Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

ENVIRONMENTAL POLICY

Renewable energy sources in figures – national and international development

- Status: March 2004 -

IT'S OUR FUTURE.

Imprint

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Dear Reader,

In 2003, renewable energy sources have continued their upward development in Germany. For the first time, their share of primary energy consumption has exceeded the three-percent mark, at 3.1 percent. Although these figures may seem low at first glance, they are the result of a concerted effort by numerous dedicated, future-minded players. I believe this to be an impressive success for the year 2003, in spite of the fact that this was a significantly below-average year for hydropower and wind power. In the year 2003, renewable energy sources helped to cut CO_2 emissions in Germany by 53 million tonnes, and provided jobs for some 120,000 people in the year 2002. In 2003, renewable energy sources already accounted for 7.9 percent of total electricity supply, as well as around 4.1 percent of heat supply and approximately 0.9 percent of fuel requirements.

The year 2004 will see a further continuation of the upward trend for renewable energy sources. The Federal Government has ensured that the necessary requirements are in place:
The "major" revision of the Renewable Energy Sources Act (EEG) is scheduled to enter into force as soon as possible, bringing this particularly efficient market economy mechanism back up to date; in 2003, the EEG single-handedly effected a 23 million tonne reduction in CO_2. The improved conditions for the remuneration of solar power entered into force on 1 January 2004. This second Act Amending the EEG took the complete renewal of the Renewable Energy Sources Act a further step forward. At the beginning of the year, the new guidelines on the promotion of measures for the utilisation of renewable energy sources came into force to cover the increased demand for support. Other Federal Government programmes round off the spectrum for successful market introduction in the field of renewable energy resources. The Federal Environment Ministry has also identified a number of priority areas in the field of research and development.

Wind energy, hydropower, solar energy, biomass and geothermal energy harbour enormous potential for jobs, climate protection, the conservation of natural resources, and the development of a sustainable energy supply in general. Thanks to the turning point in energy policy initiated by the Federal Government, this development will continue to progress apace.

This brochure is being published in a fourth, updated edition, in both German and English. It offers answers to the numerous questions surrounding the current status of the expansion of renewable energy sources and the environmental successes thereby achieved in Germany. The brochure also includes an overview of the current status in the EU and at international level. I am also delighted to announce the launch of an additional information service in the form of our new website,

www.erneuerbare-energien.de, where you will find additional facts and figures on all aspects of renewable energies.

I am confident that by the year 2010, we will be able to increase the share of electricity supply derived from renewable energy sources to 12.5 %, and that of primary energy consumption to 4.2 %, and may even exceed these figures. After 2010, the expansion of renewable energy sources can really take off, once all the foundations have been laid during the current decade. As a medium-term target, the Federal Government is aiming to increase the share of electricity supply derived from renewable energy sources to at least 20 percent by 2020.

In the long term, i.e. by the middle of this century, at least half of energy supply should be derived from renewable energy sources. The fact that this is advantageous from both an ecological and an economic viewpoint is underscored by the results of our study, “Ecologically optimised expansion of renewable energy sources”.

I will continue to do everything in my power to ensure the rapid, continuous growth of renewable energies – with beneficial effects on the environment and employment, not to mention a new, up-and-coming segment of industry. In the foreseeable future, these energy sources will be able to assert themselves on the market, but for the time being they still need our support.

Jürgen Trittin
Federal Minister for the Environment, Nature Conservation and Nuclear Safety

Contents

1998 – 2003: Renewable energy sources in Germany as the cornerstones of ecological modernisation

Ecological modernisation is based on the principle of sustainability: It is a question of bringing economy and ecology into harmony with one another and facilitating a high quality of life, both now and in the future. Sustainability aims to identify ways of managing finite resources sensibly and distributing them equitably. As such, sustainability affects all policy-making areas: environmental protection and nature conservation, social justice and economic development must all work together.

In the five most important areas of environmental policy, since 1998 the Federal Government has tackled future issues which had been neglected for many years. In addition to climate protection, energy policy and transport policy, these primarily include the issues of life and health, and the area of nature conservation.

Turning point in energy policy

En route to a sustainable energy supply, the Federal Government is focussing on the phasing out of nuclear power, the rational and economical use of energy, greater energy efficiency, and the expansion of renewable energy sources.

Renewable energy sources

The Federal Government's campaign to promote renewable energy sources has proven enormously successful within just a short period of time. The Federal Government is aiming to at least double the share of energy supply from renewable energy sources by the year 2010 compared with 2000 figures: in the case of electricity to at least 12.5 %, and in the case of primary energy consumption to at least 4.2 %. By 2020, it is expected that at least 20 percent of electricity generation will be derived from renewable energy sources, increasing to at least half of Germany's primary energy consumption by 2050.

The Renewable Energy Sources Act (EEG) of 29 March 2000 is a pivotal element of these plans. It obligates electricity grid operators to purchase electricity generated from solar power, hydropower, wind power, geothermal energy and biomass, and to pay certain minimum remuneration rates for it. The EEG has proven to be a highly effective mechanism for the expansion of renewable energy sources. It is currently being revised in the light of practical experiences and on the basis of new findings vis-à-vis the development of costs and technology, and will continue to be developed to ensure that it meets the requirements of the future. A comprehensive revision of the EEG will enter into force by the summer of 2004.

A number of other governments have since introduced similar supply and compensation provisions, or are working on the implementation thereof.

The EEG supports the continued expansion of the individual renewable energy segments. In conjunction with the Biomass Ordinance, it is expected that this will trigger a similar momentum for the use of biogenic fuels as has been achieved with wind power. Initial impetus has been lent to photovoltaics with the Renewable Energy Sources Act (EEG), the

100,000 Roofs Solar Power Programme, and – since 1 January 2004 – the Second Act Amending the EEG.

Federal support programmes for the use of renewable energy sources also help to accelerate their market launch. Between 1998 and 2003, the Federal Government provided in excess of one billion euros within the context of various programmes. These include the 100,000 Roofs Solar Power Programme, whose target had already been achieved by mid-2003 with the support applications received to date. As such, the programme was a complete success.

The market launch programme for renewable energy sources, funded from part of the revenues generated by the ecological tax reform, has been further developed; updated guidelines entered into force on 1 January 2004. In particular, the market launch programme promotes the growth of renewable energy sources in the heating sector.

This is supplemented by measures targeting research and development on renewable energy sources, including those within the framework of the Federal Government's Future Investment Programme (ZIP), together with fiscal measures.

The successes are highly visible: In the year 2003, emissions of some 53 million tonnes of CO_2 were avoided thanks to the use of renewable energy sources, including a saving of around 23 million tonnes of CO_2 as a direct result of the EEG. Renewable energy sources are increasingly emerging as a significant economic factor. In Germany alone, sales revenues of 10 billion euros were achieved in 2003.

Wind power

In January 2002, within the framework of its sustainability strategy "Prospects for Germany" [1], the Federal Government submitted a strategy for the use of off-shore wind power to be headed by the Federal Environment Ministry. The strategy identifies potentially suitable areas and the anticipated sites of the areas deemed suitable for wind farms in the Exclusive Economic Zone (EEZ) of the North and Baltic Seas. The legal framework for formal designation of particularly suitable areas and of protected areas in the EEZ was improved during the course of the revised Federal Nature Conservation Act of 25 March 2002. The designation of such areas in the EEZ and the continuing development of the strategy are currently at the implementation stage.

Biomass

The Biomass Ordinance, which entered into force on 28 June 2001, coupled with the improved compensation rates within the framework of the revised EEG, laid the foundations for climate-sound electricity generation from renewable raw materials, as well as biogenic residues and wastes.

Moreover, within the context of its legislation on the ecological tax reform in June 2002, the German Bundestag (Lower House of Parliament) resolved to exempt all biofuels from the mineral oil tax between 2004 and 2009 inclusive; this was further reinforced by a more extensive resolution in November 2003. Biogas, together with synthetic gasoline and diesel from solid biomass, bioethanol, biomethanol and hydrogen from biomass, will be exempt from the mineral oil tax during this period.

Geothermal power

In order to be able to tap into Germany's geothermal potential, the Federal Government is supporting research and development work on the use of this energy source at the earth's core. The Federal Environment Ministry's Future Investment Programme is promoting a number of projects on geothermal electricity production with a total volume of 11 million euros. For the first time, the introduction of the EEG in the year 2000 specified a compensation rate for the supply of electricity from geothermal energy. According to the Guidelines on Promoting Measures for the Use of Renewable Energy Sources, geothermal plants are also eligible for grants. Since November 2003, electricity has been generated from geothermal energy for the first time in Germany. As such, the use of geothermal energy in Germany has taken a major step forwards. Now, additional sites need to be developed in order to expand geothermal electricity production.

Hydropower

For the expansion of hydropower, the main potential lies in the replacement and modernisation of existing plants, with due regard for ecological concerns. An increase in capacity, coupled with an improvement in the ecological status of watercourses, is the Federal Government's declared objective. Both the market launch programme and the EEG make allowance for this.

Photovoltaics / solar thermal energy

Between 1998 and 2003, the Federal Government's energy policy measures have led to a rapid increase in electricity generation from photovoltaic plants. As of 1 January 2004, improved conditions for the compensation of solar power entered into force with the Second Act Amending the EEG. This was the first stage in adapting the EEG. The up-and-coming German solar industry together with tradesmen and investors enjoyed a successful year in 2003, and are on track to perpetuate this success. Clarity has been achieved regarding the level of compensation for electricity from solar energy within the context of the EEG; this will ensure a seamless transition following expiry of the 100,000 Roofs Solar Power Programme.

In the area of solar thermal energy, the market showed a positive development in 2003 with the increase in installed solar collector area, partly thanks to increased support rates available from the Federal Environment Ministry since the beginning of 2003. According to the solar industry association Bundesverband Solarindustrie, solar collector area increased by around 850,000 square metres in 2003, bringing the total figure to around 5.6 million square metres of collectors installed by the end of the year. Germany is by far the largest market for solar thermal installations in Europe.

Since 1998, the solar thermal collector area in Germany has more than doubled. By 2006, according to the Coalition Agreement, the solar collector area is expected to have increased to around 10 million square metres. Market developments mean that the cost of solar thermal systems has been reduced by around 50 percent over the past 12 years. The incentive effect of the increased taxes on heating fuels as part of the ecological tax reform has also contributed to this development.

As part of the Federal Government's energy research programme, the Federal Environment Ministry's support concept "Solarthermie2000plus", launched in February 2004, will be continuing its long-term research activities into the thermal use of solar power in the low-temperature range with a change in emphasis.

Energy saving and increasing energy efficiency

The Federal Government consistently exploits the potential for rational, economical use of energy and for improving energy efficiency. Pivotal to this is the ecological tax reform introduced in 1999, as well as the measures included in the climate protection programme of October 2000. These include the Energy Saving Ordinance, the Combined Heating and Power Generation Act, as well as measures in the field of energy consumption labelling.

Funding for the building renovation programme launched in 2001 to cut CO_2 emissions was almost doubled in May 2003, using funds generated by the ecological tax reform. An additional 160 million euros per annum is now available, bringing the total available until 2005 to around 360 million euros per annum.

From 2005 onwards, it is expected that emissions trading for industrial plants will enable German industry to attain its climate protection targets even more cost-effectively and efficiently than before.

Phasing out nuclear power

On 11 June 2001, the Federal Government and energy industry signed an agreement to phase out the use of nuclear power in Germany. The revised Atomic Energy Act (AtG) of 22 April 2002 implemented the phasing out of nuclear power into German law. Under this Act, existing nuclear power stations will be decommissioned once they have generated the specified quantity of electricity for each individual plant.

For Germany's nineteen nuclear power stations, residual operating life have been decided, based on a total operating life of 32 years for each individual power station. From June 2001, this translates into an average residual operating life of 12 years. The Stade power plant was decommissioned in November 2003. The last nuclear power plant will be shut down in around 20 years' time.

Climate protection

Germany is well on its way to meeting the obligations set out in the Kyoto Protocol and accepted within the EU, to reduce its emissions of the six main greenhouse gases by 21 % by 2008/2012 compared with 1990 levels. Of the few industrialised countries which succeeded in cutting their emissions of greenhouse gases by the year 2000 compared with 1990 levels, Germany is one of the most successful, with a reduction of 19.1%. This success continues: In October 2000, the Federal Government updated its national climate protection programme with a raft of measures to further reduce emissions of greenhouse gases. In the year 2004, the Federal Environment Ministry is planning a further revision of its climate protection programme.

Contribution of renewable energy sources to energy supply, 2003

		Final energy	Primary energy equivalent [1] acc. to efficiency method	Primary energy equivalent [1] acc. to substitution method	Share of final energy consumption		Share of total energy primary energy consumption [9] acc. to efficiency method	Share of total energy primary energy consumption [9] acc. to substitution method
		[GWh]	[PJ]	[PJ]	[%]		[%]	
Electricity generation	Hydropower [2]	20,350	73.3	184.3	Share of electricity consumption [6]	3.5	0.5	1.3
	Wind energy	18,500	66.6	167.5		3.1	0.5	1.2
	Photovoltaics	323	1.2	2.9		0.1	0.01	0.02
	Biogenic solid fuels	1,700	15.4	15.4		0.3	0.1	0.1
	Biogenic liquid fuels	70	0.6	0.6		0.01	0.004	0.004
	Biogas	1,100	10.0	10.0		0.2	0.1	0.1
	Sewage gas	770	7.0	7.0		0.1	0.05	0.05
	Landfill gas	1,500	13.6	13.6		0.3	0.1	0.1
	Geothermics [3]	0.0	0.0	0.0		0.0	0.0	0.0
	Biogenic share of waste [4]	1,945	17.6	17.6		0.3	0.1	0.1
	Total	**46,258**	**205.1**	**418.9**		**7.9**	**1.4**	**2.9**
Heat generation [5]	Biogenic solid fuels	52,264	188.2		Share of final energy consumption for heat [7]	3.5	1.3	
	Biogenic gaseous fuels	1,500	5.4			0.1	0.04	
	Biogenic liquid fuels	220	0.8			0.01	0.006	
	Solar thermal en.	2,494	9.0			0.2	0.06	
	Deep geothermal en.	114	0.4			0.01	0.003	
	Near-surface geothermal en.	1,418	5.1			0.1	0.04	
	Biogenic share of waste [4]	2,817	10.1			0.2	0.07	
	Total	**60,827**	**219.0**			**4.1**	**1.5**	
Fuel	Biodiesel	6,722	24.2		Share of final energy consumption attributable to transport	0.9	0.2	
	Total	**6,722**	**24.2**			**0.9**	**0.2**	
Total		**113,807**	**448**	**662**		**4.4** [8]	**3.1**	**4.6**

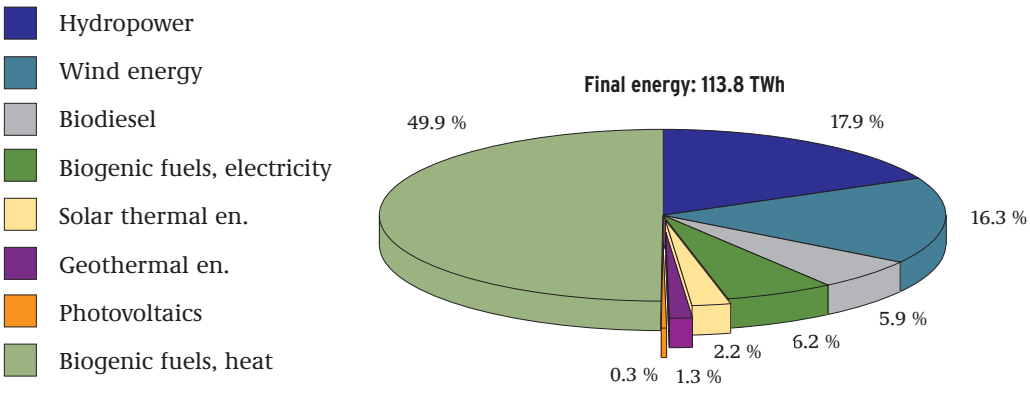
As per January 2004, provisional figures

1) For an explanation of the methods used to determine primary energy equivalent, cf. Appendix (4)
2) For pumped-storage power stations, only electricity generation from natural supply
3) Electricity generation from geothermal energy in a pilot phase to date
4) Biogenic share estimated at 50 %
5) Contributions from biogenic solid, liquid and gaseous fuels and from waste are estimated, apart from the direct final energy supply from firewood
6) In relation to gross electricity consumption 2003
7) In relation to final energy consumption for room heating, hot water and other process heat; 2002
8) In relation to final energy consumption 2002
9) For an explanation of the term "primary energy consumption", refer to the Appendix

For electricity generation from photovoltaic energy and for heat supply from solar thermal energy, cf. also the Appendix (5).

Sources:
ZSW [3]; acc. to IÖW [7]; acc. to BSi [10]; IE [20]; AGEB [9], [11]; [18]; [50]; BMVEL [15]; StBA [5]

Structure of energy supply from renewable energy sources, 2003



Around half of all final energy from renewable energy sources is provided by biomass.

In terms of heat generation from renewable energy sources, biomass (primarily wood) accounts for a share of 93 %.

In terms of electricity generation, renewable energy sources hydropower (44 %) and wind power (40 %) top the league.

Sources:
see above table

Temporal development of energy supply from renewable energy sources and installed capacity from 1990 to 2003

Final energy

	Hydropower [1]		Wind energy		Biomass electricity [2]		Electricity from biogenic portion of waste [3]	Photovoltaics [4]		Total electricity generation	Biomass heat [5]	Solar thermal energy		Geothermal energy [6]	Total heat generation	Biodiesel	Total energy supply
	[GWh]	[MW]	[GWh]	[MW]	[GWh]	[MW]	[GWh]	[GWh]	[MW_p]	[GWh]	[GWh]	[GWh]	[1,000 m^2]	[GWh]	[GWh]	[GWh]	[GWh]
1990	17,000	4,403	40	56	222	190	1,200	1	2	**18,463**	N/A	130	338	N/A	**130**	N/A	**18,592**
1991	15,900	4,403	140	98	250	N/A	1,200	2	3	**17,492**	N/A	166	466	N/A	**166**	2	**17,660**
1992	18,600	4,374	230	167	295	227	1,250	3	6	**20,378**	N/A	218	582	N/A	**218**	52	**20,648**
1993	19,000	4,520	670	310	370	N/A	1,200	6	9	**21,246**	N/A	279	749	N/A	**279**	103	**21,628**
1994	20,200	4,529	940	605	570	276	1,300	8	12	**23,018**	N/A	351	940	N/A	**351**	259	**23,627**
1995	21,600	4,521	1,800	1,094	670	N/A	1,350	11	16	**25,431**	N/A	440	1,156	1,425	**1,865**	310	**27,606**
1996	18,800	4,563	2,200	1,547	803	358	1,400	16	24	**23,219**	N/A	550	1,453	1,383	**1,934**	517	**25,670**
1997	19,000	4,578	3,000	2,082	879	400	1,600	26	36	**24,505**	48,546	695	1,817	1,335	**50,576**	827	**75,909**
1998	19,000	4,601	4,489	2,875	1,050	409	1,750	32	45	**26,321**	51,613	857	2,191	1,384	**53,854**	1,034	**81,209**
1999	21,300	4,547	5,528	4,444	1,170	448	1,850	42	58	**29,890**	50,951	1,037	2,638	1,429	**53,417**	1,344	**84,651**
2000	24,936	4,572	9,500	6,112	2,279	585	1,850	64	100	**38,629**	54,314	1,279	3,283	1,433	**57,025**	2,585	**98,239**
2001	23,383	4,600	10,456	8,754	3,206	825	1,859	116	178	**39,020**	55,326	1,626	4,207	1,447	**58,399**	3,620	**101,038**
2002	23,824	4,620	15,856	12,001	4,467	900	1,945	188	258	**46,280**	56,168	1,955	4,754	1,483	**59,606**	5,688	**111,574**
[7] 2003	20,350	4,625	18,500	14,609	5,140	950	1,945	323	388	**46,258**	56,801	2,494	5,600	1,532	**60,827**	6,722	**113,807**

Installed capacity data refers to the status as per the year-end in each case.

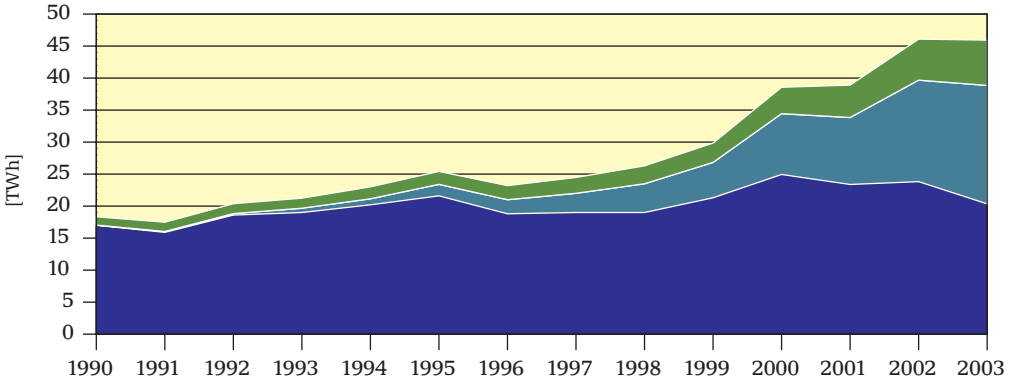
1) 1990 estimated; in the case of pumped-storage power stations, electricity generation from natural supply only.
Output data including pumped-storage power stations with natural supply (approx. 1,200 MW)
2) Estimates; up to and including 2000, allowance is only made for infeed into the general supply grid
3) Biogenic share estimated at 50 %
4) Capacity figures and electricity generation do not include isolated plants
5) Including heat supply from biogenic portion of waste, estimated
6) Deep and near-surface geothermal energy
7) Provisional figures, as per January 2004

For electricity supply from photovoltaic energy and for heat supply from solar thermal energy, cf. also Appendix (5)

Sources: ZSW [3]; StBA [5]; AGEB [9]; [14]; [50]; BWE [16]; IÖW [7]; IE [8]; [20]; acc. to BSi [10]; acc. to GtV [12]; UFOP [13]; VDEW [51]; BMVEL [15]; AGEB [59]

The energy supply from hydropower, wind power and solar energy is subject to natural fluctuations, which may have both a short-term and seasonal effect, and which may also affect the entire annual energy yield. The heat supply from renewable energy sources, on the other hand, is particularly influenced by the demand for heat, which varies depending on the exterior temperature. For example, the specific electricity yield from hydropower and wind power plants was around 15 – 20 % lower in 2003 than the long-term average of many years.

Contribution of renewable energy sources to electricity generation, 1990 to 2003



Biomass[1)]
Wind energy
Hydropower

The contribution of photovoltaic energy is not shown, because it is minimal.

1) Including biogenic portion of waste

Sources:
See table above

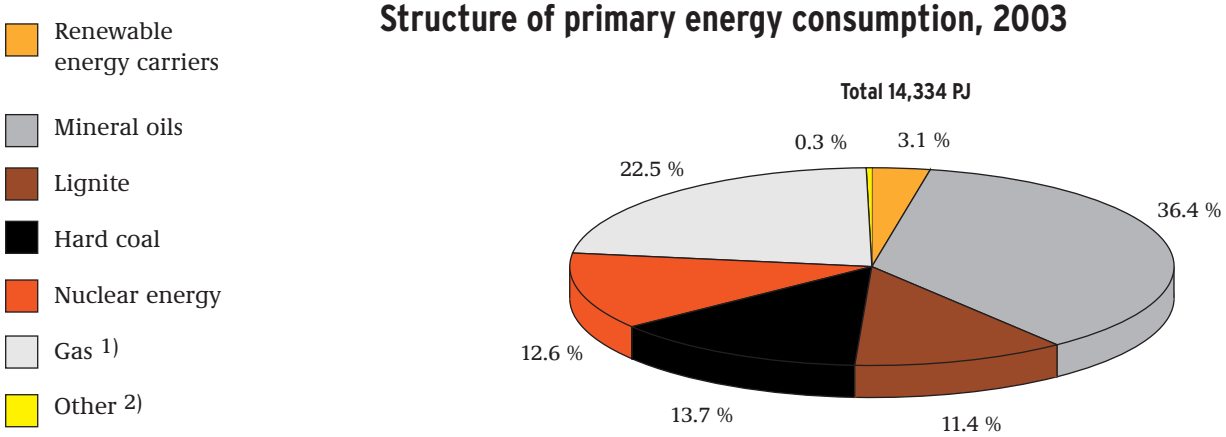
Renewable energy sources as a share of energy supply

1) Provisional figures
2) Reference year for heat supply and fuel consumption 2002
3) Cf. data on biogenic heat supply, page 12
4) According to efficiency method, see Appendix (4)

Sources:
acc. to previous tables; acc. to VDEW [17]; acc. to AGEB [11]; [18]

	2000	2001	2002	2003 1)2)
Final energy consumption		[%]		
Electricity generation				
(in relation to total gross electricity generation)	6.7	6.7	7.95	7.9
Heat supply 3)				
(in relation to total heat supply)	3.9	3.8	4.0	4.1
Fuel consumption				
(in relation to total fuel consumption)	0.3	0.5	0.8	0.9
Primary energy consumption4)	**2.6**	**2.7**	**3.0**	**3.1**
Electricity generation				
(in relation to total primary energy consumption)	1.1	1.2	1.4	1.4
Heat supply 3)				
(in relation to total primary energy consumption)	1.4	1.4	1.5	1.5
Fuel consumption				
(in relation to total primary energy consumption)	0.06	0.09	0.14	0.17

Structure of primary energy consumption, 2003



As at January 2004, provisional figures

1) Natural gas, petroleum gas, pit gas
2) Foreign trade balance for electricity and other energy carriers

Sources:
acc. to ZSW [3]; acc. to AGEB [11]

Fossil fuels saved via the use of renewable energy sources, 2003

1) Valued as primary electricity
2) Disregarding electric heaters
3) Fossil diesel fuel, final energy

On the saving of fossil energy carriers via the generation of heat from renewable energy sources, cf. also Appendix (6).

Source:
ZSW [3]

	Lignite / hard coal	Gas	Heavy oil / light fuel oil	Diesel fuel	Nuclear energy 1)	Total
	Primary energy [TWh]					
Electricity	**84.0**	**15.8**	**1.5**	**-**	**15.0**	**116.3**
Heat 2)	**0.9**	**33.6**	**26.3**	**-**	**-**	**60.8**
Fuel 3)	**-**	**-**	**-**	**6.7**	**-**	**6.7**
Total	**84.9**	**49.4**	**27.8**	**6.7**	**15.0**	**183.8**

	Primary energy [PJ]					
Total	**306**	**178**	**100**	**24**	**54**	**662**

Emissions avoided via the use of renewable energy sources, 2003

Electricity generation: 46,258 GWh (46.3 TWh) from hydropower, wind power, biomass, solar energy

	Greenhouse gas/ air pollutant	Electricity I [1]		Electricity II [2]		Electricity III [3]	
		Emission factor [4]	Avoided emissions	Emission factor [4]	Avoided emissions	Emission factor [4]	Avoided emissions
		[kg/GWh]	[1,000 t]	[kg/GWh]	[1,000 t]	[kg/GWh]	[1,000 t]
Greenhouse effect [5]	CO_2	594*10³	27,455	924*10³	42,757	800*10³	37,006
	CH_4	10.8	0.5	16.9	0.8	14.6	0.7
	N_2O	20.9	1.0	32.5	1.5	28.1	1.3
	CO_2 equivalent	600*10³	27,765	935*10³	43,240	809*10³	37,424
Acidification [6]	SO_2	334.7	15.5	521.0	24.1	451.2	20.9
	NO_X	427.4	19.8	665.9	30.8	576.0	26.6
	HCl	14.9	0.7	23.2	1.1	20.1	0.9
	HF	1.0	0.05	1.6	0.1	1.4	0.1
	SO_2 equivalent	646.9	29.9	1,007.4	46.6	871.9	40.3
Ozone [7]	CO	120.5	5.6	187.7	8.7	162.4	7.5
	NMVOC	17.5	0.8	27.2	1.3	23.5	1.1
	Fly ashes	31.4	1.5	48.9	2.3	42.3	2.0
	other dust	5.2	0.2	8.1	0.4	7.0	0.3

1) Fossil power station mix and nuclear energy, general supply only
2) Fossil power station mix only, general supply only
3) Assumed power station mix that is replaced by renewable energy sources
4) In relation to net electricity generation
5) Other greenhouse gases (SF_6, PFC, HFC) not relevant here
6) Other air pollutants with acidification potential (HCl, HF) not relevant here
7) Formation of ground-level ozone precursors

For calculation of the emission factors and for the various electricity mix variants, cf. Appendix (1).

Sources:
ZSW [3]; Gemis, Öko-Institut [2]; AGEB [18]

Heat supply: 60,827 GWh (60.8 TWh) from biomass, solar thermal and geothermal energy

When combusted, biomass only emits the same quantity of CO_2 into the atmosphere as was absorbed during its growth, and is therefore CO_2-neutral. The other pollutants created during the combustion of biomass – particularly NO_X, CO and dust – are disregarded here. With older incineration plants or when combusting wood in tile stoves or fireplaces, emission of these pollutants are significantly higher than with the fossil heat supply mix. Modern wood-fired systems (heaters and heating plants) may substantially reduce emissions.

	Greenhouse gas / air pollutant	Emission factor [1]	Avoided emissions
		[kg/GWh]	[1 000 t]
Greenhouse effect [2]	CO_2	228.5*10³	13,902
	CH_4	8.3	0.5
	N_2O	1.9	0.1
	CO_2 equivalent	229.3*10³	13,948
Acidification [3]	SO_2	140.8	8.6
	NO_X	88.3	5.4
	HCl	1.4	0.1
	HF	0.1	0.01
	SO_2 equivalent	203.6	12.4
Ozone [4]	CO	297.0	18.1
	NMVOC	11.6	0.7
	Fly ashes	7.4	0.5
	Other dust	2.9	0.2

1) In relation to final energy, only room heating plus central hot water supply to private households; heat supply mix excluding renewable energy sources, 2002
2) Other greenhouse gases (SF_6, PFC, HFC) not relevant here
3) Other air pollutants with acidification potential (HCl, HF) not relevant here
4) Formation of ground-level ozone precursors

For calculation of the emission factors and avoided emissions, cf. Appendix (2).

Sources:
ZSW [3]; Gemis, Öko-Institut [2]; Stat. Bundesamt [44]; VDEW [17]

Emissions avoided via the use of renewable energy sources, 2003

Emission reduction via the generation of electricity and heat from renewable energy sources

1) Assumed power plant mix that is replaced by renewable energy sources; cf. also Appendix (1)
2) Other greenhouse gases (SF_6, PFC, HFC) not relevant here
3) Other air pollutants with acidification potential (HCl, HF) not relevant here
4) Formation of ground-level ozone precursors

For calculation of the emission factors and avoided emissions, see Appendix (1) and (2).

Sources:
ZSW [3]; Gemis, Öko-Institut [2]

	Greenhouse gas/ air pollutant	Avoided emissions [1,000 t]		
		Electricity III [1)]	Heat	Total
Greenhouse effect [2)]	CO_2	37,006	13,902	50,908
	CH_4	0.7	0.5	1.2
	N_2O	1.3	0.1	1.4
	CO_2 equivalent	37,424	13,948	51,372
Acidification [3)]	SO_2	20.9	8.6	29.4
	NO_X	26.6	5.4	32.0
	HCl	0.9	0.1	1.0
	HF	0.1	0.01	0.1
	SO_2 equivalent	40.3	12.4	52.7
Ozone [4)]	CO	7.5	18.1	25.6
	NMVOC	1.1	0.7	1.8
	Fly ashes	2.0	0.5	2.4
	Other dust	0.3	0.2	0.5

The generation of electricity and heat from renewable energy sources reduces CO_2 emissions by around 51 million tonnes per annum.

Fuel: 650,000 tonnes of biodiesel

Sources:
ZSW [3]; Gemis, Öko-Institut [2]; Ifeu [49]; BMVEL [15]

Greenhouse gas	Emission factor	Avoided emissions
	[kg/GWh]	[1 000 t]
CO_2 equivalent	242* 10^3	1,639

Biodiesel is not classed as CO_2-neutral, because methanol of fossil origin is used in the manufacture of biodiesel, and fertilisation of the rape plants generally produces nitrogen oxide (N_2O) emissions. However, these negative effects may be at least partially compensated via appropriate use of the by-products – glycerine and rapeseed waste – that are incurred during the production of biodiesel.
For the emission factor given in the table, it is assumed that approximately 80 % of the equivalent climate gas emissions of conventional diesel are currently avoided via the use of biodiesel.

Development of energy-related emissions in Germany, 1990 to 2003

	CO_2	CO_2 equivalent	SO_2	SO_2 equivalent 1)	NO_X 2)	CO
	[million t]	[million t]	[1,000 t]	[1,000 t]	[1,000 t]	[1,000 t]
1990	986.8	1,035.5	5,096	6,958	2,675	10,511
1991	951.1	997.2	3,905	5,623	2,469	8,859
1992	902.9	948.2	3,223	4,813	2,284	7,746
1993	893.0	936.1	2,865	4,377	2,173	7,139
1994	877.2	917.3	2,395	3,804	2,024	6,471
1995	877.4	915.6	1,854	3,212	1,951	5,926
3) **1996**	898.6	935.1	1,261	2,560	1,866	5,551
3) **1997**	867.5	902.7	961	2,181	1,753	5,359
3) **1998**	860.3	894.0	756	1,900	1,643	4,855
3) **1999**	833.2	865.4	660	1,764	1,586	4,593
3) **2000**	831.8	861.1	562	1,641	1,550	4,207
4) **2001**	849.1	N/A	574	1,658	1,558	4,229
4) **2002**	833.6	N/A	N/A	N/A	N/A	N/A
4) **2003**	836.6	N/A	N/A	N/A	N/A	N/A

Figures including emissions incurred during the extraction and distribution of fuels

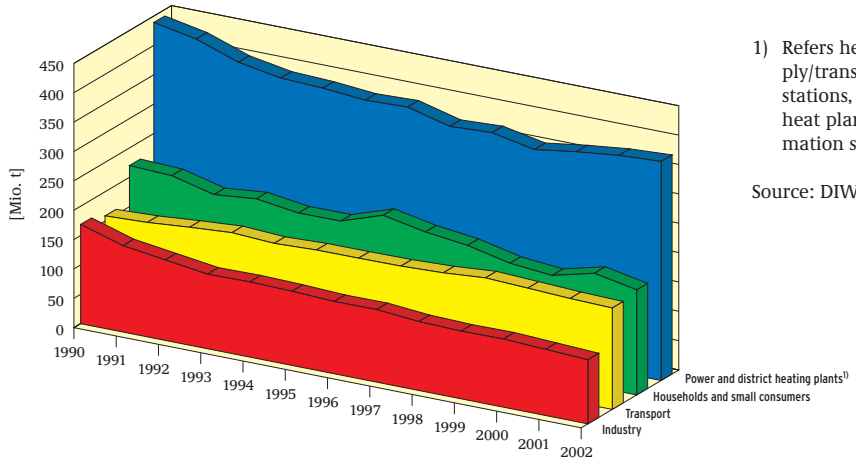
1) Includes SO_2 and NO_X
2) Calculated as NO_2
3) Provisional figures
4) Calculation/estimate DIW [40]

For the significance and calculation of CO_2 and SO_2 equivalents, see Appendix (3).

Sources:
UBA [4]; [41]; DIW [40]; ZSW [3]

Development of energy-related CO_2 emissions, 1990 to 2002

Between 1990 and 2003, energy-related CO_2 emissions were cut by around 15 %; up until the year 2000, total emissions of greenhouse gases had been reduced by 19 %.

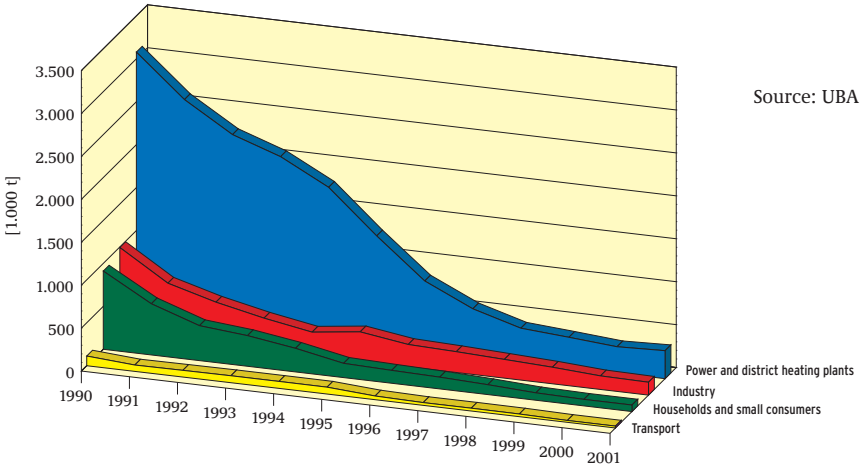


1) Refers here to all energy supply/transformation with power stations, heat plants / district heat plants and other transformation sectors

Source: DIW [40]

Development of energy-related SO_2 emissions, 1990 to 2001

Energy-related emissions of sulphur dioxide were reduced by 89 % between 1990 and 2001.



Source: UBA [41]

Structure of energy-related emissions according to consumption sectors, 2001

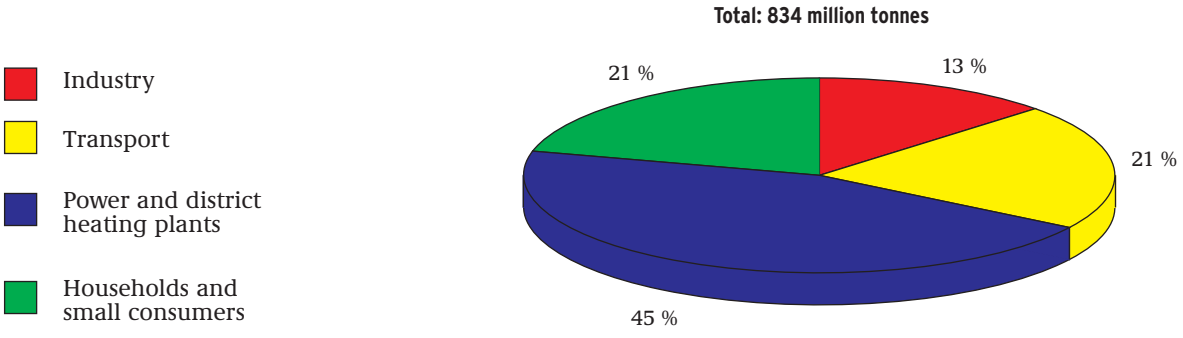
Provisional figures

1) Power and district heating plants of the public supply, refineries, coal mining, extraction of crude oil and natural gas
2) Including agriculture, forestry and military offices
3) Including rail traffic, national aviation, coastal and inland shipping
4) Manufacturing industry; excluding process-related emissions
5) Total also includes emissions from the extraction and distribution of fuels
6) Electricity and heat generation from renewable energies
7) Calculated as NO_2
8) Includes SO_2 and NO_X

Sources:
ZSW [3]; UBA [4]

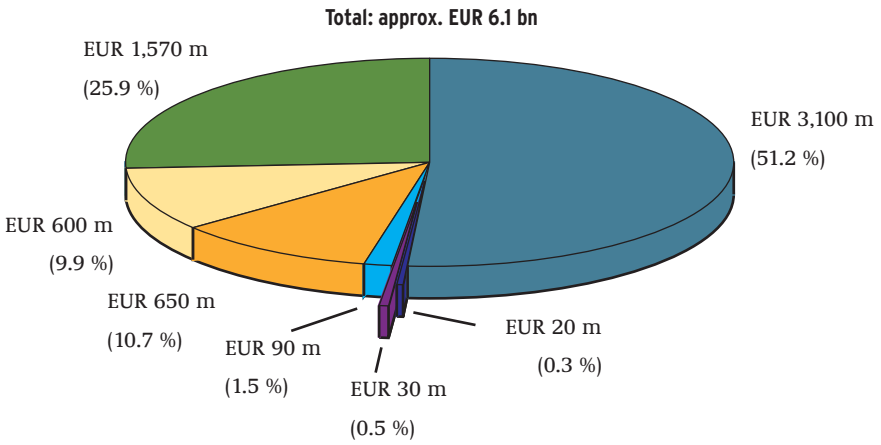
		Power and district heating-plants 1)	Households and small consumers 2)	Transport 3)	Industry 4)	Total 5)	Savings from RE 6) (2003)
CO_2	[million t]	345	190	178	133	846	50.9
CH_4	[1,000 t]	5	31	15	5	776	1.2
N_2O	[1,000 t]	12	2	21	3	38	1.4
CO_2 equivalent	[million t]	349	191	185	133	874	51.4
SO_2	[1,000 t]	326	76	21	150	594	29.4
NO_X 7)	[1,000 t]	272	128	1,000	159	1,558	32.0
SO_2 equivalent 8)	[1,000 t]	515	165	717	260	1,678	52.7
CO	[1,000 t]	104	1.063	2,395	657	4,229	25.6

Sector shares of energy-related CO_2 emissions, 2002



Source: DIW [40]

Turnover from the construction of plants for the use of renewable energy sources, 2003



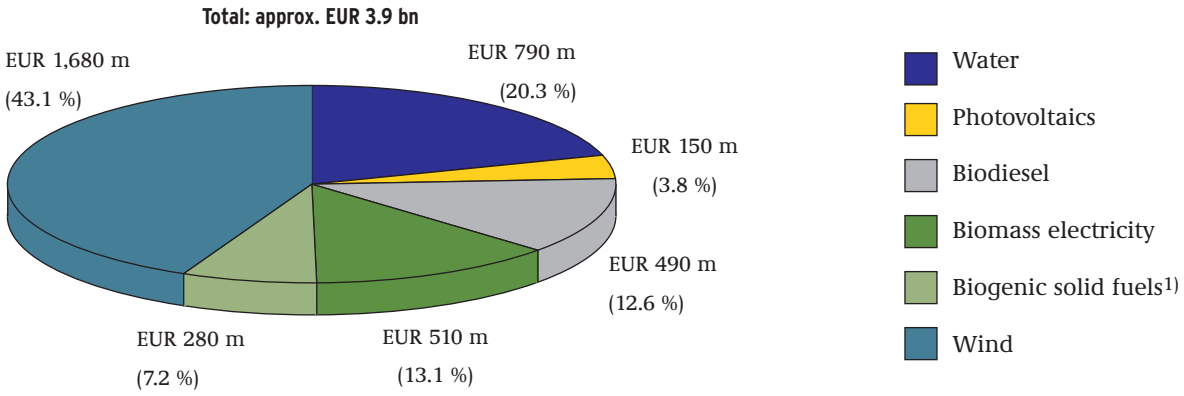
Estimate

1) Large installations
2) Including biogas

Source: ZSW [3]

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

Turnover from the operation of plants for the use of renewable energy sources, 2003



Estimate

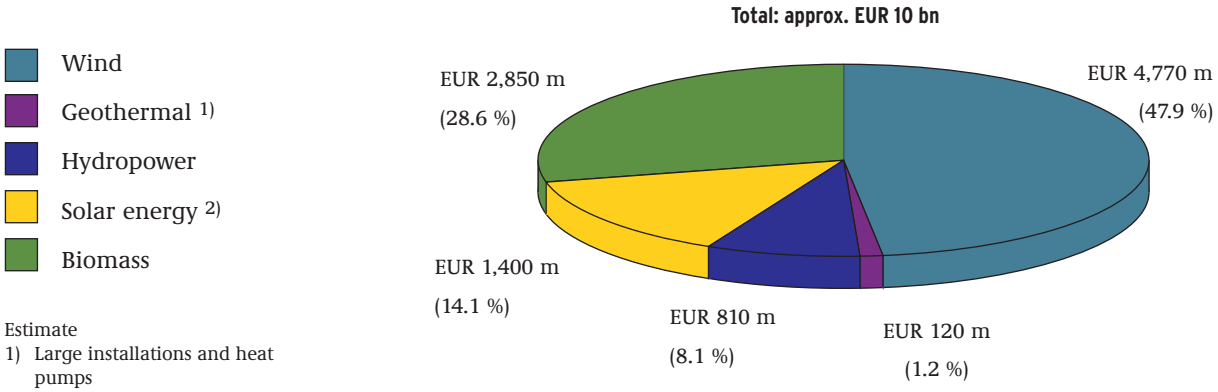
1) Only fuels used exclusively for the supply of heat.

For explanatory comments cf. Appendix (7).

Source: ZSW [3]

In the case of electricity generation, turnover is generated from the power remuneration paid or from the price attainable on the open electricity market, and in the case of fuel, from the sale of biodiesel. In the case of heat generation, turnover only refers to the sale of fuels, i.e. as a general rule wood, since in the majority of cases the heat produced is not sold, but used internally.

Total turnover with renewable energy sources, 2003

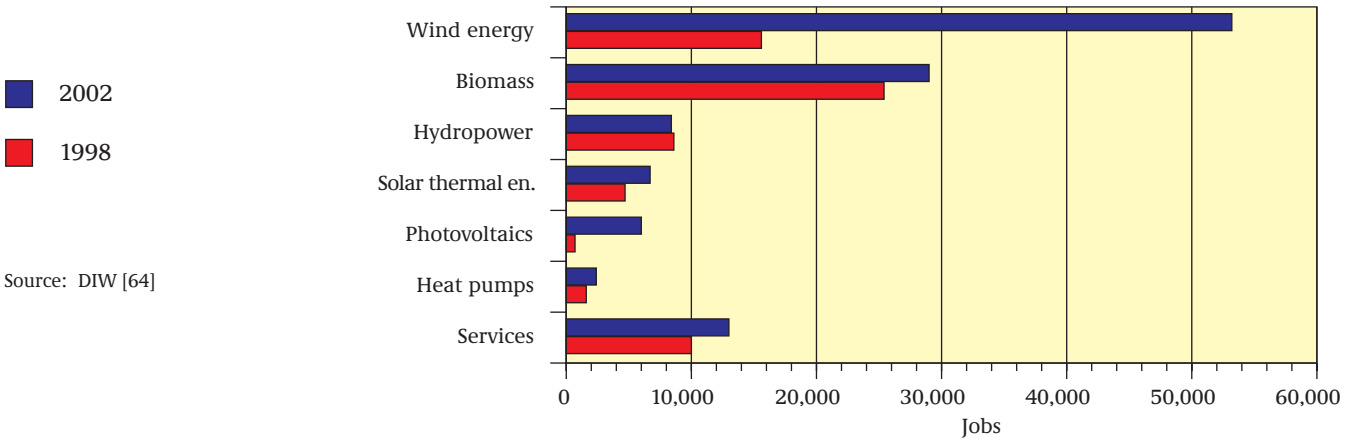


Estimate
1) Large installations and heat pumps

2) Photovoltaic and solar thermal energy

Source: ZSW [3]

Employment effects from the use of renewable energy sources

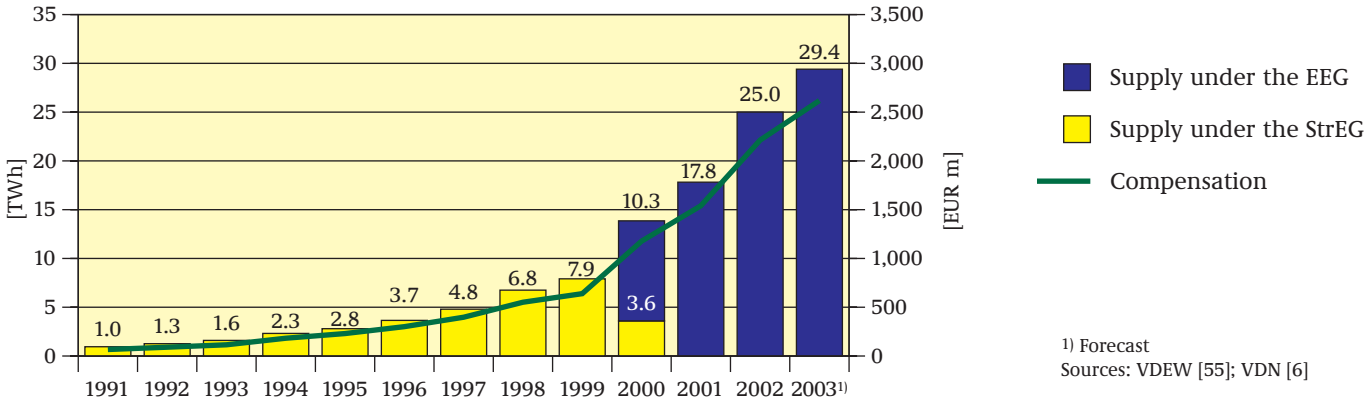


Source: DIW [64]

The employment effect from the use of renewable energy sources may be estimated by first ascertaining the overall demand for goods and services, based on the investment volume and operating costs of the plants. Taking into account the close links between the individual segments of industry, it is then possible to determine the effects on employment arising from the demand for goods and services in the individual sectors using so-called labour-output ratios (number of employees per unit of gross production value).

For the year 2002, around 120,000 employees may be allocated to the renewable energy sources segment, 50,000 more than in the year 1998.

Supply and compensation under the Act on the Sale of Electricity to the Grid (StrEG) and the Renewable Energy Sources Act (EEG)



1) Forecast
Sources: VDEW [55]; VDN [6]

On 1 April 2000, the Act on the Sale of Electricity to the Grid was replaced by the Renewable Energy Sources Act, and the compensation rates were increased. Around two-thirds of the total compensation is currently attributable to electricity from wind power. In 2003, an average rate of 8.91 ct/kWh was paid for electricity from renewable energy sources (provisional figures).

Report by the Federal Cabinet on its experiences with the EEG

On 10 July 2002, the Federal Cabinet presented its first report on experiences gleaned from the Renewable Energy Sources Act [25], which confirms the success of the EEG and the Biomass Ordinance.

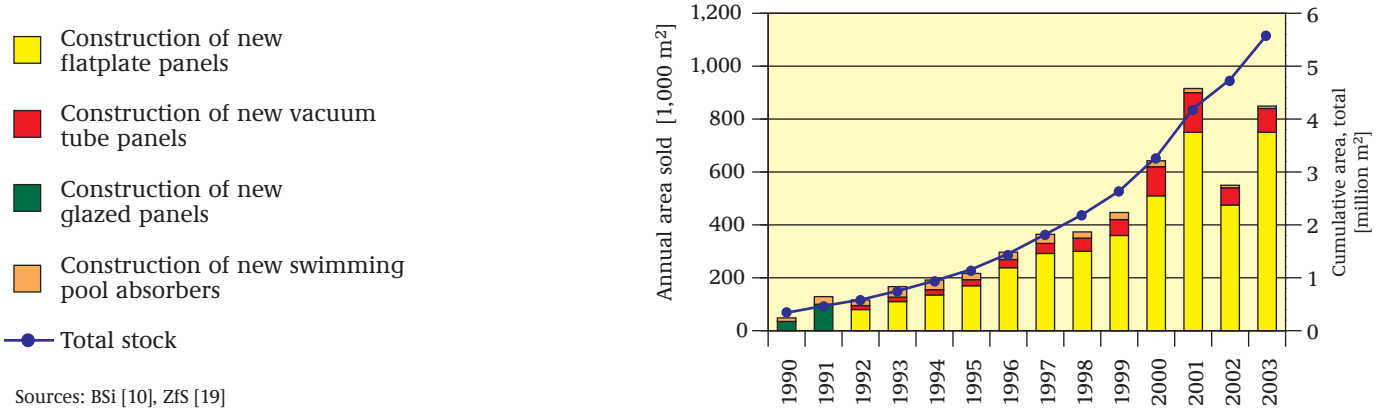
Thanks to the EEG and additional measures, it currently appears that the Federal Government's target of doubling the share of electricity generated from renewable energy sources to 12.5 % by the year 2010 compared with 2000 figures is attainable. However, in order to achieve this, government support will continue to be needed for the foreseeable future. This ranges from the promotion of research and development work, to the granting of investment incentives, through to statutory supply and compensation provisions.
The EEG enjoys an exemplary reputation worldwide and has attracted keen global interest. It has since been translated into numerous languages. A number of countries, including Spain, Portugal, Greece, France and the Czech Republic, have introduced similar provisions. European comparison has shown price provisions such as the EEG to be the most effective market economy instruments for achieving rapid growth with renewable energy sources. Development of the expansion of renewable energy sources has clearly shown that Germany has adopted the correct approach in opting for the EEG. The successes anticipated at its adoption are now becoming reality.

A revised version of the EEG containing further improvements for the expansion of renewable energy sources will enter into force by the summer of 2004.

Programme to promote measures for the use of renewable energy sources

In 2003, the programme encouraged a total support volume of 190 million euros. In 2004, 200 million euros will be available for subsidies and partial debt waivers in conjunction with soft loans, increasing to 230 million euros by 2006. The support programme is funded by the ecological tax reform.
As well as promoting installations for the incineration of solid biomass, small biogas and hydropower installations, geothermal systems and photovoltaic installations in schools, to date, almost 90 % of the subsidies granted via the programme have been used to promote solar thermal collectors.
Since the programme's launch in August 1999, it has prompted investments totalling 1.9 billion euros in solar thermal installations alone.

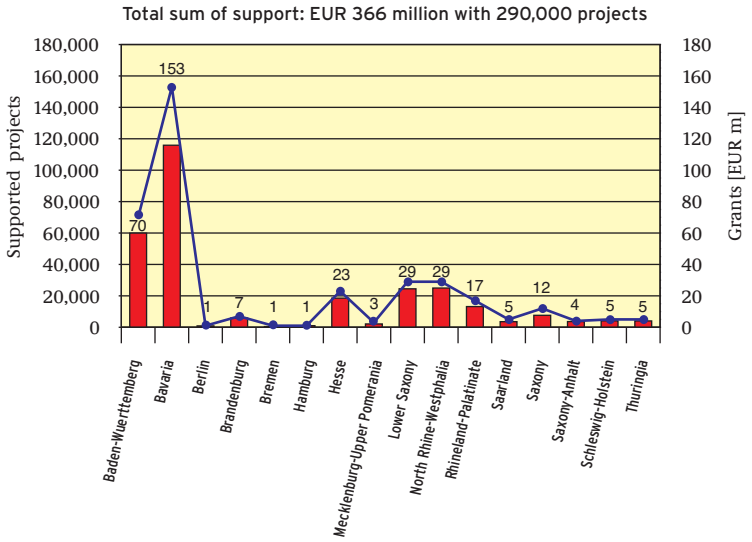
Development of the sale of solar panels



Sources: BSi [10], ZfS [19]

The decline in the number of support applications for solar thermal installations in 2002 was partly due to the reduction in subsidies offered by the programme, coupled with the general economic situation. Since subsidies were increased by the Federal Environment Ministry in 2003, the market has seen a pronounced recovery. Promotion via the programme, and the associated market development, have helped to establish German producers of solar collectors, stores, controllers and other components as world technological leaders. Over the past 12 years, costs have been cut by around 50 %. Many of these solar collectors have been awarded the eco-label RAL-UZ 73[1]. These collectors are distinguished by a high level of energy efficiency and a low level of pollutants.

Regional distribution of subsidies in the market launch programme from 1 January 1999 to 1 March 2004



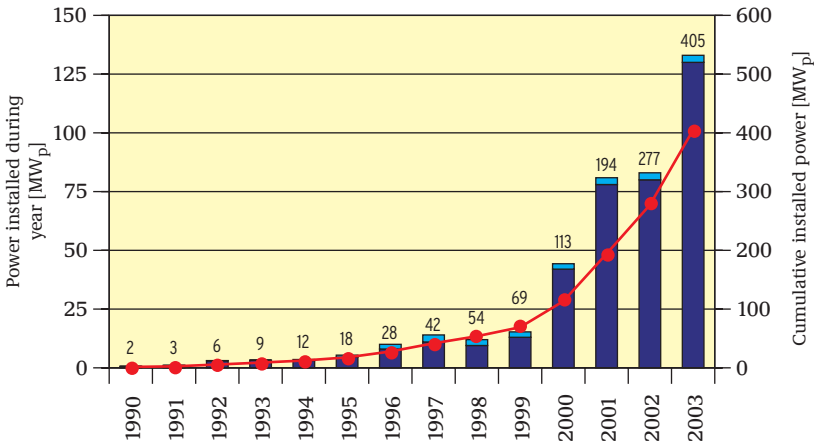
Source: BAFA [42]

1) Product requirements by the German Institute for Quality Assurance and Labelling, "Blue Angel" eco-label

100,000 Roofs Solar Power Programme

The programme, which was launched in 1999 to promote photovoltaic installations, was successfully completed in 2003. This programme was responsible for installing a capacity of around 350 MW_p on more than 60,000 roofs in Germany, thus accounting for the bulk of the total photovoltaic capacity of around 400 MW_p. The loan agreement volume totalled around 1.7 billion euros, thus prompting an investment volume of around 2.4 billion euros.

Development of installed photovoltaic capacity in Germany



With the expiry of this successful programme, the improved conditions for the remuneration of solar power entered into force on 1 January 2004 within the context of the EEG (Second Act Amending the EEG). The new remuneration rates apply to photovoltaic installations which commenced operation on or after 1 January 2004. In addition, the KfW (Reconstruction Loan Corporation) Group continues to offer attractive loans to private households within the context of the KfW CO_2 reduction programme, and to commercial enterprises within the context of the KfW environmental programme, for the funding of photovoltaic installations.

Grid-connected

Off-grid

Cumulative installed power

Source: BSi [10]

Assessment of monetary incentives for the market launch of renewable energy sources from the principal mechanisms at Federal Government level, 2003

Mechanism	[EUR m]	Calculation basis / comments
Renewable Energy Sources Act	1,225	Infeed of 29.4 bn kWh with an average infeed compensation of 8.91 cent/kWh and an assessed value for the electricity of 4.74 cent/kWh. Around 80 % of electricity from hydropower originates from plants with more than 5 MW capacity; this share is not remunerated via the EEG.
Programme to promote measures for the use of renewable energy sources (Market launch programme)	190	Data excluding the export initiative for renewable energy sources and measures for energy saving and rational energy use
100,000 Roofs Solar Power Programme	69	Estimated value based on loan agreements in the period 1999-2003 totalling approximately EUR 1.7 bn with an assumed interest rate reduction of 4.5 % p.a.
ERP environmental and energy saving programme	119	Estimated value based on loan agreements in the period 1994-2003 totalling around EUR 7.7 bn with an average assumed interest rate subsidy over 10 years of approximately 1.5 % p.a.
KfW environment programme, DtA environment programme 1)	46	Estimated value on the basis of loan agreements from the German Equalisation Bank or KfW group of banks during the period 1994-2003 of around EUR 4.0 bn with an assumed interest rate subsidy over 10 years of around 1.5 % p.a. on average
Home ownership subsidy	22	Eco-supplements paid for new technologies
Total	1,671	Excluding research and development, measures by the Länder and local authorities, and private subsidies

For evaluation of the support from loan programmes, cf. also Appendix (8).

1) As at 15 July 2003 the DtA environment programme and the KfW environment programme were combined

Sources:
ZSW [3]; VDN [6]; KfW [21]; KfW [22]; BMF [45]

Although financial supports for renewable energy sources are still required in the majority of cases, on the other hand, external costs for the supply of fossil and nuclear supply of energy can be avoided through their use.

Long-term utilisation potential of renewable energy sources for electricity, heat and fuel supply (Final energy)

	Utilisation	Potential		Comments
	2003	Yield	Capacity	
Electricity generation	[TWh]	[TWh/a]	[MW]	
Hydropower	20.4	24	5,200	Run-of-river plants and natural inflow to reservoirs
Wind energy				
on-shore	18.5	55	25,000	
off-shore	-	110	30,000	
Biomass	7.1	60	10,000	Generation partly in combined heat/power generation
Photovoltaics	0.32	105	1) 115,000	Only suitable roof, facade and human settlement areas
Geothermal energy	-	200	30,000	Bandwidth 66 - 290 TWh/a depending on heat utilisation requirements (combined heat/power)
Total	**46.3**	**554**		
Share in relation to gross electricity consumption 2003	**7.9 %**	**94 %**		

Heat generation	[TWh]	[TWh/a]	
Biomass	57	200	Including useful heat from combined heat/power generation
Geothermal energy	2	330	Only energy supply from hydrothermal sources
Solar thermal energy	2	290	human settlement areas
Total	**61**	**820**	
Share in relation to final energy consumption for heat2) 2002	**4.1 %**	**55 %**	

Fuels	[TWh]	[TWh/a]
Biomass	7	60
Total	**7**	**60**
Share in relation to fuel consumption 2003	**0.9 %**	**8 %**
Share in relation to final energy consumption 2002	4.4 %	56 %

Imports of energy carriers on the basis of renewable energy sources are not included in the figures.

1) Figures in relation to modular capacity (MWp), the corresponding A/C current is 106,000 MW
2) Room heat, hot water and other process heat

Source: Work group DLR, Ifeu, WI [27]; Work group Öko-Institut, FhG-Umsicht, IE, ifeu, izes, TU Berlin, TU Braunschweig, TU München [38]

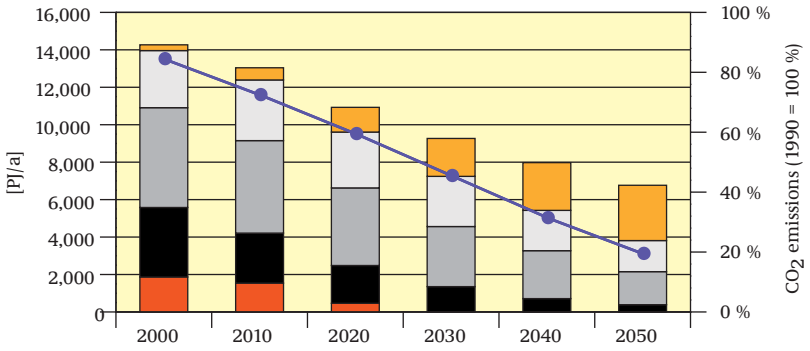
Due to varying assumptions regarding the availability of suitable locations, the technical characteristics of the utilising technologies, combined with a number of other factors, the results of potential estimates may vary considerably. The guideline values given here make particular allowance for the requirements of nature and landscape conservation, and hence represent the lower limits of the technically feasible potential.

The energetic use of biomass has a high degree of flexibility. Depending on requirements, therefore, the percentages allocated to the segments electricity, heat and fuel supply may vary. This is particularly applicable to the cultivation of energy crops (based here on a cultivation area of 4.2 million hectares).

Scenario for the ecologically optimised expansion of renewable energy sources

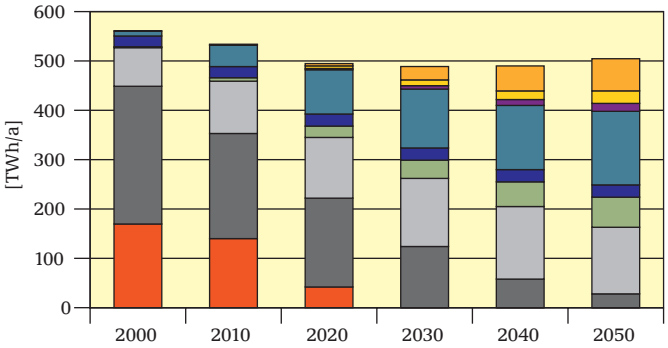
The scenario represents the potential development of energy supply until the year 2050, facilitating an 80 % reduction in CO_2 emissions compared with 1990 figures via the intensified expansion of renewable energy sources and the more efficient use of energy. It is expected that by the year 2020, 12 % of primary energy consumption and 30 % of electricity generation can be met from renewable energy sources. By the year 2050, according to the scenario, the share of electricity generation from renewable energy sources will increase to 68 %, whilst the contribution of renewable energy sources to heat supply will increase to around 50 %.

Development of primary energy consumption and CO_2 emissions until 2050



Source: DLR, ifeu, WI [27]

Development of electricity generation until 2050

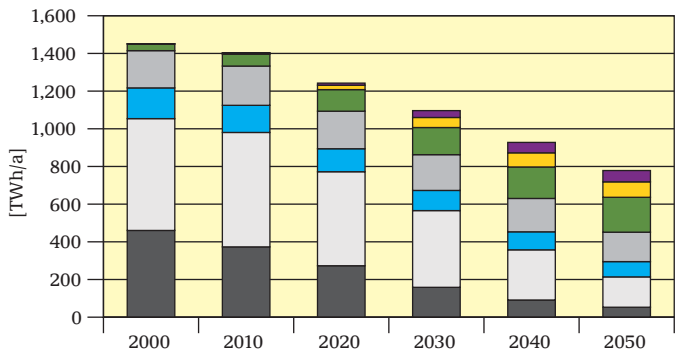


From 2030 including the electricity needed for the generation of hydrogen (2050: 70 TWh/a).

1) Combined heat/power generation

Source: DLR, ifeu, WI [27]

Development of heat supply until 2050



Source: DLR, ifeu, WI [27]

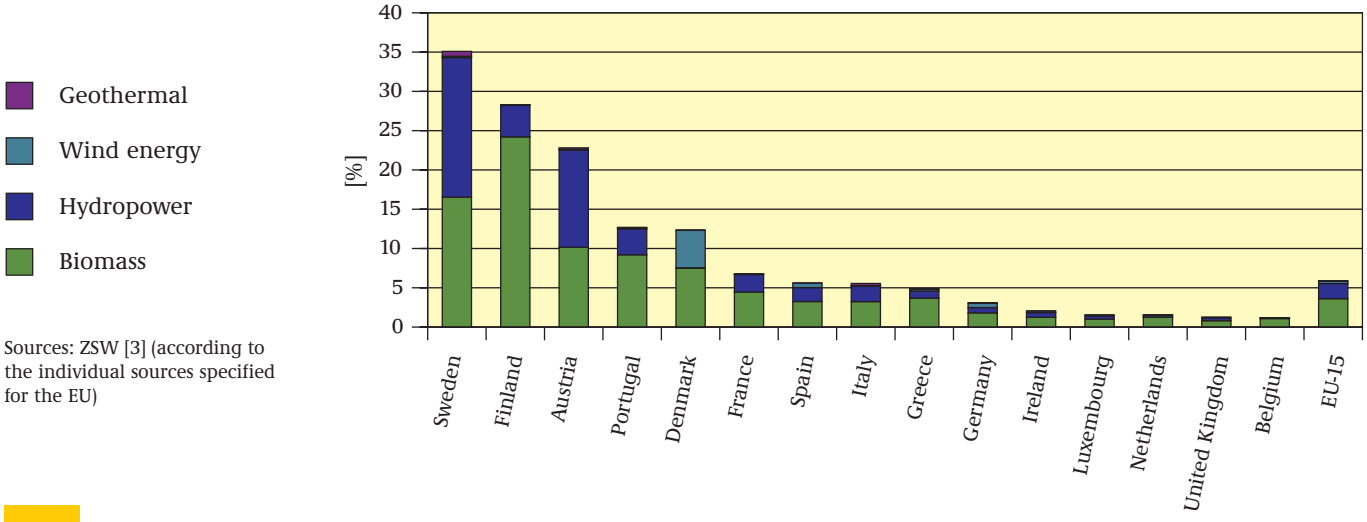
Europe: Renewable energy sources as a proportion of primary energy consumption, 1990 to 2002

The data on energy supply and use in Germany contained in European and international statistics may vary from that provided in German sources. Apart from differing data origins, this is also due in part to deviating accounting methods (cf. also Appendix 9).
In the following section on Europe, for reasons of consistency, the data for Germany has been taken from the international statistics. As a general rule, however, the detailed data from national sources on the preceding pages is more reliable.

	1990	1995	1996	1997	1998	1999	2000	1) 2001	2) 2002
	[%]								
Belgium	1.4	1.4	1.2	1.2	1.3	1.3	1.3	1.4	1.2
Denmark	6.3	7.5	6.9	8.1	8.5	9.4	10.7	11.0	12.3
Germany	1.6	1.9	1.8	2.2	2.5	2.6	2.8	2.8	3.1
Finland	18.5	21.4	19.8	20.5	21.9	23.0	23.9	22.8	28.3
France	7.0	7.6	7.2	6.8	6.7	7.0	6.9	7.1	6.8
Greece	5.0	5.3	5.4	5.2	4.9	5.4	5.0	4.6	4.9
United Kingdom	0.5	0.9	0.8	0.9	1.0	1.1	1.1	1.2	1.3
Ireland	1.6	2.0	1.6	1.6	2.0	1.9	1.9	1.8	2.1
Italy	5.3	5.5	5.9	5.9	6.6	7.0	7.0	7.6	5.5
Luxembourg	1.3	1.4	1.2	1.4	1.5	1.3	1.6	1.3	1.5
Netherlands	1.2	1.2	1.6	1.8	1.9	2.1	2.1	2.1	1.5
Austria	22.5	23.2	23.3	23.4	22.6	23.0	22.7	22.2	22.8
Portugal	15.2	13.3	16.6	15.4	13.6	11.1	12.9	13.9	12.7
Sweden	24.6	25.6	22.7	26.6	27.3	26.8	31.6	29.0	35.1
Spain	6.7	5.7	7.2	6.5	6.4	5.2	5.8	6.6	5.6
EU-15	5.0	5.4	5.4	5.6	5.7	5.8	6.0	6.2	5.9

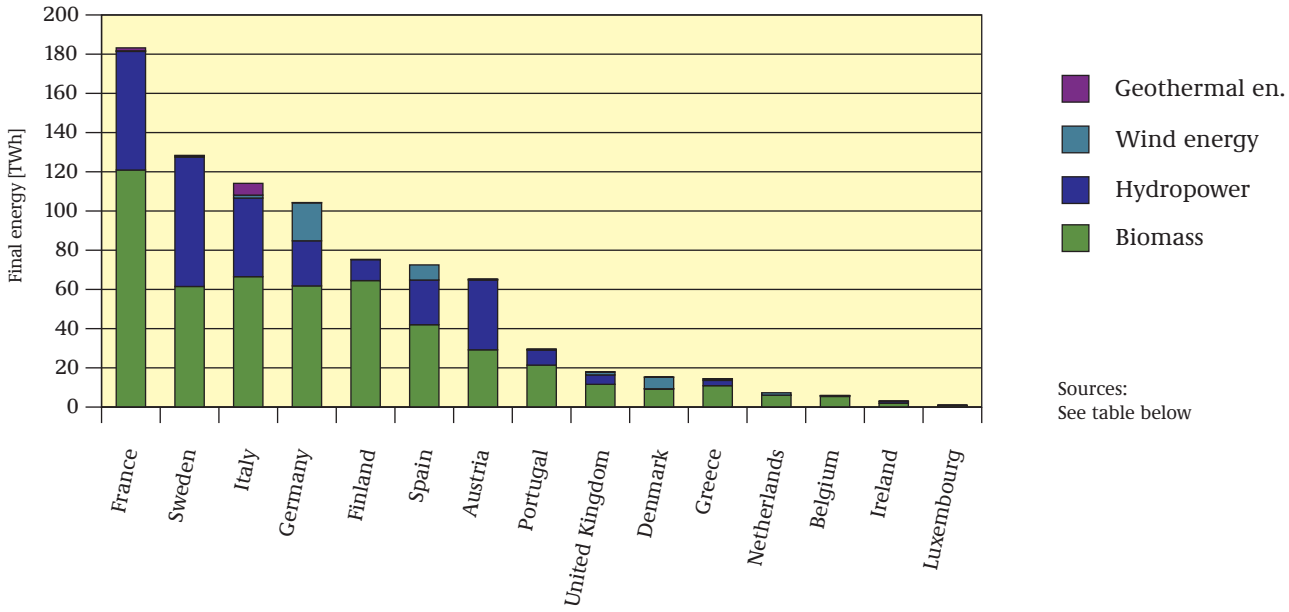
1) Provisional
2) Estimate
Sources:
Eurostat [30]; Eurostat [52]; acc. to Eurostat [26]; acc. to IEA [47]

Renewable energy sources as a proportion of primary energy consumption in the EU, 2002



Sources: ZSW [3] (according to the individual sources specified for the EU)

Use of renewable energy sources in the EU, 2002



Sources:
See table below

Use of renewable energy sources in the EU, 2002 (energy supply in TWh)

	Biomass [1]	Hydro-power [2]	Wind-energy	Geothermal energy [3]	Total	Solarthermal energy [4]	Photovoltaics
	Final energy [TWh]					[1,000 m²]	[kW_p]
Belgium	5.4	0.4	0.05	0.06	5.9	41.3	N/A
Denmark	9.3	0.03	5.9	0.02	15.3	290.3	1,590
Germany	61.8	23.0	19.4	0.51	104.7	4,715.1	277,300
Finland	64.5	10.7	0.1	0.10	75.4	43.3	3,052
France [5]	120.9	60.5	0.3	1.59	183.2	670.0	17,241
Greece	10.9	2.7	0.7	0.14	14.4	2,850.2	N/A
United Kingdom	11.6	4.8	1.5	0.01	17.9	203.4	4,136
Ireland	1.9	0.9	0.3	0.002	3.1	4.2	N/A
Italy	66.5	40.1	1.5	6.00	114.1	408.5	22,000
Luxembourg	0.2	0.1	0.03	N/A	0.4	N/A	N/A
Netherlands	6.0	0.1	1.2	0.03	7.3	395.2	26,326
Austria	29.2	35.6	0.3	0.57	65.6	2,542.0	9,000
Portugal	21.4	7.7	0.3	0.13	29.6	199.9	1,668
Sweden	61.5	66.0	0.6	2.29	130.4	199.3	3,297
Spain	42.0	22.8	7.7	N/A	72.5	282.4	[7] 16,000
EU-15	513.2	275.3	39.7	11.45	[6] 845.7	12,844.9	381,610

	Final energy [PJ]				
EU-15	1,846.1	990.3	142.9	41.2	[6] 3,041.9

1) Figures from 2001: Electricity generation from biomass, use of biomass for heat supply, including biogas and municipal waste, excluding industrial waste
2) For pumped-storage power stations, generation from natural inflow only
3) Electricity generation only in Italy (4.7 TWh), Portugal (0.12 TWh), France (0.02 TWh) and Austria (0.002) TWh
Heat generation (2002 figures) incl. heat pumps (2000 figures)
4) Glazed and unglazed panels
5) Photovoltaic systems including plants in departements overseas
6) Total includes 5.7 TWh (20.54 PJ) from solar thermal energy and 0.26 TWh (0.9 PJ) from photovoltaic energy
7) 2001 figure

Sources:
Biomass: Eurostat [52];
Hydropower: IEA [23];
Wind energy: Wind Energy Barometer [34];
Geothermal en.: Geothermal Energy Barometer [57]; European Barometer 2002 [35]
Solar thermal: 2003 Annual Assessment Barometer [58];
Solar Thermal Barometer [56];
Photovoltaics: IEA [37]; IEA [23]

Generation of electricity from renewable energy sources in the EU, 1990 to 2002

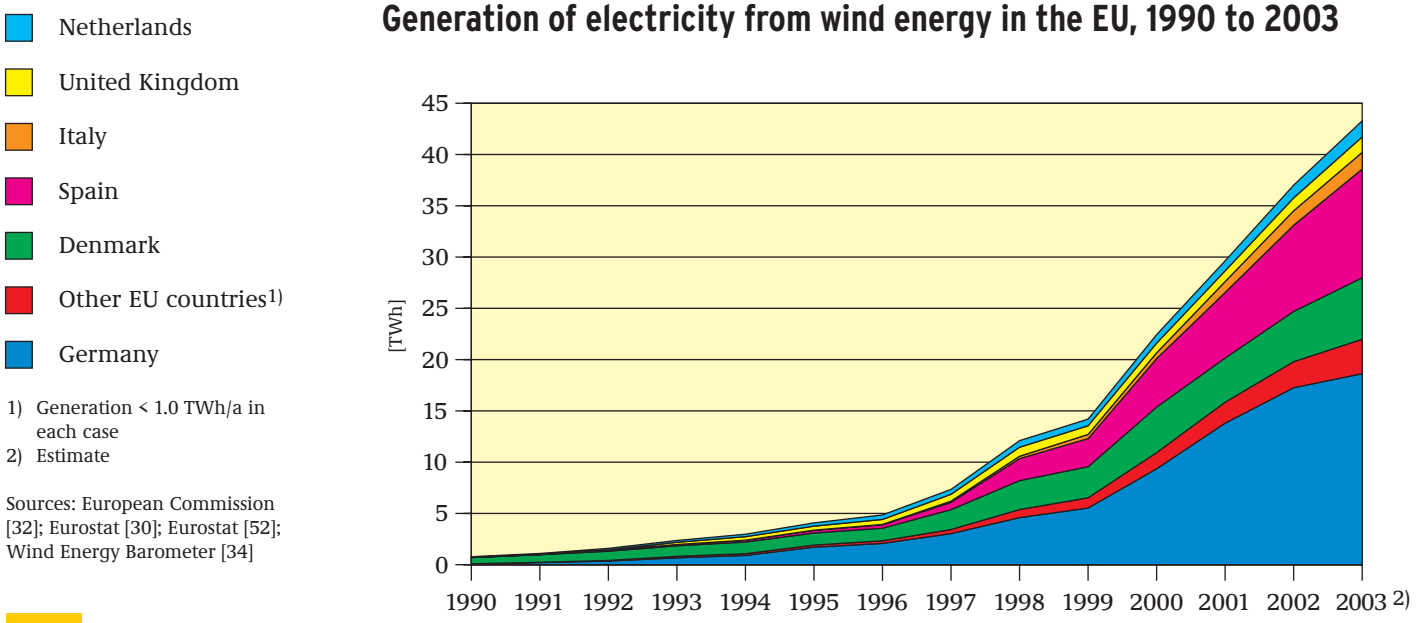
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001 [1]	2002 [2]
	[TWh]												
Biomass [3]	15.4	15.9	17.4	18.9	20.9	22.6	25.2	27.5	30.2	35.0	39.2	40.3	N/A
Hydropower [4]	257.3	264.4	281.4	285.6	293.5	287.2	287.5	292.6	301.7	300.8	315.4	335.1	275.3
Wind energy	0.8	1.1	1.6	2.4	3.0	4.1	4.9	7.3	12.1	14.2	22.4	29.6	39.7
Geothermal en.	3.2	3.2	3.5	3.7	3.4	3.4	3.8	3.9	4.3	4.5	4.8	4.5	4.8
Photovoltaics [5]	N/A	N/A	N/A	N/A	N/A	0.04	0.05	0.07	0.08	0.1	[2] 0.15	0.23	0.26
Total	276.7	284.6	303.9	310.6	320.8	317.4	321.3	331.4	348.4	354.6	381.8	409.7	[6] 360.4
RE [7] **share of gross elec.cons. [%]**	13.3	12.7	13.5	13.8	14.0	13.5	13.2	13.6	13.9	13.9	14.4	15.1	13.4

1) Provisional figures
2) Estimate
3) Including municipal waste and biogas
4) For pumped-storage power stations, only generation from natural inflow
5) EU-wide, includes around 90% of installed photovoltaic capacity; France incl. Departements overseas
6) Missing data for individual technologies replaced by previous year's figures
7) Renewable energy

Sources:
Biomass: European Commission [32]; Eurostat [52]
Hydropower: EIA [54]; IEA [23
Wind power: European Commission [32]; Wind Energy Barometer [34]; Eurostat [30]; Eurostat [52]
Geothermal en.: Systèmes Solaires [39]; Le bilan 2002 des energies renouvelables European Barometer 2002 [35];
Photovoltaics: Systèmes Solaires [39]; DFS [36]; IEA [23];
RE share: ZSW [3]

Geothermal electricity production in the EU is primarily confined to Italy. Geothermal electricity is also produced on a small scale in Guadeloupe (French) and in the Azores (Portuguese). Pilot plants exist in France, Austria and Germany, and work has begun in Greece on the construction of plants.
Photovoltaic energy is used primarily in Germany, where around two-thirds of the capacity installed in the EU is located. Together, Germany, the Netherlands, Italy, Spain and France account for well over 90 % of the total installed capacity.

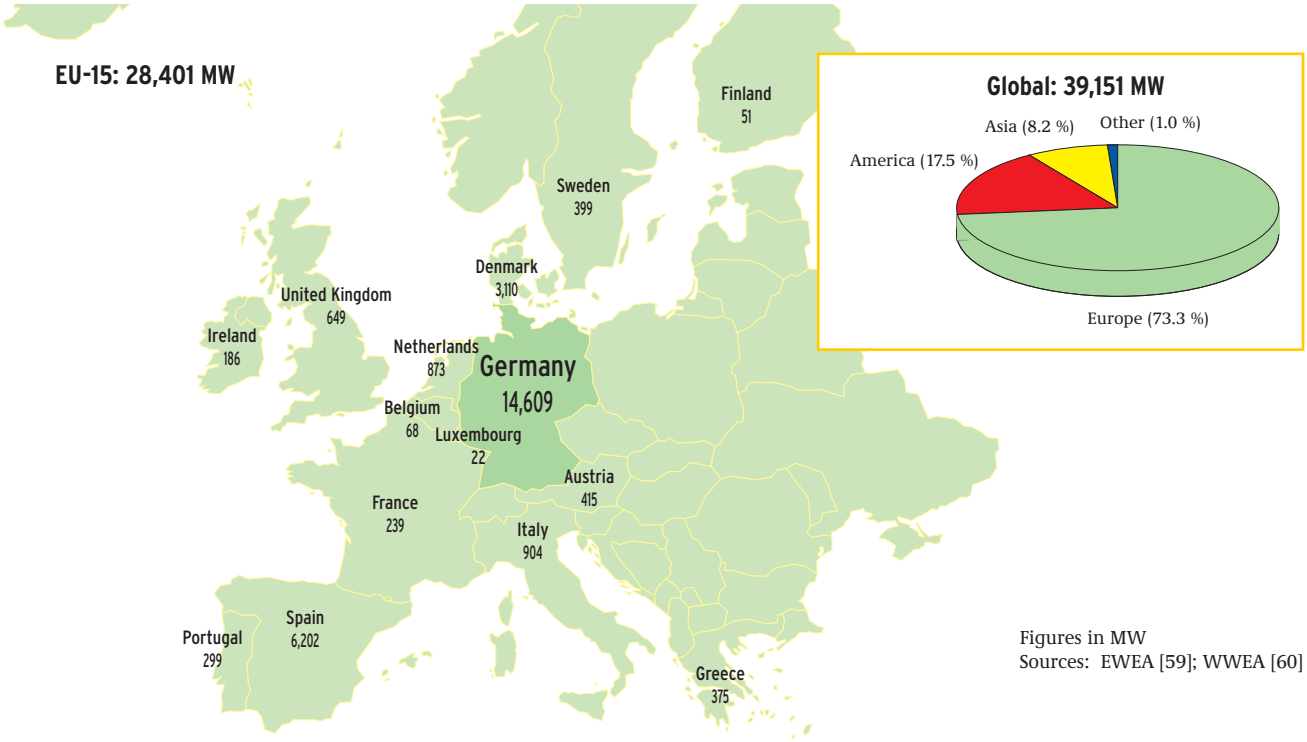
Generation of electricity from wind energy in the EU, 1990 to 2003



1) Generation < 1.0 TWh/a in each case
2) Estimate

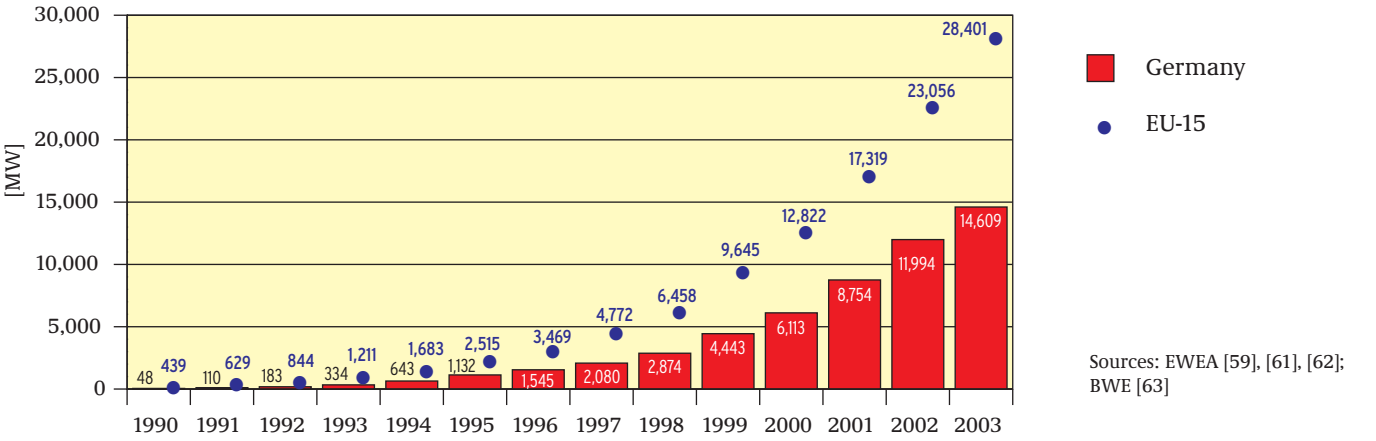
Sources: European Commission [32]; Eurostat [30]; Eurostat [52]; Wind Energy Barometer [34]

Total installed wind power in the EU, as per the end of 2003



Figures in MW
Sources: EWEA [59]; WWEA [60]

Cumulative wind power capacity in the EU, 1990 to 2003



Sources: EWEA [59], [61], [62]; BWE [63]

In recent years, the use of wind energy has experienced a very dynamic upturn, particularly in Europe – initially in Denmark, since the early nineties primarily in Germany, and later in Spain and a number of other countries. In the past five years alone, the installed capacity in the EU has more than quadrupled, to more than 28,000 MW. Just over half of this is attributable to Germany. Worldwide, almost 40,000 MW of wind power is installed, more than one-third of it in Germany.

Provisional figures

1) Fossil power station mix and nuclear energy
2) Fossil power station mix, only coal, gas, oil
3) Excluding solar thermal energy (5.7 TWh for EU-15)
4) Depending on the assumed efficiency of heat generation from biomass (according to various reference technologies), the reduction in emissions from biomass use may be less than the figures given; the calculation is based on a country-specific heat supply mix of fuel oil and natural gas
5) Biodiesel and bioethanol

For each country, avoided emissions are calculated in accordance with the method for Germany (pages 8 and 9); the methodology corresponds to the procedures outlined in Appendix (1) and (2).

Sources:
Specific emissions according to Gemis [2]; according to VIK [29]; according to Eurostat [30] and [31]; Generation via renewable energy sources; cf. individual tables/charts; 2001 figures for heat and electricity generation from biomass
Biofuels: 2003 European Barometer [46]

Avoidance of CO_2 via the use of renewable energy sources in the EU, 2002

	Generation of electricity	CO_2 avoidance		Generation of heat	CO_2 avoidance 4)	Biofuel production 5)	CO_2 avoidance	CO_2 avoidance (with electricity I 1))	CO_2 avoidance (with electricity II 2))
	RE	I 1)	II 2)	RE 3)				total	total
	[TWh]	[1,000 t]		[TWh]	[1,000 t]	[TWh]	[1,000 t]	[1,000 t]	[1,000 t]
Belgium	2.48	537	1,407	4.52	1,076	-	-	1,612	2,483
Denmark	8.07	5,554	5,554	7.21	1,778	0.1	28	7,360	7,360
Germany	50.65	29,220	46,760	57.04	13,100	5.8	1,541	43,860	61,400
Finland	19.28	6,350	12,359	56.18	14,921	-	-	21,271	27,280
France	70.28	5,392	51,007	118.82	27,779	5.0	1,332	34,504	80,118
Greece	4.06	3,643	3,643	11.07	2,959	-	-	6,602	6,602
United Kingdom	14.06	6,215	8,580	6.51	1,364	-	-	7,579	9,944
Ireland	1.69	1,150	1,150	1.82	444	-	-	1,595	1,595
Italy	56.78	33,051	33,051	65.30	14,114	2.3	616	47,781	47,781
Luxembourg	1.07	412	412	0.19	46	-	-	457	457
Netherlands	4.78	2,496	2,623	2.55	531	-	-	3,027	3,155
Austria	40.16	23,140	23,140	28.02	6,646	0.3	84	29,870	29,870
Portugal	10.25	7,358	7,358	19.84	5,225	-	-	12,582	12,582
Sweden	70.65	3,532	51,435	60.43	15,986	0.5	128	19,646	67,548
Spain	36.01	18,416	27,671	40.03	9,739	0.7	197	28,353	37,607
EU-15	390.29	137,732	273,429	479.53	116,096	14.7	3,926	257,754	393,451

In the year 2002, emissions of around 260 million tonnes of CO_2 were avoided in the countries of the European Union via the use of renewable energy sources for electricity, heat and fuel generation. The sum total of energy-related CO_2 emissions in the EU was 3.2 billion tonnes.

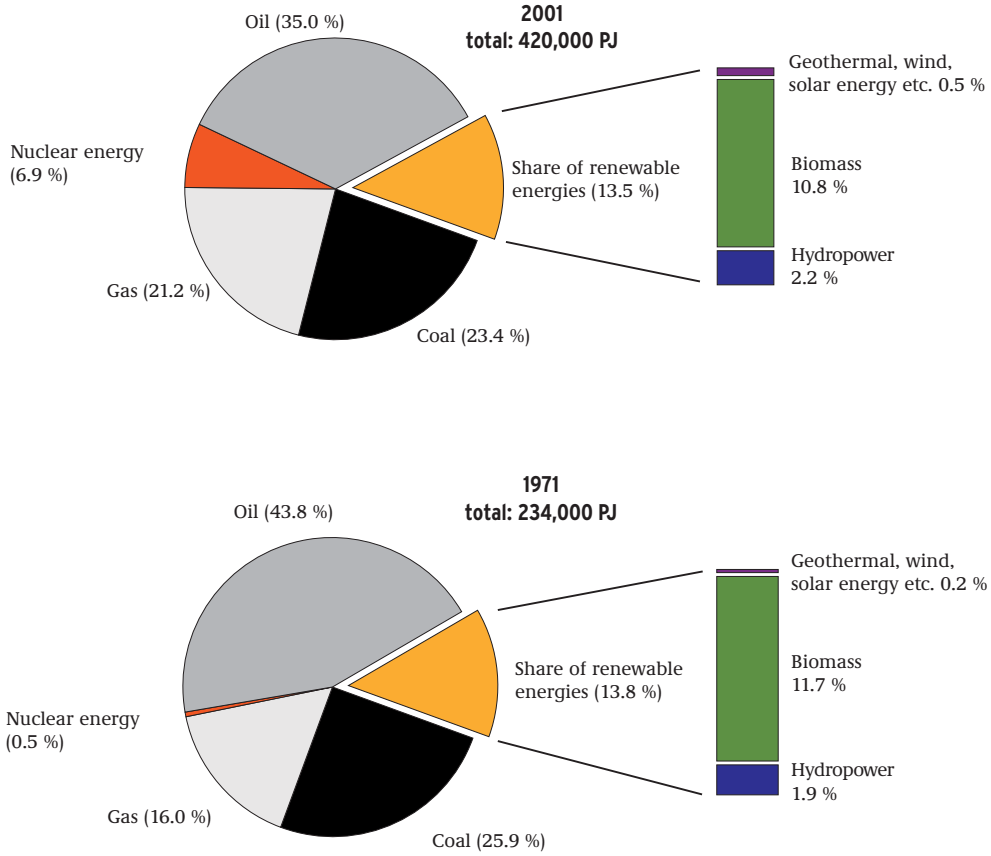
Global use of renewable energy sources

The high status afforded to renewable energy sources for sustainable development is widely recognised. At present, however, their share of global primary energy consumption remains on a par with that of the early seventies, at 13.5 % (cf. also Appendix 10). Although the supply of energy from renewable sources has almost doubled since then, at the same time, the use of fossil energy carriers and nuclear energy has also increased.

In order to meet the challenges of global energy supply and, in particular, climate protection, apart from using energy more efficiently, it is also necessary to increase the development momentum of renewable energy sources. This is particularly true of wind power, solar energy and geothermal energy, but also of modern techniques for the use of biomass. The traditional forms of use which have dominated up until now – the provision of heat from firewood and coal, and the generation of electricity from hydropower – are fast approaching their limits.

The Federal Government and the European Union have undertaken to double the share of energy supply from renewable energy sources by the year 2010. It is hoped that the international conference on renewable energy sources being staged in the summer of 2004 in Bonn, renewables 2004, will lend fresh impetus to the expansion of renewable energy sources at international level as well.

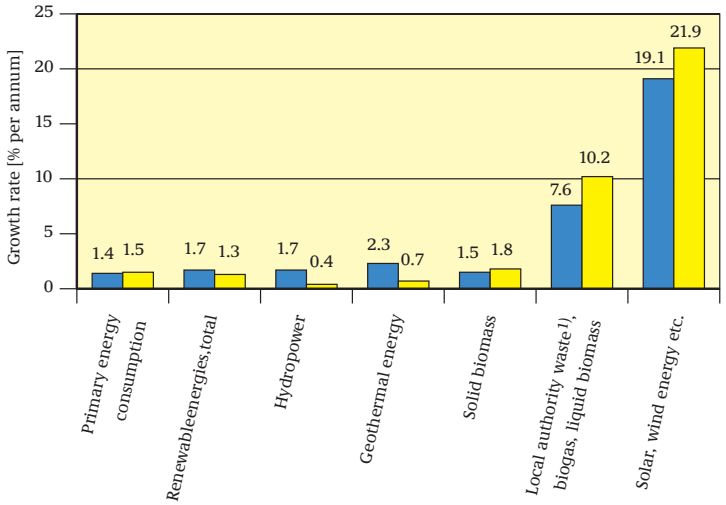
Structure of global primary energy consumption, 2001 versus 1971



Source: IEA 2003 [47]

In accordance with international agreements, electricity from nuclear energy is valued at an average conversion efficiency of 33 % in terms of primary energy. In the case of hydropower, on the other hand, a figure of almost 100 % is used.For the share of primary energy consumption attributable to nuclear energy, this produces a significantly higher figure, whereas the contributions to electricity generation are almost identical in both cases; for efficiency method, cf. Appendix (4).

Average growth rates of primary energy consumption and renewable energy sources for the period 1990 to 2001



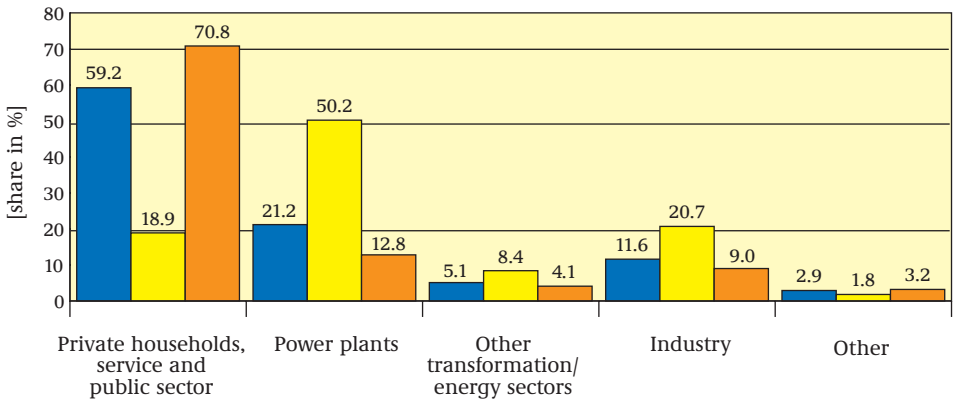
Source:
IEA 2003 [47]

The OECD Member States are listed in Appendix (11)

1) Share of renewable energy sources only

Against the background of various climate protection targets, and specifically in the wake of the Kyoto Protocol, particular interest has been directed at the development of renewable energy sources since 1990. Since then, however, efforts to significantly raise its status in energy supply have failed. Although energy supply increased by an average of 1.7 % until 2001, growth was only slightly higher than that of primary energy consumption as a whole, at 1.4 % p.a. In the western industrialised countries (OECD), the contribution of renewable energy sources actually declined, from 5.9 % in 1990 to 5.7 % in 2001.

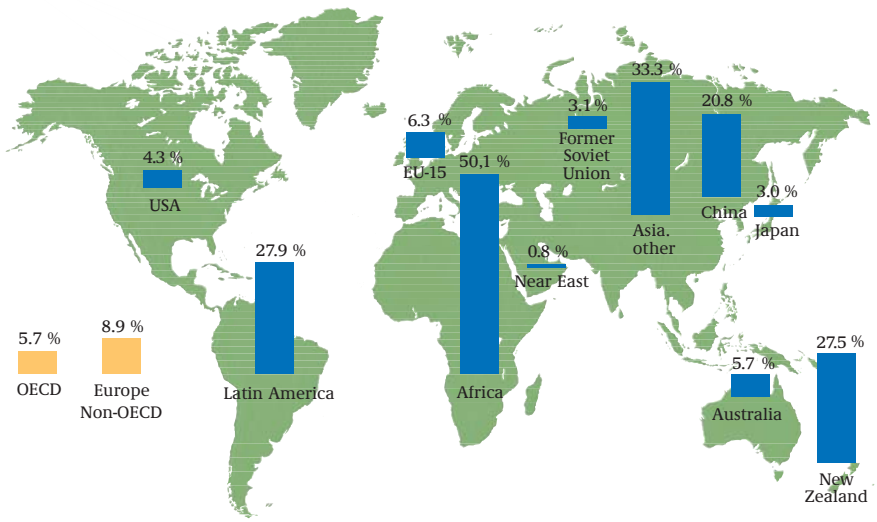
Structure of renewable energy use according to application areas, 2001



Source:
according to IEA 2003 [47]

Globally, around 60 % of renewable energies are currently used to supply heat in private households and in the public and services sectors. This essentially refers to wood and coal. The second principal application area is that of 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 13 %. The proportion attributable to decentralised heat supply in such countries is correspondingly high, at over 70 %, compared with only 19 % or so in the OECD countries.

Renewable energy sources as a share of primary energy consumption in various regions, 2001



Sources:
IEA 2003 [47]; Wissenschaftlicher Beirat der Bundesregierung 2003 [48]

The proportion of primary energy consumption attributable to renewable energy sources differs enormously from region to region, and in particular from one country to another. Its significance is particularly high in Africa, where around half of energy consumption is met from renewable energy sources. In selected countries such as Ethiopia, Tanzania or Zambia, the figures even exceed 90 %. This is explained by the traditional use of biomass in households, which in turn is related to the income situation amongst the population: The lower incomes are, the less can be spent on energy as a whole, and in particular on commercial energy carriers.

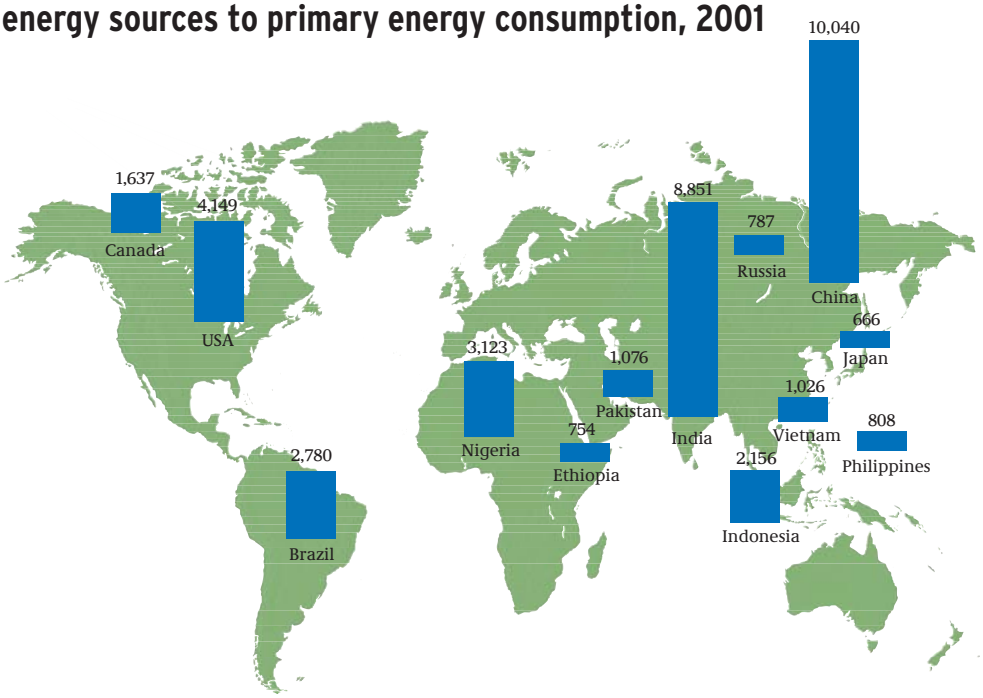
Development of renewable energy sources as a share of primary energy consumption in selected countries, 1990 to 2001

	1990	1995	1996	1997	1998	1999	2000	2001
	[%]							
Asia & Oceania								
Australia	5.8	5.9	6.1	6.3	6.0	5.9	6.1	5.7
Japan	3.6	3.4	3.4	3.6	3.4	3.3	3.2	3.0
Korea	0.6	0.6	0.7	0.8	1.0	1.0	1.1	1.1
New Zealand	35.1	32.5	30.5	28.7	31.1	32.0	31.3	27.5
Turkey	17.9	17.1	16.3	15.4	15.4	14.5	12.5	12.9
Europe (excluding EU-15)								
Poland	1.6	3.9	3.6	3.7	4.0	4.0	4.2	4.5
Slovakia	1.5	2.8	2.5	2.4	2.5	2.6	2.8	3.9
Czech Republic	0.3	1.4	1.3	1.5	1.6	1.8	1.4	1.5
Hungary	1.3	1.9	1.4	1.5	1.4	1.5	1.6	1.6
Norway	53.4	49.3	43.7	43.9	44.1	44.9	52.8	44.5
Switzerland	13.0	15.9	13.6	14.8	14.7	16.7	15.9	16.7
Iceland	62.5	64.4	61.8	63.6	66.3	71.7	72.6	72.9
Latin America								
Mexico	11.1	11.4	11.3	10.6	10.3	10.5	10.4	10.2
North America								
Canada	16.1	16.7	17.0	16.7	16.3	16.9	16.8	15.8
USA	5.2	5.2	5.3	5.2	5.1	5.0	4.8	4.3

Waste is only considered in terms of its biogenic share

Quellen:
Source: IEA [47]

Countries with the highest absolute contributions of renewable energy sources to primary energy consumption, 2001



Figures in PJ

By way of comparison:
Germany 385 PJ
France 779 PJ

Source: IEA 2003 [47]

The absolute contributions from country to country differ even more widely than the relative proportions of renewable energy sources within energy supply. Additional factors play a role here, such as the size of the population. China is by far the largest user of renewable energy sources. Its contribution is around 10,000 PJ, which alone translates into 18 % of the total energy supply from renewable energy sources worldwide. It is closely followed by India, well ahead of the USA, Nigeria, Brazil, Indonesia and Canada. Together, these seven countries account for just under 60 % of the energy supply from renewable energy sources.

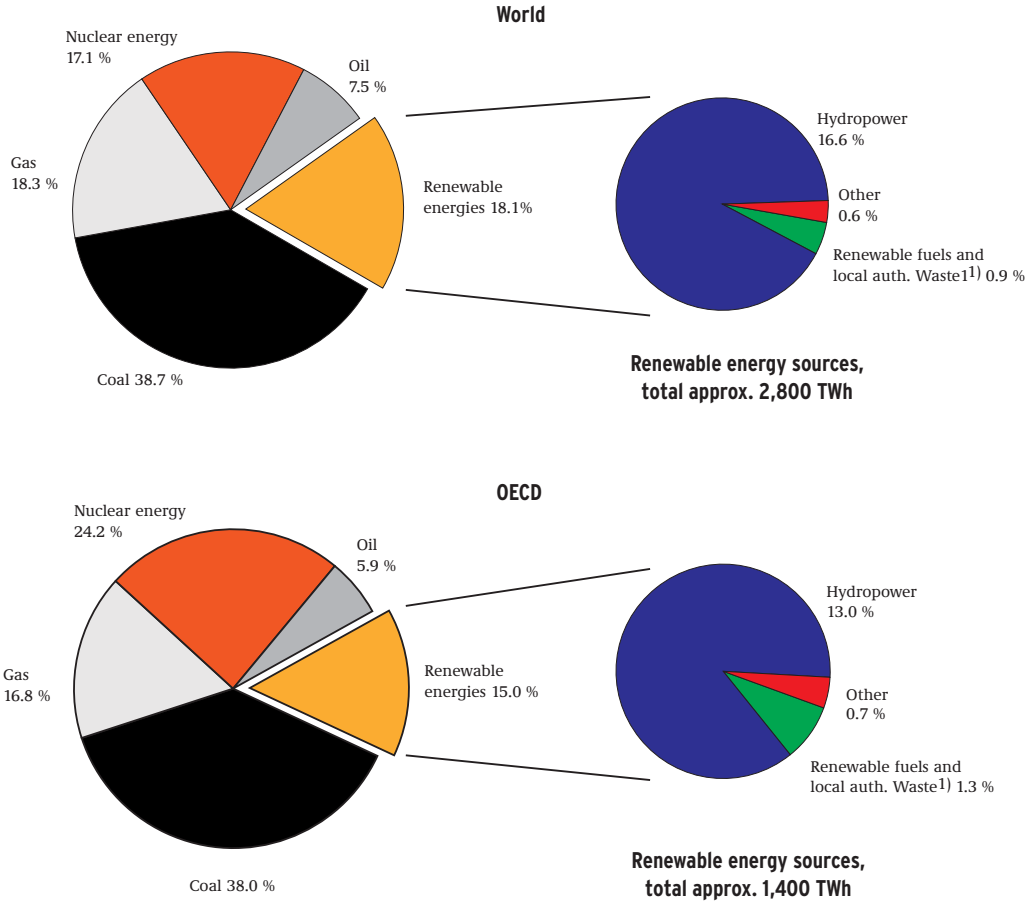
	PEV [1]	Of which RE [2]	RE share of PEC	Principal RE as a share of total RE proportion [%]		
	[PJ]	[PJ]	[%]	Hydro-power	Geothermal, solar, tidal energy	Biomass and biogenic share of local authority waste
China	47,704	10,040	21	10	0.0	90.0
India	22,253	8,851	40	3	0.1	96.9
USA	95,518	4,149	4	18	14.9	67.6
Nigeria	3,994	3,123	78	1	0.0	99.2
Brazil	7,750	2,780	36	35	0.0	65.3
Indonesia	6,376	2,156	34	2	5.0	93.2
Canada	10,392	1,637	16	73	0.1	26.7
Pakistan	2,700	1,076	40	6	0.0	93.7
Vietnam	1,650	1,026	62	6	0.0	93.6
Philippines	1,767	808	46	3	46.4	50.4
Russia	26,364	787	3	80	0.4	20.1
Ethiopia	804	754	94	1	0.0	99.1
Japan	21,801	666	3	46	23.4	31.0

1) PEC primary energy consumption; for efficiency method, cf. Appendix (4)
2) RE = renewable energy sources

Indicators of renewable energy sources, 2001

Source:
IEA 2003 [47]

Renewable energy sources as a share of global electricity generation, 2001



Sources:
IEA 2003 [47]; Wissenschaftlicher Beirat der Bundesregierung [48]

1) Share of renewable energy sources only

Worldwide, renewable energy sources account for 18.1 % of total electricity generation, and this figure has declined slightly since 1990 (19.3 %). The reason for this is the relatively low growth in the use of hydropower in western industrialised countries (OECD), which fell short of the increase in electricity generation as a whole.

This was not compensated via the use of other resources such as biomass or wind energy. Amongst electricity generation from renewable energy sources worldwide, hydropower dominates. It accounts for around 92 % (corresponding to 16.6 % of total electricity generation), whereas biomass accounts for 5 % and the remaining renewable energy sources for just over 3 %.

Appendix: Methodological notes

Differences between the figures in the tables and the corresponding column or line totals are due to rounding up or down. In some cases, the data published here only reflects provisional results. This is also true of individual time series which are currently being reviewed for Germany by the working group on renewable energy statistics (AGEE-Stat) (cf. also www.erneuerbare-energien.de). Changes may still arise compared with earlier publications until the finalised data is published.

The standard terminology in energy statistics includes the term (primary) energy consumption, although this is not strictly accurate 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). Admittedly, this process is not completely reversible, so that a certain proportion of energy's useful work potential is lost.

1. Calculation of emission factors for electricity generation

This calculation only considers direct emissions, i.e. no upstream or downstream processes such as the manufacture or disposal of plants.
In order to calculate the emissions avoided, it is necessary to make an assumption regarding which energy carriers are substituted by renewable energy sources and in which quantities. Electricity from hydropower and biogenic fuels is generated comparatively constantly and primarily replaces electricity from base load power stations (lignite, nuclear energy), whereas electricity generated from wind power and solar energy fluctuates significantly and is therefore primarily used to substitute electricity generation in medium-load and peak-load power stations (hard coal, natural gas, oil). For this reason, and also due to differing geographical situations vis-à-vis the structure of electricity generation, it is not possible to ascertain unequivocally which energy carriers are substituted by renewable energy sources in which proportions. For this reason, we consider three variants here:
Electricity I: Total power plant mix in the year 2000 including nuclear power, excluding renewable energy sources
Electricity II: Power plant mix in the year 2000 excluding nuclear power, excluding renewable energy sources
Electricity III: Assumed value, which only makes partial allowance for the substitution of nuclear power, but not to the same extent to which it currently contributes to electricity generation. In the medium term, this figure may be retained as a comparative basis for calculating the emissions avoided and should make allowance for the fact that nuclear energy's contribution to electricity generation will diminish, due to the gradual phasing-out of its use.

	Nuclear power	Lignite	Hard coal	Natural gas	Oil
Electricity I	35.9	31.2	23.9	7.8	1.3
Electricity II	0.0	48.6	37.2	12.2	2.0
Electricity III	13.5	42.0	32.2	10.6	1.7

The individual energy carriers account for the following percentage shares in the three variants:

Source: Electricity I, electricity II: acc. to AG Energiebilanzen [18]

This does not make allowance for the fact that fossil-based medium- and peak-load power stations must occasionally be operated in part-load mode with irregular electricity feed in from renewable energy sources, and their efficiency decreases as a result, which in turn leads to increased emissions.

2. Calculation of emission factors and avoided emissions for heat generation

The calculation only considers direct emissions (including auxiliary power and heat distribution), i.e. no upstream or downstream processes such as the manufacture or disposal of plants. Emissions from the combustion of biomass are disregarded.

Natural gas	Fuel oil	Coal	Electricity
52.9 %	41.5 %	1.5 %	4.1 %

Structure of the heat supply mix substituted by renewable energy sources:

Sources: acc. to VDEW [17]; acc. to Statistisches Bundesamt [44]

Calculation of the emissions avoided by heat supply from renewable energy sources is derived from final energy use. For biomass plants, a level of efficiency comparable with that of conventional heating plants is assumed. Due to the large number of different technologies for both biomass use and for gas/oil heaters, a precise determination of the average levels of efficiency (and hence the emissions avoided) cannot be reliably obtained. The assumption made represents a good approximation for pellet furnaces, central heating boilers and heating plants (efficiencies of 80 % to more than 90 %); however, this overestimates the emission reduction for the tile stoves, fireplaces and chimneys with low efficiencies that are commonly used today. Assuming an average efficiency for heat generation from biomass of 60 % and of 80 % for conventional heating installations, the specified emission avoidance is reduced by 25 %.

3. CO_2 and SO_2 equivalent

CO_2 equivalent

	Relative greenhouse potential
CO_2	1
CH_4	21
N_2O	310
SF_6	23,900
PFC	6,500 – 9,200
HFC	140 – 11,700

Key greenhouse gases are the so-called Kyoto gases CO_2, CH_4, N_2O, SF_6, PFC and HFC, which contribute to the greenhouse effect to varying degrees. 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 represents a measure of their greenhouse effect compared with the "lead gas" CO_2.

The CO_2 equivalent of the Kyoto gases is derived by mul
tiplying the relative greenhouse potential by the mass of the respective gas, and indicates the quantity of CO_2 which would develop the same greenhouse effect over an observation period of 100 years.

SF_6, PFC and HFC are disregarded in this report.
Source: Intergovernmental Panel on Climate Change (IPCC)

SO_2 equivalent

	Relative acidification potential
SO_2	1
NO_X	0.696
HF	1.601
HCl	0.878
H_2S	0.983
NH_3	3.762

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.

H_2S and NH_3 are disregarded in this report.
Source: Gemis, Öko-Institut [2]

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

Since 1995, the **efficiency method** has been used in Germany to calculate the primary energy equivalent for the generation of electricity from renewable energy sources. For those energy carriers to which no calorific value can be allocated, efficiency is specified for the conversion of primary energy into final energy. For electricity from hydropower, wind power and photovoltaics, this is set at 100 %. Hence, for example, 1 kWh of electricity from hydropower is equivalent to a primary energy equivalent of 1 kWh.

The **substitution method**, by contrast, calculates the quantity of fuel in conventional power plants that is replaced by renewable energy sources. The so-called substitution factor indicates the ratio of fuel consumption to gross electricity generation. For the year 2002, this is 9,055 kJ/kWh. The substitution method is always used when determining the primary energy equivalent for electricity from biomass.
In order to determine the primary energy equivalent of the supply of heat and fuels from renewable sources, final energy and primary energy are considered to be the same.

5. Supply of energy from photovoltaic and solar thermal energy

Photovoltaic energy

The specified electricity generation is calculated from the installed capacity and the specific electricity yield calculated by the Solarenergie-Förderverein Deutschland [28] as the average value for Germany (2003: 1,400 plants). In the years 1992 to 2003, this figure fluctuated between 760 and 1,025 kWh/kW_p. For the years prior to 1992, a figure of 800 kWh/kW_p has been assumed. Because the capacity available during the course of the year is lower than the specified installed capacity at the end of the year, due to the construction of new plants, only half of the capacity increase in any given year is used when calculating electricity generation during that year.

Solar thermal energy

The specified heat supply is calculated from the installed collector area and an average annual yield of 450 kWh/m^2 for glazed collectors, and 300 kWh/m^2 for swimming pool absorbers. 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 plants, only half of the area increase in any given year is used when calculating heat supply for that year. A 10 % higher specific yield is assumed for 2003, as an outstanding year for solar energy.

6. Saving of fossil fuels via heat generation from renewable energy sources

Calculation of the fossil fuels saved via heat supply from renewable energy sources is derived from final energy use; electric heaters are disregarded for this purpose. For biomass plants, a level of efficiency comparable with that of conventional heating plants is assumed. Due to the large number of different technologies for both biomass use and for gas/oil heaters, precise determination of the average levels of efficiency (and hence the fossil fuels avoided) cannot be reliably achieved. The assumption made represents a good approximation for pellet furnaces, central heating boilers and heating plants (efficiencies of 80 % to more than 90 %); however, this overestimates the emission reduction for the tiled stoves, fireplaces and chimneys with low efficiencies that are predominantly used today. Assuming an average efficiency for heat generation from biomass of 60 % and for conventional heating installations of 80 %, the specified savings of natural gas, fuel oil and coal are reduced by 25 %.

7. Sales revenues from the use of renewable energy sources

Turnover from the generation of electricity may be estimated based on the quantities of electricity fed into the grid and the compensation rates paid under the Renewable Energy Sources Act. For electricity from hydropower plants with more than 5 MW capacity, the price attainable on the open electricity market is used. With an assumed average figure of 3 ct/kWh and electricity generation of approximately 16 TWh in the year 2003, this produces a turnover of approximately 480 million euros. For the fuel sector, the proceeds are 490 million euros, with sales of 650,000 tonnes (745 million litres) and an average petrol station price of approximately 0.67/litre euros (net).

The value of heat supply from renewable energy sources is disregarded, since the bulk of the heat is used internally. One conceivable valuation in such cases, however, would be the avoided costs for fuel oil or natural gas. With a heat supply of around 61 TWh and an average fuel oil/natural gas price of 3 ct/kWh, this would equate to a value of approximately 1.8 billion euros. The following factors are furthermore disregarded: The cost of maintenance and repair for heat-generating plants, the revenues from the sale of heat in district heating systems, and the cost of firewood that is not traded via markets (the vast majority). This leaves the valuation of biogenic input materials such as forestry residue and residual industrial wood which is not used in electricity-generating plants. With average valuations of EUR 25/t for residual industrial wood and EUR 50/t for forestry residue, this translates into a turnover in the magnitude of 280 million euros.

8. Valuation of subsidies from loan programmes

The Federal Government's loan programmes offer an incentive by granting interest-subsidised loans. When assessing the subsidies provided in this way, the following assumptions have been made for reasons of simplicity:
For the subsidised loans, only the average interest rate reduction in the specified, estimated amount is used. A bank loan taken on the open capital market serves as a reference for calculating the support equivalent. For this purpose, an average interest rate of 6.5 % p.a. with a term of 10 years and a 100 % payout is assumed. The loans would be repaid in equal annual instalments. When calculating the total support equivalent in the year under review, therefore, the total loan amount committed by the support programme in this year and a maximum of 10 preceding years is used as a basis, less the assumed repayment amounts over this period.

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

When calculating the primary energy equivalent for the generation of electricity from hydropower, wind energy and photovoltaic energy, in collaboration with Eurostat, primary energy has been equated with the generation of electricity. Biomass and bio-fuels for electricity and heat generation are used in accordance with their calorific value (in collaboration with Eurostat, but deviating from the methodology used in this brochure for Germany; cf. Appendix [4]). For geothermal electricity generation, an efficiency level of 10 % is assumed, i.e. 1 GWh of electricity from geothermal energy is valued at 36 TJ primary energy. For heat generation from geothermal and solar thermal energy, final energy and primary energy are considered equal.

The deviations arising from the different methodologies used are minimal, and are disregarded when calculating the overall contribution of renewable energy sources to primary energy consumption.

10. Renewable energy sources as a share of global primary energy consumption

Various sources give different figures for the share of global primary energy consumption that is attributable to renewable energy sources. The reasons for this include the accounting of the thermal recovery of domestic and industrial waste, as well as the generation of electricity in pumped-storage power stations. However, the greatest influence is attributable to the so-called traditional use of firewood and coal, which can only be estimated with considerable uncertainties, and for which variations in the figures can be as much as 50 % or more. In some cases, for this reason, traditional biomass use is not included in energy statistics. With due regard for the current status of knowledge in this field, it can be said that renewable energy sources account for around 13.5 % of primary energy consumption.

11. OECD/IEA

The Organization for Economic Cooperation and Development was founded on 30 September 1961. Its main tasks include the coordination of economic policy, particularly trade cycle 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 the "energy branch" of the OECD; it is also located in Paris.

Conversion factors

Prefixes and symbols

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

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

Units for energy and capacity

These units have been statutorily binding in Germany since 1978. The calorie and derived units such as coal equivalent and crude oil equivalent are still used as an aid.

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

Conversion factors

The figures refer to calorific value.

		kJ	kcal	kWh
1 kilojoule	kJ	1	0.2388	0.000278
1 kilocalorie	kcal	4.1868	1	0.001163
1 kilowatt hour	kWh	3,600	860	1
1 kg coal equivalent	kg ce	29.308	7.000	8,14
1 kg oil equivalent	kg oe	41,868	10,000	11.63

Greenhouse gases

CO_2	-	Carbon dioxide
CH_4	-	Methane
N_2O	-	Dinitrogen oxide (laughing gas)
SF_6	-	Sulphur hexafluoride
PFC	-	Perfluorinated hydrocarbons
HFC	-	Hydrofluorohydrocarbons

Other air pollutants

SO_2	-	Sulphur dioxide
NO_X	-	Nitrogen oxide
HCl	-	Hydrochloride
HF	-	Hydrofluoride
CO	-	Carbon monoxide
NMVOC	-	Non-methane volatile organic compounds

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