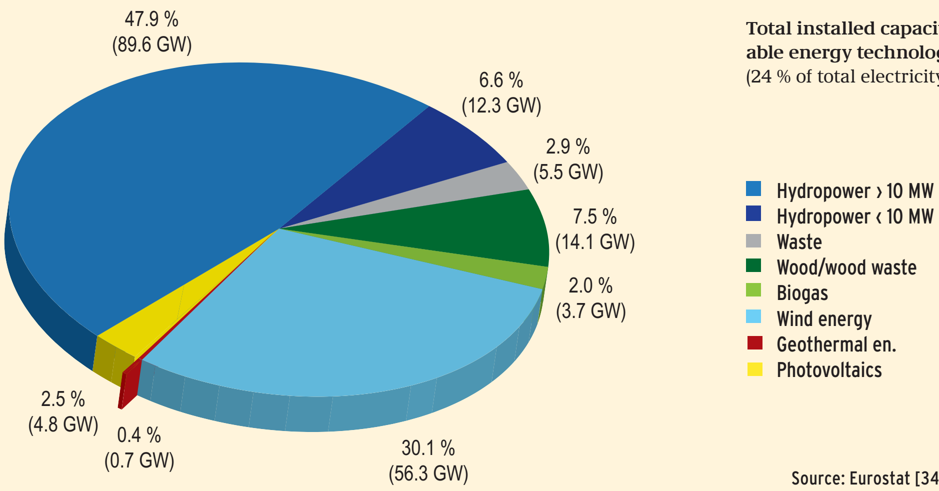
The increase to date is primarily attributable to developments in two renewable energy sectors: Wind energy with an average growth of around 25 % p.a. in the period under review, and the use of biomass for the production of electricity with around 16 % p.a. The photovoltaic sector has also shown encouraging development, albeit from a low starting level, with an average growth of 64 %.

Supply of electricity from renewable energy sources in the EU



Source: See previous table

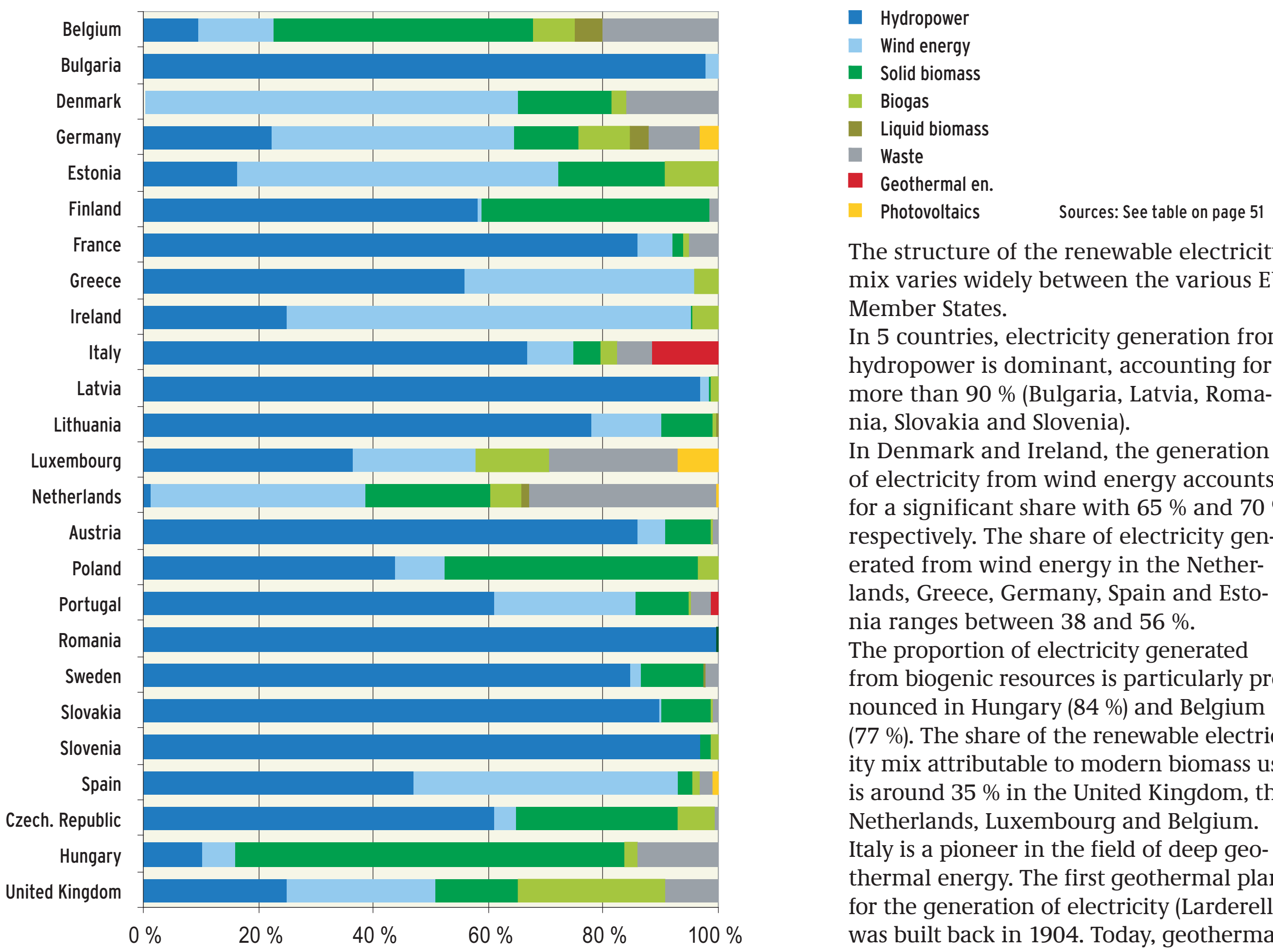
Installed capacity for the supply of electricity from renewable energy sources in the EU, 2007



Total installed capacity on the basis of renewable energy technologies: approx. 190 GWh
(24 % of total electricity generation capacity)

Source: Eurostat [34]

Structure of electricity supply from renewable energies in EU countries, 2007



Sources: See table on page 51

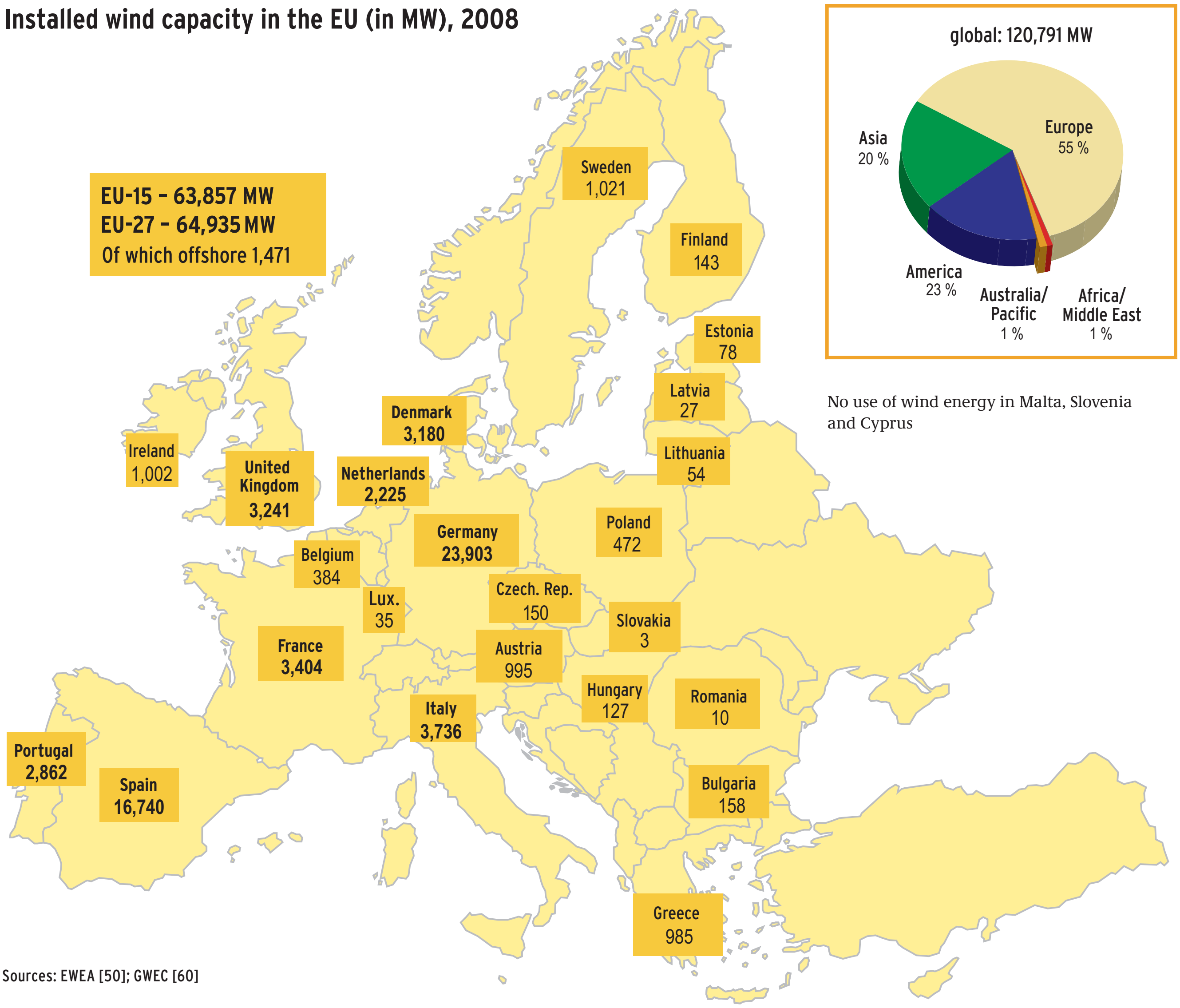
The diagram represents the current status of available statistics (see sources). This data may vary from the national statistics, partly due to different methodologies.

For Malta, the sources used did not contain any data on the supply of electricity from renewables. Renewable electricity generation in Cyprus remains negligible at present.

The structure of the renewable electricity mix varies widely between the various EU Member States.
In 5 countries, electricity generation from hydropower is dominant, accounting for more than 90 % (Bulgaria, Latvia, Romania, Slovakia and Slovenia).
In Denmark and Ireland, the generation of electricity from wind energy accounts for a significant share with 65 % and 70 % respectively. The share of electricity generated from wind energy in the Netherlands, Greece, Germany, Spain and Estonia ranges between 38 and 56 %.
The proportion of electricity generated from biogenic resources is particularly pronounced in Hungary (84 %) and Belgium (77 %). The share of the renewable electricity mix attributable to modern biomass use is around 35 % in the United Kingdom, the Netherlands, Luxembourg and Belgium.
Italy is a pioneer in the field of deep geothermal energy. The first geothermal plant for the generation of electricity (Larderello) was built back in 1904. Today, geothermal energy already accounts for a significant proportion of the country's renewable electricity supply, at 11 %. Meanwhile, photovoltaic energy is relevant in Luxembourg, where it accounts for a 7 % share.

USE OF WIND ENERGY IN THE EU

Installed wind capacity in the EU (in MW), 2008



No use of wind energy in Malta, Slovenia and Cyprus

Sources: EWEA [50]; GWEC [60]

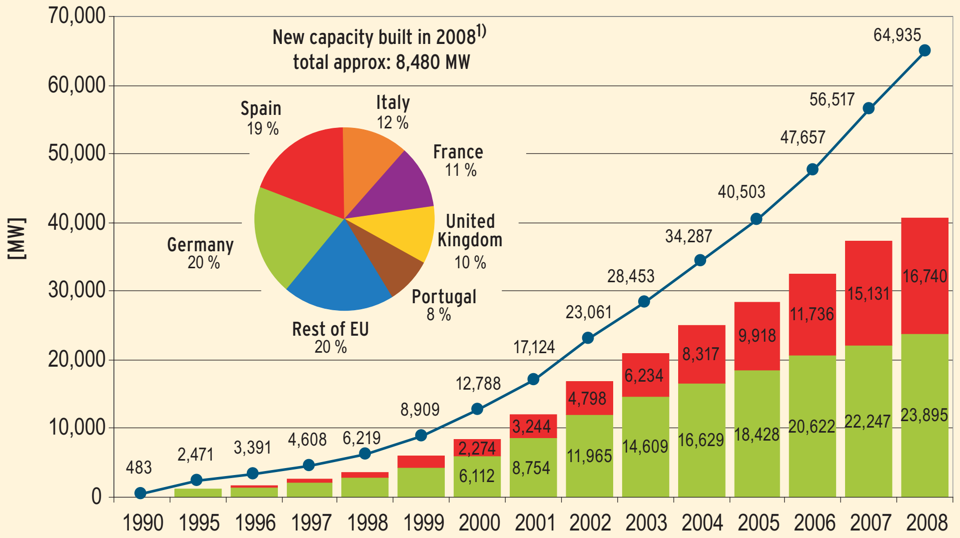
The constant expansion of wind energy use in the EU continued during 2008. According to the European Wind Energy Association (EWEA), for the first time, wind energy outstripped the installation of other electricity generation capacity, with the construction of an additional 8.5 GW in 2008. As per the end of 2008, a total wind energy capacity of around 65 GW was installed in the EU, corresponding to 54 % of the global wind energy capacity at just under 121 GW in total.
In the past, the growing use of wind energy in the EU was primarily attributable to the expansion of the wind energy market in Germany and Spain. As per the end of 2008, almost two-thirds of the total EU wind energy capacity, and around 34 % of global capacity, was attributable to these two countries. At the end of 2008, Germany ranked second in the world's Top 10 with 23,903 MW, after the USA (25,170) and ahead of Spain (16,754 MW), China (12,210 MW) and India (9,645 MW).

At the end of 2008, there were just under 1.5 GW of offshore wind energy capacity installed in total in the EU. According to recent EWEA statistics, there is a further 2.6 GW already under construction in EU coastal waters. If all offshore wind farms planned by the year 2015 (around 32 GW) are implemented, there could be a total of 36 GW of offshore wind power already installed by the end of 2015 [96].

As part of the German Government's offshore strategy, in 2008 construction began on Germany's first offshore wind farm "alpha ventus" to the north of the island of Borkum in the North Sea. With a capacity of 60 MW, the wind farm will be made available to the German wind industry as a test and demonstration field. The research projects are being coordinated by the research initiative RAVE (Research at alpha ventus). By the end of 2008, the BMU had already approved 20 projects with a volume of around EUR 34 million for research in the test field [106].

Development of wind energy capacity in the EU Member States

EU
Spain
Germany



1) The total wind capacity in 2008 does not precisely correspond to the sum total of installed capacity as per the end of 2007 plus new installation in 2008; this is due to repowering and decommissioning of existing wind farms.

The time series includes the new EU Member States from their year of accession (2004: EU-25; 2007: EU-27).

Sources: EWEA [50]; Eurostat [34]; Germany see page 17

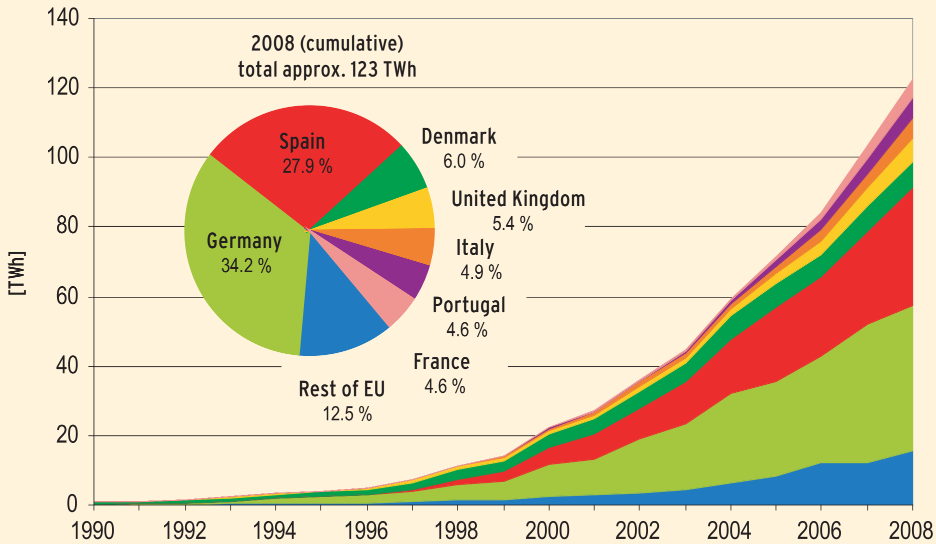
With a generated electricity volume of 123 TWh and an estimated share of 4 % of total EU electricity generation in 2008, wind energy is the most important renewable resource in the EU's electricity generation portfolio after hydropower.

In 2008, expansion continued at the previous year's high level, with a wind capacity of 8,484 MW. Around 40 % of this additional wind energy capacity was built in Germany (new construction: 1,665 MW) and Spain (new construction: 1,609 MW). Compared with previous years, however, the wind market was more balanced in 2008, since Italy (1,010 MW), France (950 MW) and the United Kingdom (836 MW) also significantly expanded their use of wind energy. The new EU Member States (EU-12) increased their market share in 2008 to around 5 % (2007: 1.2 %).

In 2007, the wind energy sector accounted for a total of 154,000 jobs in the EU. By 2020, the EWEA expects this figure to double to just under 330,000. Growth potential is found primarily in the offshore sector, which could provide almost half of jobs by 2020 [104].

Development of electricity generation from wind energy in the EU

France
Portugal
Italy
United Kingdom
Denmark
Spain
Germany
Rest of EU



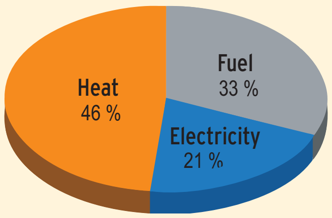
Figures for 2008 are provisional

The time series includes the new EU Member States from their year of accession (2004: EU-25; 2007: EU-27).

Sources: Eurostat [34]; Observ'ER [46]

HEAT SUPPLY FROM RENEWABLE ENERGY SOURCES IN THE EU

Structure of total final energy supply 2007



Around half of the total energy supplied to the EU-27 in 2007 was attributable to the heating sector. However, the contribution made by renewable energy sources in this segment was just 10 %. Hence, the significance of renewable energies in the heating market is considerably lower than in the electricity market (cf. preceding pages).
By far the most important renewable resource in the heating sector is biomass, accounting for a share of around 97 %, or 623 TWh, the largest share being attributable to heat generation from wood in private households. The contribution of the other two sectors, solar thermal energy and geothermal energy, remains comparatively insignificant, at around 2 % and 1 % respectively.

	2000	2001	2002	2003	2004	2005	2006	2007
	Final energy [TWh]							
Biomass, of which	548.5	540.1	545.7	579.0	592.2	597.8	616.7	622.7
Wood/wood waste	537.1	525.2	527.8	567.1	579.3	585.2	603.2	608.2
Biogas	4.8	7.1	9.2	4.0	4.1	4.2	4.6	4.5
Municipal waste	6.6	7.8	8.8	8.0	8.9	8.4	8.9	10.0
Solar thermal en.	4.8	5.5	6.0	6.4	7.1	7.9	9.0	10.9
Geothermal en.	5.3	6.5	6.9	6.9	6.8	7.3	7.9	8.4
RES heat, total	**558.5**	**552.1**	**558.6**	**592.4**	**606.2**	**613.0**	**633.5**	**642.0**

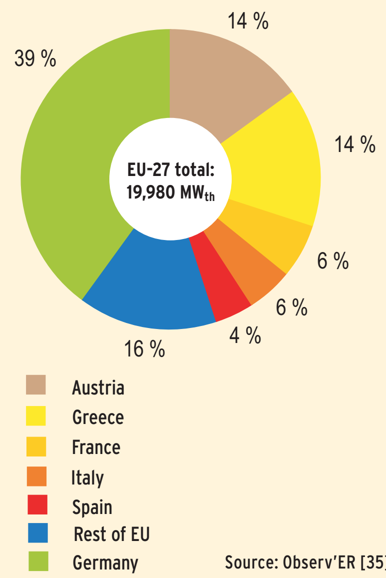
Contrary to the approach used in the international part of this brochure (cf. also the remarks on page 49), this table lists figures for the EU-27 throughout.

Source: According to Eurostat [34]

Development in the solar thermal market

With a growth of 51.4 % the EU solar thermal market developed extremely favourably in 2008. The newly built solar thermal collector capacity totalled 3,238.5 MW_{th} (2007: 2,138 MW_{th}). This equates an additional collector surface of around 4.6 mill. m². The total cumulative capacity in the EU was just under 20 GW_{th} as per the end of 2008. However, the levels of market penetration of solar thermal applications in different countries diverge strongly. Like in the preceding years, Cyprus is keeping the leading position with a capacity of around 590 kW_{th} per 1,000 inhabitants. The EU average was just 40 kW_{th} per 1,000 inhabitants [35].
To date, water heating has been the principal application area of solar thermal energy. In recent years, however, a growing number of combination plants have also been built which help meet the demand for heating energy as well as providing hot water. For example, in 2008, combination plants accounted for almost 50 % of new plants built in Germany in numerical terms, and around two-thirds in capacity terms As per the end of 2007, a total of 130 large plants (≥ 500 m²; 350 kW_{th}) were operational with a total capacity of 137 MW_{th}, which was used partly for solar local and district heating [58].
The world's largest solar district heating plant is located in Marstal (Denmark). With a collector area of 18,365 m² and a thermal capacity of 12.9 MW_{th} the plant covers one-third of Marstal's heating requirements. The largest solar local heating plant in Germany is currently under construction in Crailshaim, with a capacity of 7 MW_{th} and a collector area of 10,000 m² [93, 97].
Worldwide, there was a total of 146.8 GW_{th} of solar collector capacity installed at the end of 2007 (for 2008, SHC [58] estimates a capacity of 165 GW_{th}). This installed capacity produced around 89 TWh_{th} (320 PJ), which in turn avoided emissions of around 39 million tonnes of the greenhouse gas carbon dioxide. Globally, it is estimated that 200,000 people were employed in the solar thermal sector in 2007.

Total installed solar collector capacity in the EU as per the end of 2008



Source: Observ'ER [35]

FUELS FROM RENEWABLE ENERGY SOURCES IN THE EU

Alongside the electricity and heating sectors, the transport sector likewise plays an important role in increasing the substitution of fossil fuels with renewable energy sources. One-third of the total EU final energy consumption is attributable to the transport sector.

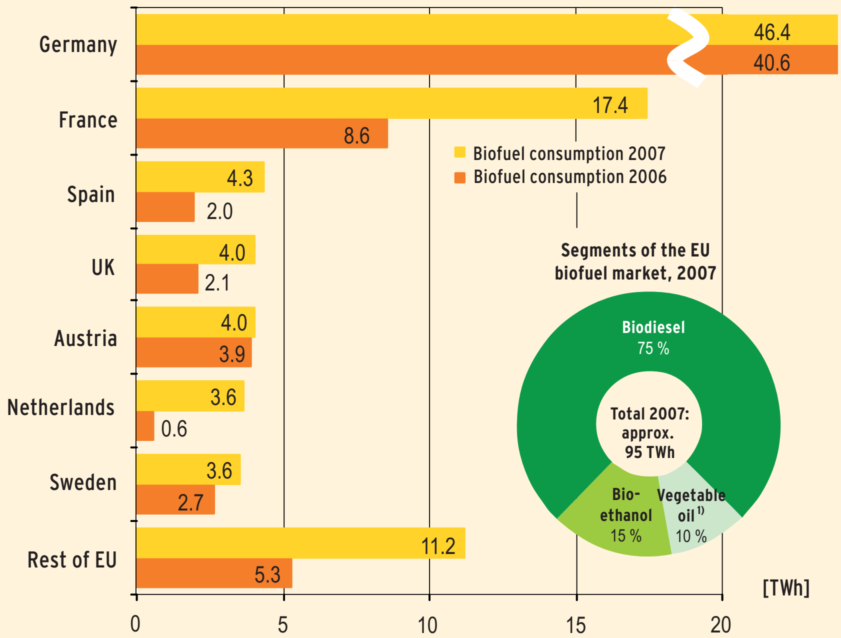
Germany plays a leading role in the EU biofuel market, accounting for just under 50 % of Europe's total biofuel consumption. In total, Euroserv'ER estimates the consumption of biofuels in the EU at around 95 TWh in 2007. This corresponds to one-fifth of the global biofuel supply, estimated at 450 TWh. For 2007, it is estimated that biofuels accounted for around 2.4 % [1] of the world's total fuel consumption by road traffic [according to 107].

Biodiesel is the most important biofuel in the EU, accounting for 75 % of total biofuel consumption. In the EU, biodiesel is produced primarily from rapeseed oil, and may be added to fossil diesel. In 2007, some 71 TWh of biodiesel were consumed across the EU as a whole. This represented an increase of around 49 % (+ 23.3 TWh) in the use of biodiesel by road traffic in the EU compared with 2006. In global terms, biodiesel only accounts for one-quarter of total biofuel supply, with the most important biofuel being ethanol or ETBE produced from this.

In the EU, ethanol is produced primarily via the fermentation of sugar beet and/or wheat. It may be either be added directly to petrol or processed into ETBE (ethyl tertiary butyl ether). In 2007, bioethanol consumption increased by around 40 % (consumption in 2006: 10.2 TWh). In total, some 14.3 TWh (2006: 10.2 TWh) of this biogenic fuel was used in 2007.

Alongside biodiesel and ethanol, vegetable oil likewise makes a significant contribution to the portfolio of biofuels in the EU. 8.8 TWh out of a total of 9.2 TWh of vegetable oil was consumed in Germany alone in 2007. Outside of Germany, vegetable oil fuel is only relevant in Ireland and the Netherlands.

Consumption of biofuels by road traffic in the EU, 2006 and 2007



Figures for 2007 are estimates.
1) Vegetable oil as a biofuel only in Germany, Ireland and the Netherlands, including biogas (Sweden only).

The diagram represents the current status of available statistics (see source). This data may vary from the national statistics, partly due to different methodologies.

Source: Observ'ER [53]

The relevance of the transport sector vis-à-vis the expansion of renewables is obvious, and not only with regard to reducing our dependency on energy imports. Biofuels also make a significant contribution to reducing greenhouse gas emissions from road traffic.

The Biofuels Directive 2003/30/EC formulated the first indicative targets for biofuels at EU level: A share of 2 % in the year 2005 and 5.75 % by 2010. Implementation of these legally non-binding targets occurred with varying degrees of intensity at national level. For the year 2007, Eurobserv'ER estimates that biofuels account for 2.7 % [1] of total consumption by road traffic in the EU.

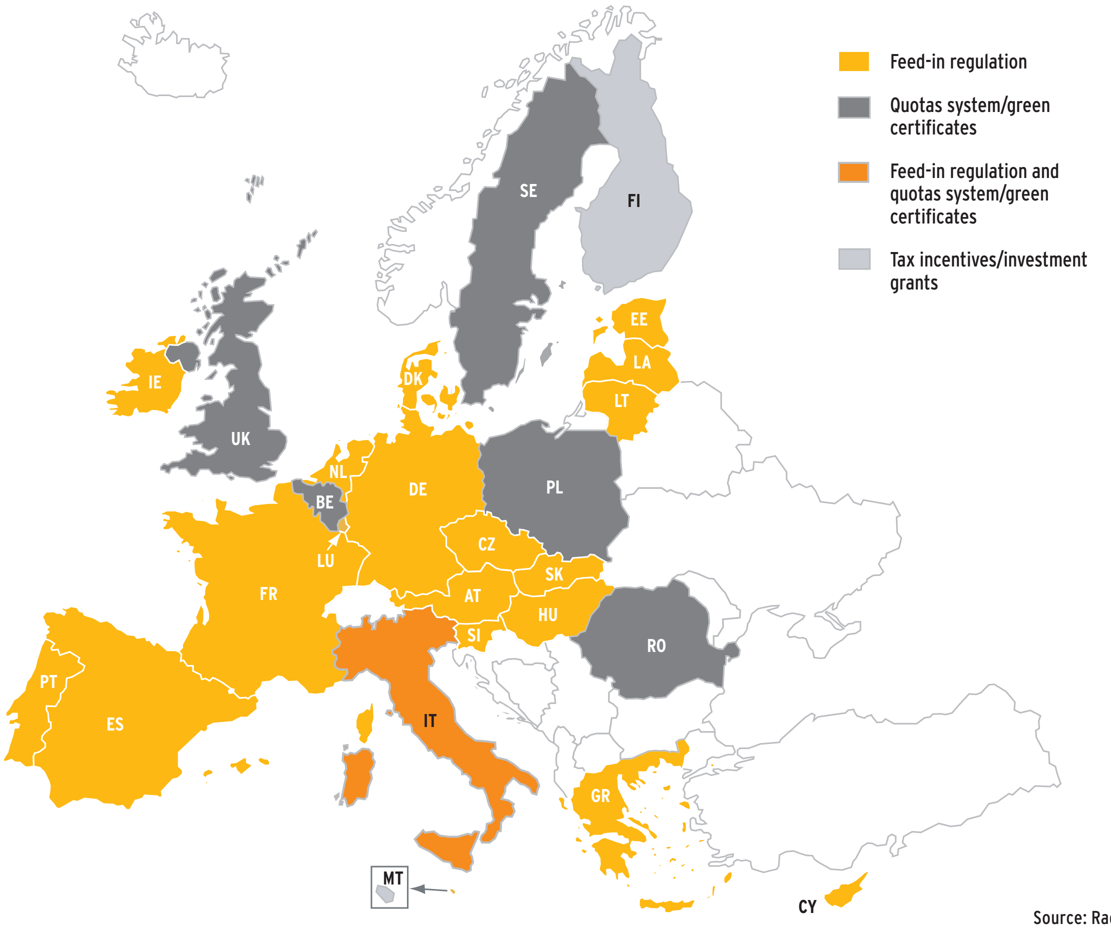
For the first time, the new EU Directive (2009/28/EC) formulates a binding target for the transport sector.

By 2020, the proportion of energy from renewable sources in the individual EU Member States should equate to at least 10 % of final energy consumption by the transport sector across all modes of transport.

The Directive does not confine itself explicitly to biofuels, but instead refers to energy from renewable sources in general. This means that in addition to the biofuels already established in the fuel sector and other biofuel options which are not yet market-ready (e.g. bioethanol from raw materials containing lignocellulose), in future the contribution of electricity and hydrogen generated from renewable resources can also be used to meet the minimum share.

1) Quantity of biofuels in 2007 in relation to the total fuel consumption by road traffic in 2006.

INSTRUMENTS FOR THE PROMOTION OF RENEWABLE ENERGY SOURCES IN THE EU ELECTRICITY MARKET



Source: Ragwitz [52]

The new EU Directive on renewable energies (2009/28/EC) implements the European Council resolution of March 2007 to increase the share of total energy consumption in the EU from renewable energies to 20 % by 2020 (cf. also page 48).

For Germany, the Directive stipulates a binding target – namely, that renewable energies should account for 18 % of final energy consumption by 2020. In order to meet this target, as part of the integrated energy and climate package, Germany has set itself the target of achieving a renewable share of electricity at national level of at least 30 % by 2020. After 2020, this expansion process is to be continuously increased, corresponding to a share of around 50 % renewables in the electricity sector by 2030.

The example of wind energy and other renewables shows that expansion success levels vary significantly between individual EU states. This is primarily due to the respective framework conditions vis-à-vis energy policy, rather than natural potential. Germany's Renewable Energy Sources Act (EEG) and Spain's legislation in particular compare particularly favourably with other international support models. For example, in its report of January 2008, the European Commission asserts that well-formulated feed-in regulations for electricity from renewable energy sources, such as those contained in the EEG, are more effective and more efficient than other instruments at promoting renewable energies. Quota systems with tradable certificates that exist in some countries have thus far failed to produce comparable results. The costs of such systems are also higher than in countries with feed-in regulations. In particular, this reflects the higher risks for plant operators with quota regulations. While the EEG guarantees a fixed, technology-specific fee for 20 years, the revenues from the sale of electricity and certificates in the quota system are extremely unpredictable and depend on a multitude of factors that are difficult to assess. Additionally, in the absence of technology-differentiated support, not all technologies required are promoted, and this may potentially lead to high levels of profit-taking. Thanks to the EEG, by 2007 Germany had already significantly exceeded its national contribution to the European Union's formulated expansion target for 2010, well ahead of the set time limit.

On a global level, by early 2009, 45 countries and a further 18 states/provinces/regions had already introduced feed-in regulations for electricity from renewable energy sources [33].

Structure of feed-in regulations among EU Member States

1) Exemptions for electricity-intensive industry in Austria, Denmark and Germany
2) In the Netherlands, subsidies have been temporarily discontinued for applications submitted after 18 August 2006. In April 2008, they were reintroduced as the principal support instrument with new fee rates.
3) In the Netherlands, costs are shared equally among all consumers, regardless of individual electricity consumption.

Note:
The 2008 Energy Act created the legal foundations for the introduction of a feed-in regulation in the UK. Support of RES plants and CHP plants with an electrical capacity ≤ 50 kW via feed-in fees will occur parallel to the existing quotas system, and is limited to plants with a capacity of up to 5 MW. A feed-in regulation is scheduled to be introduced by 2010.

	Compulsory purchase	Tariff differentiation	Tariff degression	Bonus option	Equal cost distribution	Predicted obligation
Bulgaria	x	x	-	-	-	-
Denmark	x (except onshore wind)	x	-	x (wind only)	x 1)	-
Germany	x	x	x	-	x 1)	-
Estonia	x (up to level of grid losses)	-	-	x (new draft act)	x	x (new draft act)
France	x	x	Wind	-	x	-
Greece	x	x	-	-	x	-
Ireland	x	x	-	-	x	-
Italy	x	x	PV	-	x	-
Latvia	x	x	-	-	-	-
Lithuania	x	-	-	-	x	-
Luxembourg	x	x	-	-	x	-
Netherlands 2)	-	x	-	x	3)	-
Austria	x	x	-	-	x 1)	-
Portugal	x	x	-	-	x	-
Slovakia	x (up to level of grid losses)	x	-	-	x	-
Slovenia	x (where fixed fee)	x	-	x	x	x
Spain	x (where fixed fee)	x	-	x	x	x
Czech. Republic	x (where fixed fee)	x	-	x	x	-
Hungary	x	-	-	-	x	-
Cyprus	x	x	-	-	x	-

Source: BMU [37]

The above table illustrates the varying formulation of support policies in the EU Member States. The new EU Directive on renewable energies gives Member States the necessary flexibility to be able to utilise their country-specific potential to optimum effect with effective national support systems.
For all interested parties, the German Environment Ministry offers a free Internet database "RES LEGAL" containing legal sources on electricity generation from renewables at www.res-legal.eu, where users can research key legal materials on the promotion of electricity from renewable energy sources and its access to the grid within 25 EU Member States. Technology-specific regulations are also explicitly listed.

International Feed-In Cooperation (IFIC)

At the 2004 International Conference for Renewable Energies in Bonn, Spain and Germany decided to share their experience of feed-in regulations for electricity from renewables and to intensify their cooperation (International Feed-In Cooperation). This cooperation was placed on a formal footing when the two countries signed a joint declaration in October 2005. In January 2007, Slovenia also signed the joint declaration. In this way, these countries are complying with the Commission's recommendation to cooperate more closely. Other states have also expressed an interest and are welcome to join.

The aims of cooperation are to promote the exchange of experience with and optimise feed-in remuneration systems, to support other countries in improving and developing feed-in systems, and to incorporate the experience acquired into international forums, particularly into the political debates of the European Union.

In total, a further 17 EU Member States now have priority and fee regulations which are comparable with the German, Slovenian and Spanish systems (cf. also the diagram on p. 59).
Further information on cooperation may be found on the Internet at www.feed-in-cooperation.org.

PART III: GLOBAL USE OF RENEWABLE ENERGY SOURCES

Meeting the energy demands of a growing world population in a sustainable manner is one of the major challenges facing us in the future. Renewable energy sources already make an important contribution in this respect – around 13 % of the global energy supply is from renewable sources.

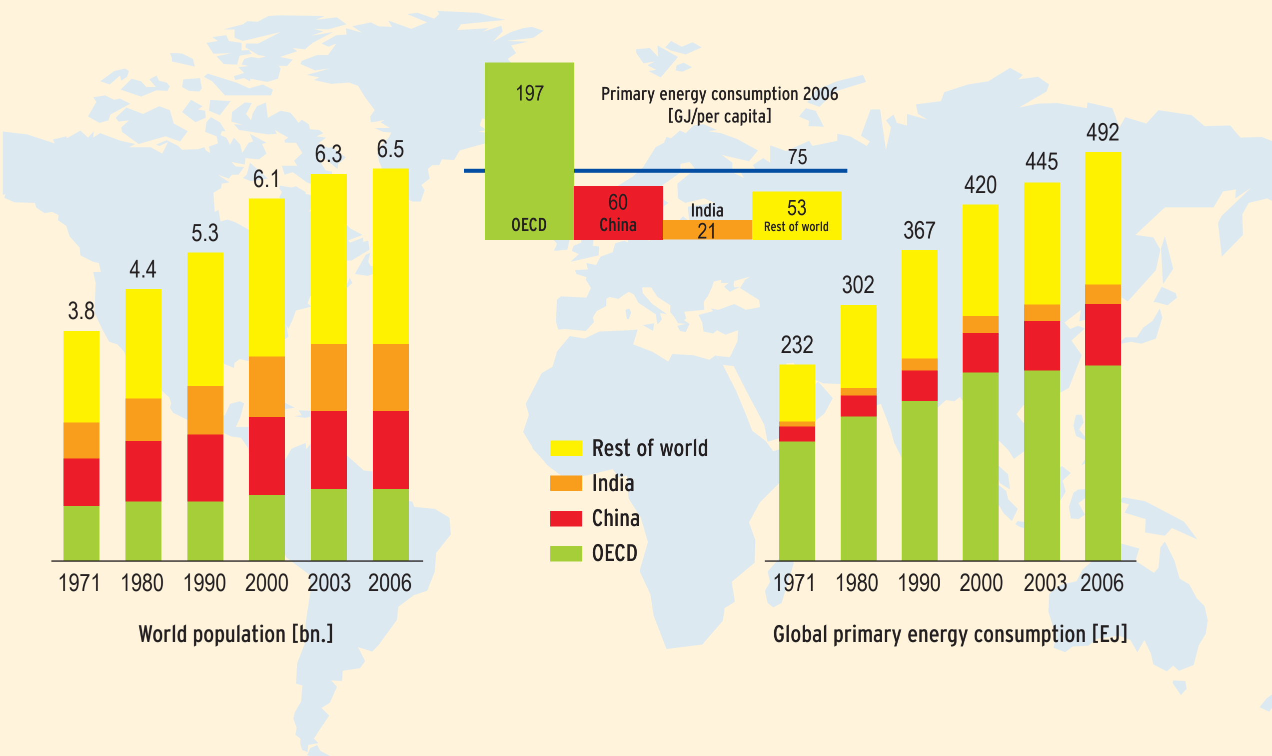
Even on a global scale, our future energy supply will not satisfy the criteria of sustainability without a substantial and continuous expansion in renewable energy sources. Further expansion is also crucial for limiting emissions of climate-damaging greenhouse gases, in keeping with the targets of the Kyoto Protocol. Furthermore, renewable energy sources represent an important opportunity for developing countries, since access to energy is a key factor in combating poverty. A large proportion of the population in these countries inhabit rural areas. The lack of transmission grids makes conventional energy supply impossible in such locations. The decentralised nature of renewables means that they are able to provide a basic supply, e.g. in the form of off-grid photovoltaic plants for domestic demands. More than 2.5 million households in developing countries currently produce electricity from a photovoltaic plant [33]. In this way, renewable energies provide access to modern energy – particularly electricity – for a larger number of people, which in turn improves living conditions and offers opportunities for economic development.

The huge importance of renewable energy sources for sustainable development is widely recognised. At national level, a range of mechanisms are currently used to promote the development of renewable energy sources (cf. also pages 36-39 and 59-60). Considering the absolute figures, the global supply of renewable primary energy increased by just under 3.3 % to around 62,500 PJ in 2006 (2005: around 60,500 PJ). On average, renewables have increased by 1.8 % per annum since 1990. Nevertheless, the share of global primary energy consumption from renewables has tended to remain just below the 13 % mark since the Eighties (2006: 12.7 %). In other words, the increase in total primary energy consumption was only just compensated by the increase in the supply of renewable energy.

Just under one-fifth of the global population (OECD) continues to consume around half of the global primary energy. Per capita consumption in industrialised countries (OECD) is almost three times higher than the global average (around 200 GJ compared with an average of 75 GJ). In China and India, the most densely populated countries on earth, the per capita energy demand is just 60 and 21 GJ respectively. However, the energy demands of developing and newly industrialising countries are on the increase.

Against this background, it becomes clear that in order to meet the challenges of global energy supply and, in particular, climate protection, as well as using energy more efficiently, it is also necessary to increase the development momentum of renewable energy sources. This is particularly true of wind, solar and ocean energy (the so-called “new” renewables), but also applies to geothermal energy and modern techniques for the use of biomass. Traditional forms of use which have dominated up until now – the provision of heat from firewood and charcoal (traditional use of biomass) and the generation of electricity from hydropower – are fast approaching their limits, and no longer represent a sustainable use of renewables (cf. also page 65).

Development of world population and global primary energy consumption

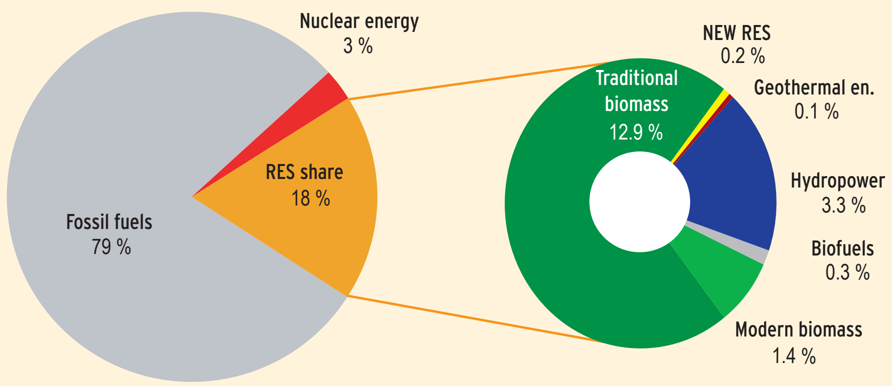


PEC calculated according to the physical energy content method

Sources: IEA [54], [63]

GLOBAL ENERGY SUPPLY FROM RENEWABLE ENERGY SOURCES

Structure of global final energy consumption, 2006



The global final energy share is higher than the global primary energy share. This is partly due to traditional biomass, all of which represents final energy consumption

Furthermore, the level of primary energy share also depends on the method used to calculate the primary energy equivalent of renewable energy sources, cf. Appendix, para 5, 11 and 12.

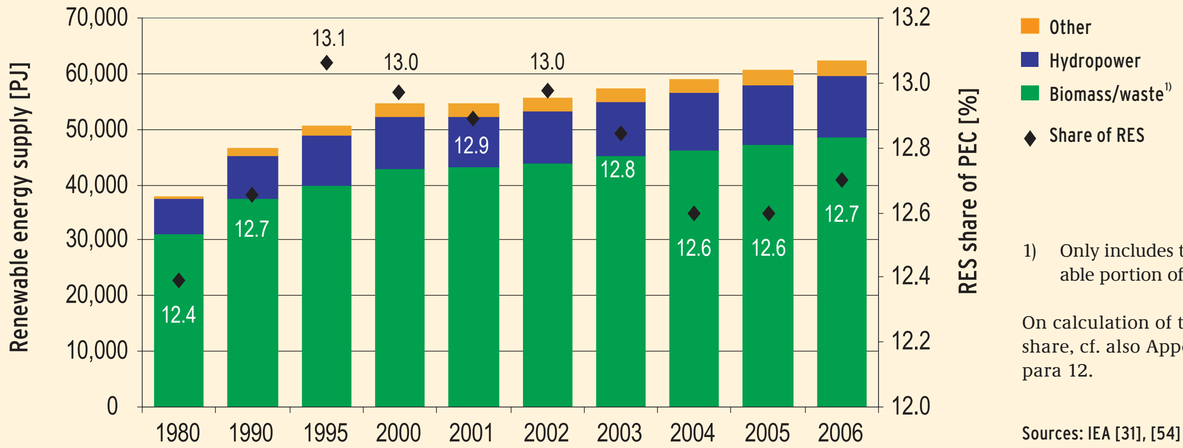
New RES = Wind, solar and ocean energy

Source: according to REN21 [33]

In 2006, almost one-fifth (18 %) of the global demand for final energy was met from renewable sources. However, the largest share (13 %) was attributable to traditional biomass use (cf. also page 65), while 3 % was attributable to large-scale hydropower (> 10 MW). The remaining share of 2.4 % is distributed among the other renewable energy technologies. Considering recent developments in the construction of new global production capacity in these technologies, a pleasing trend is emerging. For example, wind energy, geothermal heat generation, solar hot water supply and stand-alone photovoltaic systems have increased capacity by between 15 and 30 % per annum over the five-year period from 2002 to 2006. Grid-connected photovoltaics expanded at a significantly faster pace than all other renewable technologies, with an average annual growth rate of 60 % [33].

The development for global final energy consumption follows the same trend as primary energy consumption, which has almost doubled since 1971 (2006: around 491,600 PJ). In 2006 alone, global demand for energy rose by around 2.5 %, or in absolute terms, by around 12,000 PJ (by way of comparison: in 2008, total primary energy consumption in Germany totalled around 14,000 PJ).

Global development of renewable primary energy supply and share of renewable energy sources (RES)

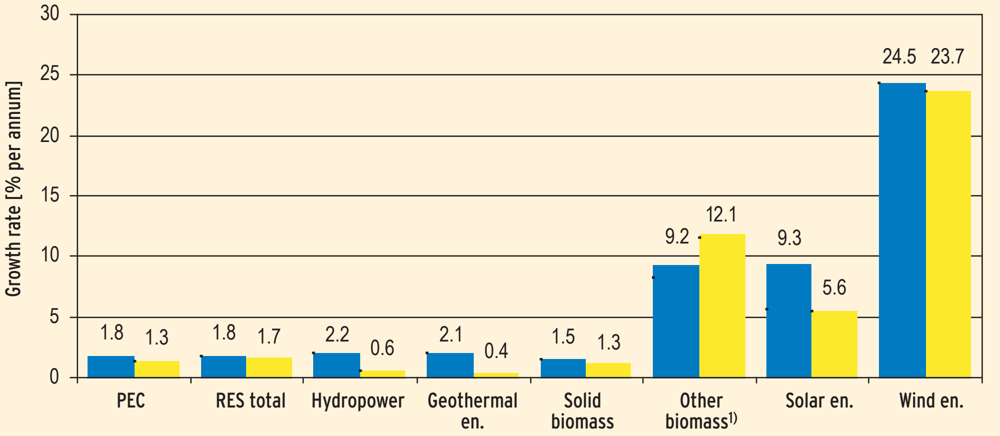


1) Only includes the renewable portion of waste

On calculation of the RES share, cf. also Appendix, para 12.

Sources: IEA [31], [54]

Average growth rates of primary energy consumption and renewable energy sources for the period 1990 to 2006



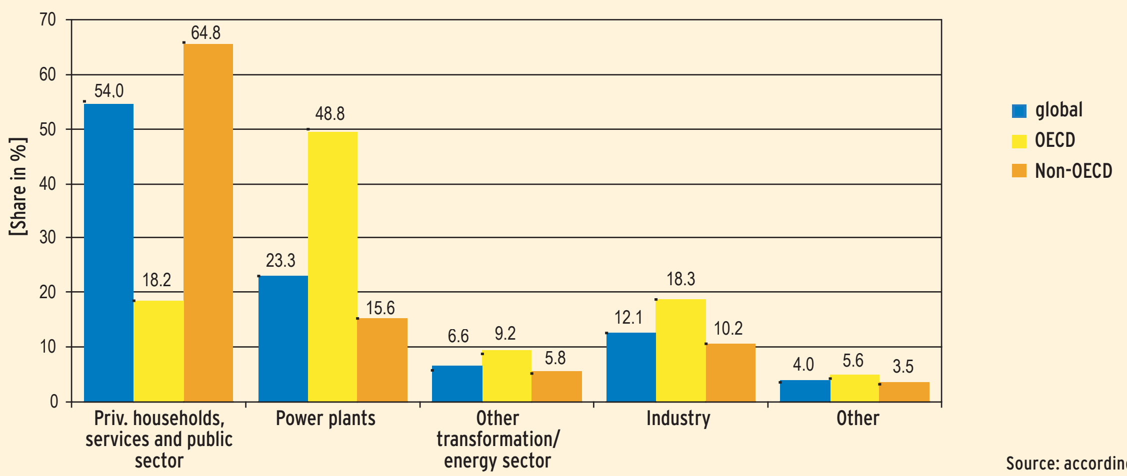
The OECD Member States are listed in the Appendix, para. 10

1) Biogenic portion of municipal waste, biogas, liquid biomass

Source: IEA [31]

Against the background of the Kyoto Protocol's climate protection targets, the development of renewable energy sources has been a particular focal point since 1990. Since then, however, efforts to significantly raise their profile amongst energy supply have failed. At a global level, energy supply rose by an average of 1.8 % p.a. until 2006, only just managing to keep pace with the growth in total primary energy consumption. Among industrialised countries (OECD), there have been signs of a trend reversal since 2005, since the growth in renewable energy supply at 1.5 % p.a. outstripped the growth in total primary energy consumption (2005: 1.4 % p.a.) for the first time in five years. In 2006, renewables were already demonstrating growth rates of 1.7 % p.a., whilst the growth rate in total primary energy consumption by the OECD decreased slightly from 1.4 % p.a. in 2005 to 1.3 % p.a. in 2006. The percentile increase in renewable energy sources, at 6.2 %, was only 0.4 % up on the figure for 1990. For 2007, the International Energy Agency estimates this share at 6.4 %.

Shares of renewable energies in energy demand in the various sectors, 2006



Source: according to IEA [31]

Globally, today, around 54 % of renewable energies are used to supply heat to private households and to the public and services sectors. Essentially, this refers to wood and charcoal. The second main area of application is electricity generation. However, there are substantial regional differences: Whereas in the western industrialised countries (OECD), half of renewable energy sources are used to generate electricity, in non-OECD countries this figure is only 15.6 %. The share attributable to decentralised heat supply is correspondingly high in these countries, at just under 65 %, compared with only 18 % or so in the OECD countries.

GLOBAL USE OF RENEWABLE ENERGY SOURCES IN 2006 ACCORDING TO REGIONS

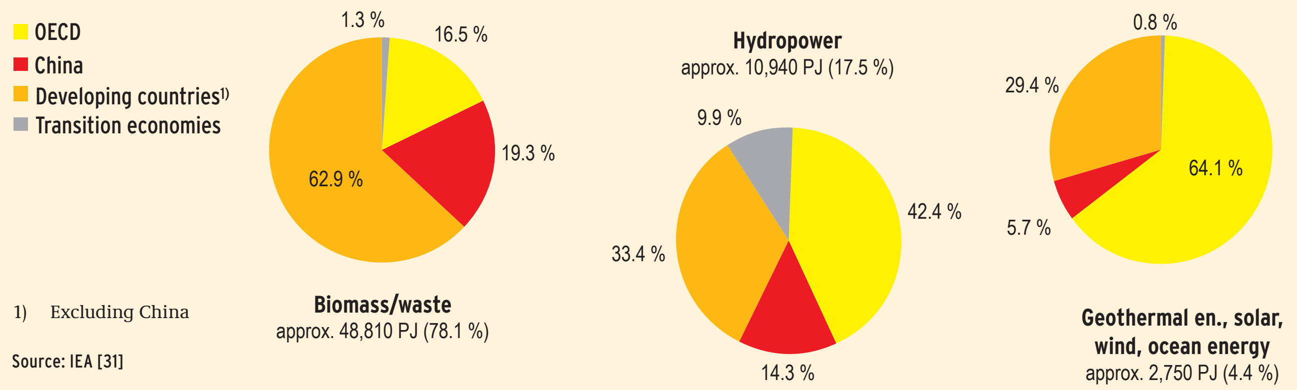
	PEC	of which RES	RES as a share of PEC	Principal RES as a share of total RES [%]		
	[PJ]	[PJ]	[%]	Hydo-power	Biomass / waste 1)	Other 2)
Africa	25,749	12,619	49.0	2.7	97.0	0.3
Latin America 3)	22,216	6,699	30.2	35.1	63.4	1.5
Asia 3)	55,740	15,667	28.1	5.5	90.3	4.2
China	79,388	11,171	14.1	14.0	84.5	1.4
Middle East	21,877	167	0.8	50.1	29.4	20.5
Trans. economies	47,124	1,721	3.7	62.8	35.9	1.3
OECD	231,845	14,449	6.2	32.1	55.7	12.2
Global 4)	**491,601**	**62,498**	**12.7**	**17.5**	**78.1**	**4.4**

Transition economies: Countries that are in transition from a planned economy to a market economy; the IEA uses this term to refer to the countries of non-OECD Europe and the countries of the former USSR.

1) OECD biogenic portion of waste only; other regions also include non-biogenic portions
2) Geothermal energy, solar energy, wind energy, ocean energy
3) Latin America excluding Mexico, and Asia excluding China
4) Including high sea bunkers

PEC calculated according to the physical energy content method, cf. Appendix, para. 12

Source: IEA [31]



1) Excluding China

Source: IEA [31]

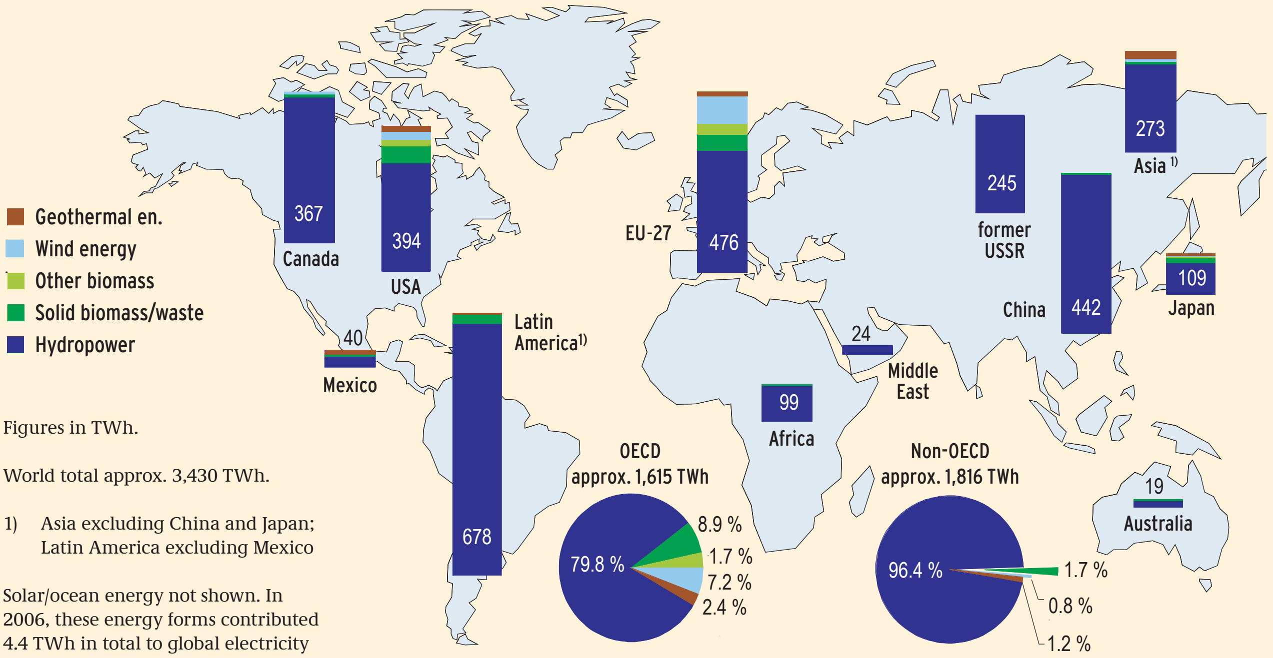
Persons relying on traditional biomass	2004 [mill.]
Sub-Saharan Africa	575
North Africa	4
India	740
China	480
Indonesia	156
Rest of Asia	489
Brazil	23
Rest of Latin America	60
Total	**2,528**

Source: according to IEA [23]

The share of energy that is generally considered renewable is particularly high in Africa, due to the traditional use of biomass; however, this is not sustainable in the long term. Basic forms of cooking and heating can impair health through the use of open fires, and lead to deforestation, the effects of which are often irreversible. Among developing countries, particularly in rural regions, around 2.5 billion people are solely reliant on traditional biomass for their cooking and heating requirements, corresponding to 40 % of the world population. Allowing for population growth, the IEA expects this figure to rise to more than 2.6 billion by the year 2015 (2030: 2.7 bn.). The use of hydropower from large embankment dams can also be an unsustainable use of renewable energies, since such dams can have serious social and ecological consequences.

GLOBAL ELECTRICITY GENERATION FROM RENEWABLE ENERGY SOURCES

Electricity generation from renewable energy sources in various regions, 2006



Figures in TWh.

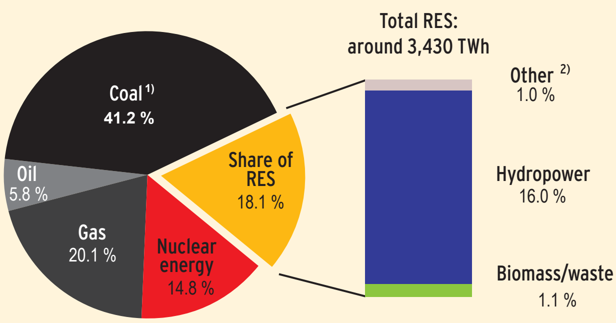
World total approx. 3,430 TWh.

1) Asia excluding China and Japan; Latin America excluding Mexico

Solar/ocean energy not shown. In 2006, these energy forms contributed 4.4 TWh in total to global electricity production.

Sources: IEA [31], [54]

Share of renewable energy sources in global electricity generation, 2006



At 16 %, global electricity generation from hydropower is higher than that from nuclear energy (14.8 %). Looking at the PEC shares, this ratio is inverted, with nuclear energy providing a considerably higher share of PEC at 6.2 % than hydropower at 2.2 %. The reason for this distortion is that according to international agreements, electricity from nuclear power is rated at an average conversion efficiency of 33 % in relation to primary energy, while electricity from hydropower is rated at a conversion efficiency of 100 % according to the so-called physical energy content method; cf. Appendix, para. 5.

1) Includes non-renewable portion of waste (0.2 %)
2) Geothermal energy, solar energy, wind energy, ocean energy

Sources: IEA [31], [54]

In 2006, just under one-fifth of global electricity was generated from renewable energies. However, the renewable portion of global electricity has failed to break through the 20 % barrier over the course of time, and has even dipped recently, from 19.5 % in 1990 to 18.1 % in 2006. The further development of this share is influenced by the varying framework conditions in the industrialised countries of the OECD and non-OECD countries.

The relatively small growth rate for hydropower in the OECD is the main reason for the decline in the global share. Hydropower contributes the highest proportion of renewable electricity generation, at around 80 %. However, hydropower potential in most industrialised countries has already been exhausted. In these countries, the growth push needed to increase the global share can only be achieved by stepping up the use of other renewable technologies.

Considering the non-OECD countries, who provide more than half (around 53 %) of the world's renewable electricity generation, the growth in total electricity demand will be higher than in the OECD in future, due to the sharper growth in population compared with industrialised countries, coupled with rising income levels. This means that the growth in renewables must at least keep pace in order to maintain the global share.

INTERNATIONAL RENEWABLE ENERGY AGENCY (IRENA)

The International Renewable Energy Agency (IRENA) was founded in Bonn on 26 January 2009. 75 of 124 participating countries signed the Statute (founding treaty). More than 130 countries throughout the world have now joined the Agency, which was created as the result of an initiative by the German Government.

As an international government organisation, IRENA aims to advise industrialised and developing countries on the expansion of renewable energy sources and provide them with support. IRENA will promote and accelerate the global spread of all sustainable, regenerative energy sources. IRENA will be a knowledge base for successful political measures and practical applications, and will also make available technological expertise on renewable energy sources.

The Statute enters into force when 25 countries have ratified it in accordance with their respective national regulations. Until then, a Preparatory Commission appointed at the Founding Conference, of which all signatory states are members, will make all necessary decisions for establishing the Agency.

At its second session on 29 and 30 June 2009 in Sharm El Sheikh, Egypt, the Preparatory Commission decided on the location of the headquarters and appointed Ms. Hélène Pelosse (France) the first Director-General. The IRENA headquarters will be established in Abu Dhabi. Additionally, a centre of innovation and technology will be established in Bonn and Vienna will host a liaison office for cooperation with the UN and other international organisations. Further information on IRENA can be found at www.irena.org.

The former Plenary Chamber of the German Bundestag (Lower House of Parliament) in Bonn, where the founding conference took place.

INTERNATIONAL CONFERENCE FOR RENEWABLE ENERGIES – RENEWABLES 2004 – AND THE FOLLOW-UP PROCESS

The International Conference for Renewable Energies – renewables2004 – has led to a breakthrough in the expansion of renewable energies in a global context. The successful implementation of around 200 activities under the Bonn International Action Programme (IAP) is already contributing to global climate protection and sustainable development; if the IAP is implemented in full, emissions of CO_2 could be reduced by 1.2 billion tonnes per annum by the year 2015, corresponding to around 5 % of global emissions in 2015. Moreover, up to 300 million people will have access to electricity for the first time as a result of implementation of the IAP. The official closing documentation, conference documents and an evaluation of the IAP are available for downloading at www.renewables2004.de.

A further outcome of the conference was the creation of a global policy network (Renewable Energy Policy Network – REN 21).

Governments, international organisations and representatives of civil society will work together in the REN21 network to promote renewables worldwide. REN21 publishes a global status report each year, providing a comprehensive overview of support policies, markets, investments and jobs (available on the Internet at www.ren21.net). Additionally, REN21 supports the report "Global Trends in Sustainable Energy Investments" (available on the Internet at www.sefi.unep.org). The REN 21 Network is also involved in implementation of the IAP. REN21 also supported implementation of the Bonn Resolutions at the United Nations, particularly the 14th and 15th meetings of the UN Commission on Sustainable Development.

Following the Bonn renewables conference, a fixed process of follow-up conferences became established. In 2005, the Chinese Government hosted the first follow-up conference – the Beijing International Renewable Energy Conference (BIREC 2005) – with the support of the German Government. The conference, attended by 1,300 delegates from 100 countries, including 30 government representatives at ministerial level, was a great success.

In 2008, the second follow-up conference, the Washington International Renewable Energy Conference (WIREC), was hosted by the US Government. The principal outcome of the conference is an action programme comprising more than 90 declarations of commitment by governments, companies and civil associations. These declarations of commitment are available for downloading at the conference website www.wirec2008.gov.

The third follow-up conference is due to be hosted by the Indian Government in the second half of 2010.

The German Government also supports regional activities and cooperation with key developing and newly industrialising countries. This includes the promotion of renewable energies in Arabic countries, including the Arabic initiative by the Middle East and North Africa Renewable Energy Conferences (MENAREC), held in 2004 in Sana'a (Yemen), in 2005 in Amman (Jordan), in 2006 in Cairo (Egypt) and in 2007 in Damascus (Syria). The fifth conference is due to take place in Morocco in 2010. The expansion of renewables is likewise promoted within the context of the German-Indian energy dialogue and the German-Brazilian energy agreement.

The Implementing Agreement Renewable Energy Technology Deployment (RETD) was founded at the initiative of the BMU. This is a cross-technology agreement designed to accelerate the market launch of technologies for the use of renewable energies within the framework of the International Energy Agency. The Agreement was adopted in 2005, and now has the active involvement of 10 countries (Germany, France, Japan, Italy, the United Kingdom, Denmark, the Netherlands, Canada, Ireland and Norway). The RETD supports suitable projects on renewable energy sources and hosts expert conferences, most recently in April 2009. Further information may be found at www.iea-retd.org.

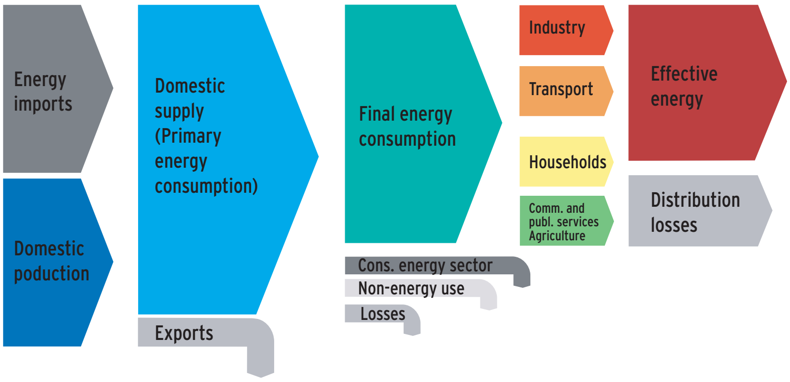
APPENDIX: METHODOLOGICAL NOTES

Some of the data published here reflects provisional results only. This is also true of individual time series which are currently being reviewed by the Working Group on Renewable Energy Statistics (AGEE-Stat) (cf. also www.erneuerbare-energien.de/inhalt/3860/). Figures may still change in comparison with earlier publications until final data is published.

Differences between the figures in the tables and the corresponding column or line totals are due to rounding up or down.

The standard terminology in energy statistics includes the term (primary) energy consumption, although this is not strictly true in a physical sense, because energy is neither extracted nor consumed, but can merely be transformed into different forms of energy (such as heat, electricity, mechanical energy). However, this process is not completely reversible, so that part of the useful energy is lost.

Diagrammatic representation of the energy flow



The magnitudes shown do not correspond to energy consumption in Germany. The chart is merely designed to aid understanding of the various energy terms.

An energy flow diagram for Germany for 2007 may be found on the website of the Arbeitsgemeinschaft Energiebilanzen (AGEB) at www.ag-energiebilanzen.de

Source: according to Erdmann [61]

1. Calculation of savings factors and avoided emissions for electricity generation from renewable energy sources

Calculation of the emissions avoided by the use of renewable energy sources is derived from the volume of renewable electricity generation as well as substitution and emission factors. Substitution factors indicate which fossil fuels are replaced by the respective renewable energy source. Emission factors represent the quantity of greenhouse gases and air pollutants emitted per unit of fossil or renewable electricity generation. These comprise both direct emissions from the combustion of fossil fuels, and emissions from the so-called prechain. The prechain includes pollutant emissions from the manufacture of generating plants and from the extraction, processing and transportation of both fossil and renewable fuels. With regard to the cogeneration of heat and power, allocation is based on the "Finnish method" as specified in EU Directive 2004/8/EC.

The substitution factors used are based on the "Report on CO_2 Reduction through the Use of Renewable Energy Sources, 2006 and 2007" (Klobasa et al. [41]). Using an electricity market model, the report examines the extent to which renewable energies can replace conventional energy sources in the light of the current power plant portfolio. The substitution factors for the year 2006 were used to calculate emission savings. According to this, the base load supplied by nuclear power plants is not currently substituted by renewable energy sources, since it indicates lower variable costs compared with lignite power plants.

The emission factors for fossil and renewable electricity production are taken from various databases or derived from research projects. Direct emission factors for fossil electricity generation are taken from the UBA database for national emissions reporting (ZSE) [24]; emissions from fossil prechains are taken from the Öko-Institut's GEMIS database [22]. Representative data records from various databases were selected for the emission factors of renewable energy sources, and adapted in some cases. The sources consulted include in particular Öko-Institut [22], Ecoinvent [111], UBA [24], Vogt et al. [112], Ciroth [113] and Frick et al. [115]. Detailed information on the calculation methodology and data sources may be found in UBA [110].

1) RES electricity substitutes x % of conventional electricity.
2) Portion of biogenic waste estimated at 50%

Source: Klobasa et al. [41]

	Substitution factors for RES electricity [1]				
	Nuclear energy	Lignite	Hard coal	Neutral gas	Mineral oil
Hydropower	0 %	30 %	45 %	25 %	0 %
Wind	0 %	11 %	63 %	24 %	2 %
Photovoltaics	0 %	0 %	50 %	50 %	0 %
Solid Biomass	0 %	16 %	59 %	25 %	0 %
Liquid biomass	0 %	5 %	62 %	32 %	1 %
Biogas	0 %	5 %	62 %	32 %	1 %
Landfill gas	0 %	5 %	62 %	32 %	1 %
Sewage gas	0 %	5 %	62 %	32 %	1 %
Biogenic portion of waste [2]	0 %	16 %	59 %	25 %	0 %
Geothermal energy	0 %	30 %	45 %	25 %	0 %

2. Calculation of savings factors and avoided emissions for heat generation from renewable energy sources

The emissions of greenhouse gases and air pollutants that have been avoided via the use of renewable energy sources in the heating sector are calculated in three stages:
First, substitution factors are calculated for each of the renewable heat supply paths. These indicate which fossil primary and secondary energy sources, such as district heating or electricity, would need to take over from a renewable heating supply if it was not available. Important information in this regard was derived from the results of an empirical survey on the use of solar thermal energy, heat pumps and wood-fired installations in private households [114]. Additionally, we also consulted AGEB data on energy consumption by the industry sectors stone and earth extraction, paper industry and other industry (including wood industry) as well as private households. Regarding the supply of renewable local and district heating from wood, from the biogenic portion of waste and from geothermal energy, we have assumed 100 % substitution of local and district heating generated from fossil fuels, and that the grid losses are equal.

In a second stage, emission factors are calculated both for renewable heat supply in private households, agriculture and industry, as well as for the corresponding fossil fuel heat supply that has been avoided, using data taken or derived from UBA [24], Öko-Institut [22], Ecoinvent [111], Vogt et al. [112], Ciroth [113], Frick et al. [115]. The emissions factors include the entire "prechain" for the supply of both fossil and renewable fuels. For cogeneration of heat and power, allocation to electricity and heat is based on the "Finnish method" as specified in EU Directive 2004/8/EC.
In the final stage, the avoided fossil emissions are compared with the emissions occurring from the use of renewable energies in order to calculate the net avoidance of greenhouse gases and air pollutants. Detailed information on the calculation methodology and data sources may be found in UBA [110].

BCHP = Block-type heating power station
H(P) = Heating (power) station

Source: UBA [110], [24] based on AGEE-Stat and Frondel et al. [114]; AGEB [1], [18]

	Substitution factors for RES heat					
	Fuel oil	Natural gas	Hard coal	Lignite	District heating	El. Heating
Individual wood furnaces (households)	41 %	50 %	0 %	1 %	2 %	6 %
Central wood furnaces (households)	65 %	20 %	2 %	3 %	0 %	10 %
Solid biomass (industry)	11 %	62 %	11 %	13 %	4 %	0 %
Solid biomass (heat plants)	0 %	0 %	0 %	0 %	100 %	0 %
Liquid biomass (industry)	4 %	78 %	11 %	2 %	5 %	0 %
Liquid biomasse (households)	35 %	48 %	1 %	1 %	6 %	8 %
Biogas, sewage gas, landfill gas (BCHP)	48 %	46 %	6 %	0 %	0 %	0 %
Biogenic portion of waste – H(P)	0 %	0 %	0 %	0 %	100 %	0 %
Deep geothermal energy – H(P)	0 %	0 %	0 %	0 %	100 %	0 %
Concentrating solar power (households)	45 %	51 %	0 %	0 %	2 %	3 %
Heat pumps (households)	45 %	44 %	1 %	2 %	5 %	3 %
Total	**33 %**	**43 %**	**3 %**	**3 %**	**13 %**	**4 %**

3. Calculation of avoidance factors and avoided emissions when using biofuels

The emissions of greenhouse gases that are avoided thanks to the use of biofuels are calculated on the basis of the following core assumptions:

- Greater consideration of the nature and origin of raw materials for the production of biofuels, and the inclusion of biofuel imports
- Allocation of main products and by-products on the basis of lower calorific values
- Consideration of different production technologies/energy supply
- Reference to the typical values of the EU Directive on renewables.

The substitution relationships are very simple: 1 kWh of bioethanol replaces 1 kWh of petrol, and 1 kWh of biodiesel or vegetable oil replaces 1 kWh of mineral diesel. The biofuels are allocated to individual vehicle types/modes of travel in an analogous manner to fossil fuels (structural elements in TREMOD and ZSE).

There is no differentiation of vehicle-related emissions due to the use of biofuels or conventional fuels.

The bases and origins of the raw materials are a key factor for the level of emissions saved when using biofuels. The table below provides an overview.

Proportion of individual raw materials among total biofuel use in Germany, 2008 (%)

	Rapeseed	Soya	Palm	Waste	Wheat	Sugar cane	Beets	Other
Biodiesel	45.4	44.7	7.5	2.4				
Veget. oil	95.0	5.0	0	0				
Bioethanol					44.2	27.5	25.9	2.4

Sources: UBA [110] based on BDB[e] [90]; UFOP [87], [108]; TFZ [109]

The scope of emission reduction is also determined by the emission factors of the various biogenic and fossil fuels. The calculations of greenhouse gas reductions are based on the typical values in the new EU renewables Directive (2009/28/EC). The Directive does not contain any figures for soya-based vegetable oil fuel. For this fuel, we used the standard value from the Biomass Sustainability Regulation (BioNachVO), which is based on the methods and assumptions of the EU Directive on renewables, and converted it into a typical value analogous to the system used in the EU Directive on renewables.

In a final step, the net avoidance of CO_2 and total greenhouse gases is calculated by offsetting the fossil emissions avoided against the emissions incurred from the use of renewable energies. Detailed information on the calculation methodology and data sources may be found in UBA [110].

Direct and indirect land use changes – which play a major role with biofuels – have not previously been included in the balance sheet. As land use changes may indicate high emissions of greenhouse gases and are therefore highly relevant, they must be taken into account in the balance sheet. However, methodological approaches that make allowance for land use changes are currently still under development and therefore are not yet available for calculation purposes. Also, direct land use changes play only a minor role at present for raw materials produced on German territory. In the case of imports, the level of knowledge regarding direct land use changes remains very limited.

GHG emission factors used for various fuels

Fuel (raw material basis)	Emission factor [g CO_2-equi./kWh]
Fuel/diesel (fossil)	301.7
Biodiesel (rapeseed)	165.6
Biodiesel (soya)	180.0
Biodiesel (palm)	115.2
Biodiesel (waste)	36.0
Vegetable oil (rapeseed)	126.0
Vegetable oil (soya)	152.6
Bioethanol (grain)	180.0
Bioethanol (beets)	118.8
Bioethanol (sugar cane)	86.4
Bioethanol (other)	36.0
Biodiesel (weighted)	**165.1**
Vegetable oil (weighted)	**127.3**
Bioethanol (weighted)	**134.9**

GHG = Greenhouse gas

Sources: UBA [110] based on AGEE-Stat and EP [92]; BR [98]; BMU [56]

4. CO_2- und SO_2-equivalent

CO_2-equivalent
The key greenhouse gases are the so-called Kyoto gases CO_2, CH_4, N_2O, SF_6, PFC and HFC, which must be reduced under the terms of the Kyoto Protocol. They contribute in varying degrees to the greenhouse effect. In order to be able to compare the greenhouse effect of the individual gases, they are allocated a factor known as relative greenhouse potential (GHP), which measures their greenhouse effect in comparison with the reference substance CO_2. The CO_2 equivalent of the Kyoto gases is derived by multiplying the relative greenhouse potential by the mass of the respective gas; this figure indicates the quantity of CO_2 which would develop the same greenhouse effect over an observation period of 100 years.

In this brochure, calculations are based on the figures according to IPCC, 1995 [51]. These are prescribed for greenhouse gas reporting under the Framework Convention on Climate Change and the Kyoto Protocol in accordance with UNFCCC guidelines [65].

1) Based on a time scale of 100 years; CO_2 as reference substance

	Relative greenhouse potential 1)	
Gas		Figures acc. to IPCC 1995 [51]
CO_2	Carbon dioxide	1
CH_4	Methane	21
N_2O	Laughing gas	310
HFC	Hydrogenous fluorocarbons	140–11,700
PFC	Perfluorinated hydrocarbons	6,500–9,200
SF_6	Sulphur hexafluoride	23,900

SO_2-equivalent
The acidification potential of SO_2, NO_x, HF, HCl, H_2S and NH_3 is determined analogously to the CO_2 equivalent. The SO_2 equivalent of these air pollutants indicates the quantity of SO_2 which would produce the same acidifying effect.

Gas	Relative acidification potential	
SO_2	Sulphur dioxide	1
NO_x	Nitrogen oxides	0.696
HF	Hydrofluoric acid	1.601
HCl	Hydrochloric acid	0.878
H_2S	Hydrogen sulphide	0.983
NH_3	Ammonia	1.88

5. Calculation of the primary energy equivalent for electricity, heat and fuels from renewable energy sources

The standard international method for calculating the primary energy equivalent of electricity is the **physical energy content method**. In the case of electricity whose net calorific value is known (fossil fuels), the net calorific value is multiplied by the quantity used. In the case of energy carriers for which the calorific value is not known, as in the case of the renewable energy sources hydropower, wind energy and photovoltaics, primary energy is deduced from final energy using an efficiency factor of 100 %. Hence, for example, 1 kWh of electricity from hydropower equates to a primary energy equivalent of 1 kWh. In the case of nuclear power, an efficiency of 33 % is assumed when determining the primary energy equivalent. This method means that in the definition of primary energy consumption, the energy resources water, wind and photovoltaics are heavily underrepresented compared with energy resources with a lower level of efficiency.

In the case of electricity from biomass, whose calorific value or quantity used is difficult to ascertain, primary energy is deduced from final energy using a so-called substitution factor [15]. This substitution factor corresponds to the ratio of fuel used to generate electricity from that fuel (only general supply power plants; fuel consumption in cogeneration plants based on the so-called Finnish method).

When calculating primary energy consumption according to the **substitution method**, the fossil fuel saved is calculated for all renewable energy sources using the substitution factor. In derogation of this,

however, for the purposes of this brochure we have calculated substitution in accordance with the expert report [41] (see pages 69–70). By specifying which renewable energy source replaces which fossil fuel, it is possible to calculate the fuel saving, with due regard for the efficiencies of fossil fuel-fired power plants.
The primary energy equivalent of electricity from hydropower, wind energy and photovoltaics is slightly lower with this method than with a calculation based on the substitution factor.
The effects of the different calculation methods are elucidated by the significant difference in the proportion of renewable energies among primary energy consumption. When applying the physical energy content method, this share is 7 %, whereas the substitution method produces a significantly higher share of 9.2 % (see page 12).

6. Supply of energy from photovoltaic and solar thermal energy

Photovoltaic energy

The figures on electricity generation in 2008 are based on the figures provided by the BDEW's medium-term forecast for renewable energy sources. For 2003 to 2007, electricity generation corresponds to the annual accounts of the VDN or BDEW. Up to and including 2002, electricity generation was calculated using the installed capacity at the beginning of the year and half of the capacity increase of that year multiplied by a specific electricity yield. The specific electricity yield was supplied as an average for Germany by the Solarenergie-Förderverein Deutschland [Solar Promotion Association for Germany, 28]. Taking half the capacity increase allows for the fact that newly installed capacity of the respective year can only contribute to electricity generation on a pro rata basis.

Solar thermal energy

The specified heat supply is calculated from the installed collector area and an average annual heat yield of 450 kWh/m²*a for water heaters. In addition, however, solar thermal plants are not only used for hot water supply, but also for combined hot water supply and heating support. For 2008, the proportion of newly installed glazed collector surface is estimated at 66 %. Because in the summer months, the generation capacity cannot be fully utilised with heating support systems, they are ascribed a reduced heat yield of 300 kWh/m²*a. In the case of swimming pool absorbers, a yield of 300 kWh/m²*a is likewise used for calculation purposes.

Because the collector area available during the course of the year is lower than the specified installed area at the end of the year, due to the construction of new plant, only half of the area increase in any given year is used when calculating heat production during that year.

7. Saving of fossil fuels through renewable energy sources

Fossil energy resource savings attributable to the use of renewable energies in the electricity, heating and transport sectors is calculated using a method that is closely based on the methodology and data sources for emission balance sheets (cf. Appendix, para. 1-3). Depending on the substitution relationship, the various renewable energy supply paths save different fossil fuels. Consideration is also given to the upstream processes of the extraction, processing and supply of both fossil and renewable energy sources, and manufacture of the relevant plant.

The saving of fossil fuels in the **electricity sector** is calculated from the substitution factors for renewable energies ascertained by Klobasa et al. [41] (cf. Appendix, para. 1), the average fuel efficiency ratios for German power plants, and the cumulative amount of fossil primary energy needed to supply and use fossil energy sources. The gross saving calculated in this way is then compared with the fossil primary energy needed to supply biogenic energy carriers and to manufacture and operate renewable electricity generation plants (cf. Table). In conclusion, for 2008 this produces an average saving across all renewable energy sources of approximately 2.51 kWh of primary energy per kWh of renewably produced electricity.

Energy source	Consumption of primary energie (fossil) kWh_{prim}/kWh_{el}
Lignite (power plant)	2.70
Hard coal (power plant)	2.81
Natural gas (power plant)	2.40
Petroleum (power plant)	2.66
Hydropower	0.01
Wind energy	0.04
Photovoltaik	0.31
Solid biomass (CHP)	0.06
Liquid biomass (block-type CHP)	0.26
Biogas (block-type CHP)	0.37
Sewage/landfill gas (block-type CHP) (BHKW)	0.00
Biogenic portion of waste	0.03
Geothermal energy	0.47

Sources: Öko-Institut [22]; Ecoinvent [111]; Vogt et al. [112]; Frick et al. [115]

Energy source	Lignite	Hard coal	Natural gas	Mineral oil
Average fuel utilisation rate	38.5 %	39.3 %	46.3 %	43.5 %

Source: UBA [110]

Energy source	Consumption of primary energy (fossil) kWh$_{prim}$/kWh$_{input}$
Natural gas (heating)	1.15
Fuel oil (heating)	1.18
Lignite briquette (furnace)	1.22
Hard coal coke (furnace)	1.38
District heating (inc./exc. grid losses)	1.12/0.98
Electricity (base load inc. grid losses)	1.81
Firewood (heating)	0.04
Biomass (industry)	0.15
Biomass (CHP)	0.02
Liquid biomass (block-type CHP)	0.09
Biogas (block-type CHP)	0.06
Biogenic portion of waste	0.01
Deep geothermal energy	0.47
Heat pumps	0,72
Concentrating solar power	0.12

Sources: Öko-Institut [22]; Ecoinvent [111]; Vogt et al. [112]; Frick et al. [115]

The saving of primary energy in the **heating sector** is likewise calculated from the substitution factors and the cumulative fossil energy inputs of both fossil and renewable heat supply (table; cf. Appendix, para. 2). The saving of district heating and electricity, as secondary energy sources, is divided on a pro rata basis among the primary energy sources used to supply district heating and electricity. Accordingly, the fuel mix saved in the case of district heating is comprised of 54 % natural gas, 27 % hard coal, 6 % petroleum, 2 % lignite and 11 % domestic waste. The electricity mix used for base load electricity is comprised of 40 % lignite, 12 % hard coal, 8 % natural gas and 40 % nuclear energy. Grid losses are included at a fixed rate of 14 % in the case of district heating and 10 % in the case of electricity. Overall, this produces a weighted savings factor of 1.06 kWh of primary energy per kWh of renewable heat.

Energy source	Consumption of primary energy (fossil) kWh$_{prim}$/kWh$_{input}$
Petrol	1.21
Diesel	1.15
Biodiesel (rapeseed)	0.47
Biodiesel (soya)	0.39
Biodiesel (palm oil)	0.65
Vegetable oil (rapeseed)	0.24
Vegetable oil (soya)	0.18
Bioethanol (sugar beet)	0.28
Bioethanol (sugar cane)	0.23
Bioethanol (wheat)	0.50

Source: Öko-Institut [22]

The saving of fossil primary energy in the **transport sector** is based on the assumption that diesel is substituted by biodiesel and vegetable oil, while petroleum is substituted by bioethanol. In addition to the agricultural production and origin of biofuels, in particular, the allocation method used to distribute energy consumption among main products and by-products, such as soya waste and soya oil, determines the amount of primary energy saved with biofuels. In preparing this brochure, data records from Öko-Institut [22] were used, and allocated according to the energy weighting of the products. This indicates that every used kilowatt hour of biodiesel results in a saving of 0.69 kilowatt hours of primary energy compared with fossil diesel fuel. In the case of bioethanol and vegetable oil, the savings factors are, on average, 0.84 kWh of primary energy and 0.91 kWh of primary energy respectively.

8. Sales proceeds from the use of renewable energy sources

Sales from the **generation of electricity** may be estimated based on the quantities of electricity fed into the grid and the fee rates payable under the Renewable Energy Sources Act. The revenues from facilities that fall outside the scope of the Act must also be added, especially hydropower plants over 5 MW capacity and electricity generation from thermal waste handling (biogenic portion only). An average value of 5.7 cents/kWh is assumed, based on the stock market price for base load electricity. With electricity generation at around 22 TWh in 2008, this produces a figure of approximately 1.3 billion Euros.

For the **fuel sector**, the revenues can be calculated directly from the sale of biofuels. This must take into account the different types of fuel as well as the distribution channels. An average price of 92 cents/litre net (127 cents/litre gross), for example, was estimated for the sale of biodiesel to public petrol stations, while lower prices were assumed for sales to vehicle fleets and the blending of diesel fuel.

The value of **heat supplied** from renewable energy sources is disregarded, since the bulk of the heat is used internally. One conceivable valuation here, however, would be to calculate the avoided costs for fuel oil or natural gas. Assuming a substituted heat volume of approximately 94 TWh, an average fuel oil price of 65 cents per litre and an average natural gas price of 7 ct/kWh, this would correspond to approximately 6.4 billion Euros for the private household sector. The costs of the maintenance and repair of heat-generating plants as well as the revenues from the sale of heat in district heating systems have been disregarded here. This leaves the valuation of biogenic input materials such as logging residues, industrial wood residues, wood pellets etc. as well as a proportion of firewood, which have been estimated at 2.1 billion Euros in total.

9. The European Union (EU)

The EU enlargement in 2004 was the most extensive enlargement to date of the European Union. Ten new Member States – Estonia, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, the Czech Republic, Hungary and Cyprus – joined the Community when the Accession Treaty entered into force on 1 May 2004. This meant that by the end of 2006, the EU was comprised of 25 Member States (EU-25). Two further countries – Bulgaria and Romania – acceded to the Community as at 1 January 2007, so that the European Union now comprises a total of 27 countries (EU-27). Where this brochure outlines information on the development of renewable energies, the new Member States are included in the figures from their year of accession.

10. OECD

The Organisation for Economic Cooperation and Development was founded on 30 September 1961. Its main tasks include the coordination of economic policy, particularly economic and currency policy, and the coordination and intensification of development aid from the Member States: Australia, Belgium, Germany, Denmark, Finland, France, Greece, the United Kingdom, Ireland, Iceland, Italy, Japan, Canada, Korea, Luxembourg, Mexico, New Zealand, the Netherlands, Norway, Austria, Portugal, Poland, Sweden, Switzerland, the Slovak Republic, Spain, the Czech Republic, Turkey, Hungary and the USA. The OECD headquarters is in Paris. The International Energy Agency (IEA) is a sub-organisation of the OECD; it is also based in Paris.

11. Calculation of the primary energy equivalent of renewable energy sources for the EU

In the Eurostat statistics, the primary energy equivalent for electricity from hydropower, wind energy and photovoltaics is equated with the generation of electricity according to the physical energy content method (cf. Appendix, para.5). In the case of electricity and heat generation from biomass, conclusions regarding primary energy may either be drawn using the calorific values and quantity of fuel used, or else the primary energy equivalent is calculated according to the amount of electricity and/or heat generated using typical plant efficiencies (in contrast to the method used for Germany in this brochure, cf. Appendix, para. 5). An efficiency of 10 % is assumed for geothermal electricity production, and 50 % for heat generation. In other words, 1 GWh of electricity from geothermal energy is rated at 36 TJ of primary energy, while 1 GWh of heat is rated at 7.2 TJ. For the generation of heat outside of the conversion sector (heating power plants, heating plants) e.g. using firewood, heat pumps and solar thermal plants, the final energy supplied is considered equal to primary energy.

The deviations arising from the different methodologies used compared with accounting in Germany are, however, minimal, and are disregarded when calculating the overall share of renewable energy sources in relation to primary energy consumption. However, major disparities would arise if energy supply in Germany were to be calculated using the substitution method (see pages 12, 72).

To date, most statistics have tended to focus on primary energy, but following the entry into force of the new EU Directive (2009/28/EC) on the promotion of the use of energy from renewable sources, final energy is becoming more significant as a statistical yardstick for the use of energy.

12. Renewable energy sources as a share of global energy consumption

The data available on renewable energies at international level has seen a marked improvement in recent years. Aggregating national figures in order to be able to comment on the development of renewable energies at global level is problematic in several respects, particularly due to the use of different accounting methods (e.g. the differences outlined above in calculating the primary energy equivalents of renewable energy sources), and problems associated with record-keeping, particularly regarding the traditional use of firewood and coal, which can only be very roughly estimated.

The International Energy Agency (IEA) estimates that renewables account for 12.7 % of global primary energy consumption in the year 2006 (calculated according to the physical energy content method, see above). By contrast, the share of global final energy consumption attributable to renewables was estimated at 18 % according to REN21.

According to REN21, the fact that the share of final energy consumption is significantly higher than the share of primary energy consumption is due firstly to traditional biomass use, which wholly represents final energy consumption; and secondly, the problem of the different methods used to calculate primary energy equivalent.

CONVERSION FACTORS

Terawatt hour:	1 TWh = 1 billion kWh
Gigawatt hour:	1 GWh = 1 million kWh
Megawatt hour:	1 MWh = 1,000 kWh

Kilo	k	10^3	Tera	T	10^{12}
Mega	M	10^6	Peta	P	10^{15}
Giga	G	10^9	Exa	E	10^{18}

Units for energy and capacity

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

These have been the binding statutory units in Germany since 1978. The calorie, and units derived from it, such as coal equivalent and crude oil equivalent, are still used for information purposes.

Conversion factors

		PJ	TWh	mill. t ce	mill. t oe
1 Petajoule	PJ	1	0.2778	0.0341	0.0239
1 Terawatt hour	TWh	3.6	1	0.123	0.0861
1 mill. t coal equivalent	mill. t ce	29.308	8.14	1	0.7
1 mill. t oil equivalent	mill. t oe	41.869	11.63	1.429	1

The figures refer to calorific value.

Greenhouse gases

CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide (laughing gas)
SF_6	Sulphur hexafluoride
H-FKW	Hydrofluorocarbons
FKW	Perfluorinated carbons

Other air pollutants

SO_2	Sulphur dioxide
NO_x	Ntrogen oxide
HCl	Hydrogen chloride
HF	Hydrogen fluoride
CO	Carbon monoxide
NMVOC	Non-methane volatile organic compounds

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