Agentur für Erneuerbare Energien

# Renewable Energy – Predictions and Reality

## Comparison of forecasts and scenarios with the actual development of renewable energy sources Germany – Europe – the world

Report
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**Patron**
"Germany has endless energy"
Prof. Dr. Klaus Töpfer

**Supporters:**
Bundesverband Erneuerbare Energie (BEE) – German Renewable Energy Federation

Bundesverband Solarwirtschaft (BSW) – German Solar Industry Association

Bundesverband Windenergie (BWE) – German WindEnergy Association

Geothermische Vereinigung (GtV) – Geothermal Networks

Bundesverband Bioenergie (BBE) – German Bioenergy Federation

Fachverband Biogas – German Biogas Association

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz – Federal Ministry of Food, Agriculture and Consumer Protection

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**deutschland hat unendlich viel energie**
windenergie wasserkraft sonnenenergie bioenergie erdwärme

Agentur für Erneuerbare Energien

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# 1. Introduction and methodology

Energy forecasts provide important information for political decision-making processes. They are of great importance for the development of renewable energy sources because appropriate framework conditions for fully exploiting renewable energy potential need to be created. Forecasts that are too low can hamper the development dynamic of renewable energy sources. This is especially the case if important decisions are not taken, such as extending energy networks or making timely adaptations to power plant facilities. Energy forecasts, therefore, play a central role in the sustainable development of the energy supply. They need to be updated constantly in order to appropriately map out current and future growth rates of renewable energy sources.

This report evaluates 50 forecasts from recent decades and compares the predicted progression of renewable energy sources with actual developments in Germany, Europe and the world. Almost all the forecasts examined underestimated the percentage of energy consumption actually covered by renewable energy sources. In many cases, renewable energy sources reached the predicted values several years earlier than planned, and surpassed these by several hundred percent.

Our analysis is based on the following selection criteria:

- The study examines development forecasts which map out the extended economic potential of renewable energy sources[1].
- Studies which only refer to theoretical or technical potential are not taken into account.
- In addition to trend scenarios, alternative scenarios are also included which are subject to certain assumptions and objectives, such as increased promotion of renewable energy sources.
- The most important forecasts from scientific and political institutions as well as associations in the energy sector are analysed.

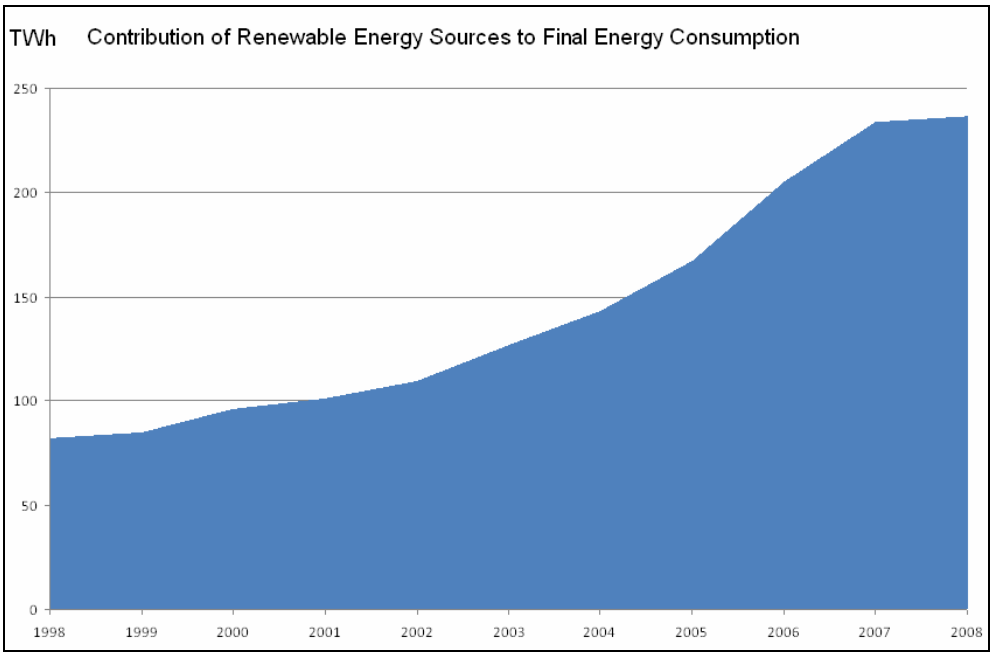
[1] The extended economic potential is the portion of technical potential which one arrives at if total costs (investment, operations and waste removal) for converting energy from a renewable energy source are calculated - taking into account potential promotion instruments – and if these costs lie within the same spectrum as the total costs for competing systems. Cf. Piot 2007.

In addition to the evaluation of scientific studies, this report also contains statements from the world of politics and associations in Germany on the development potential of renewable energy sources.

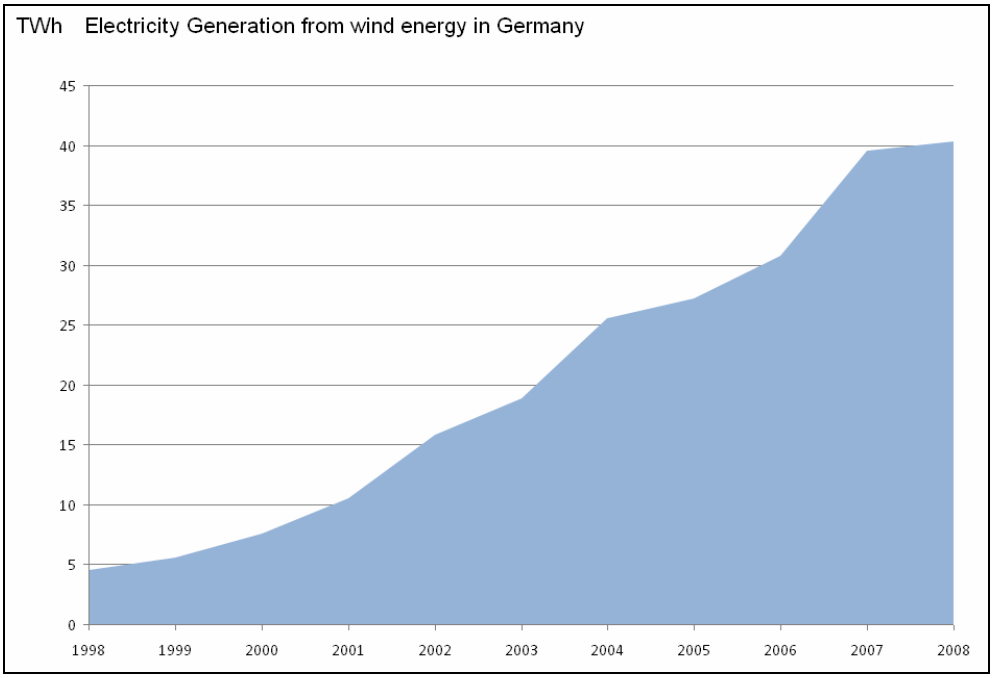
## 2. The reality – the actual development of renewable energy sources in Germany, Europe and the world

The following graphs demonstrate the high-paced development of renewable energy sources in Germany, Europe and the world within the last ten years:

- The contribution of renewable energy sources to final energy consumption in Germany has tripled.
- The electricity generation from wind energy in Germany has increased by a factor of ten.
- The electricity generation from photovoltaics in Germany has increased more than a hundredfold.
- The supply of electricity, heat an fuels from bioenergy in Germany has tripled.
- The installed capacity of wind energy across the globe has increased by a factor of twelve in the last decade.

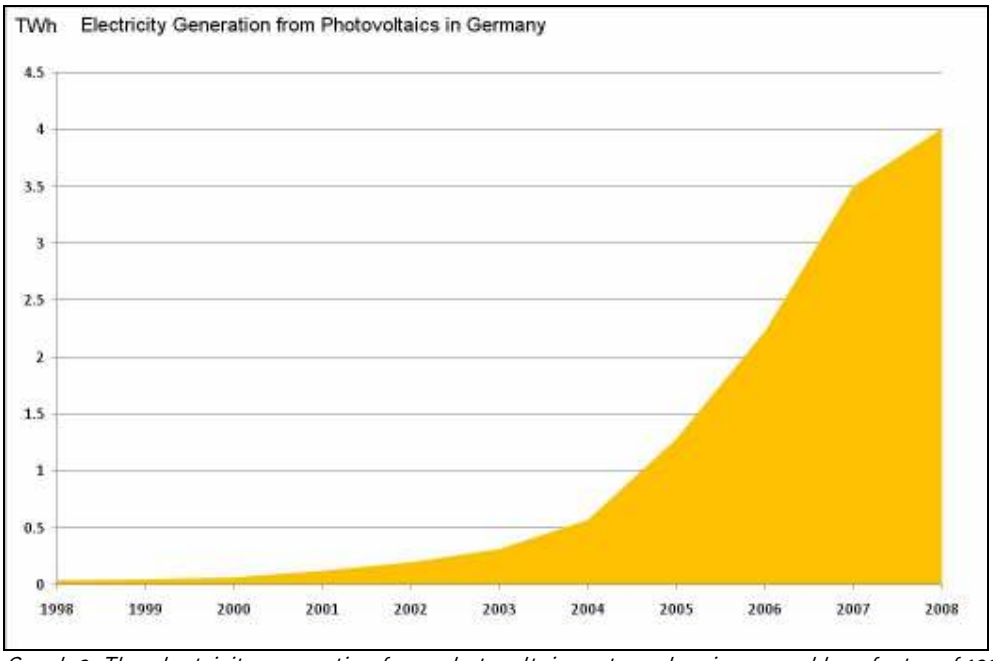



*Graph 1: The contribution of renewable energy sources to final energy consumption has tripled in Germany within the last 10 years from 82 to 238 terawatt hours (TWh)[2].*

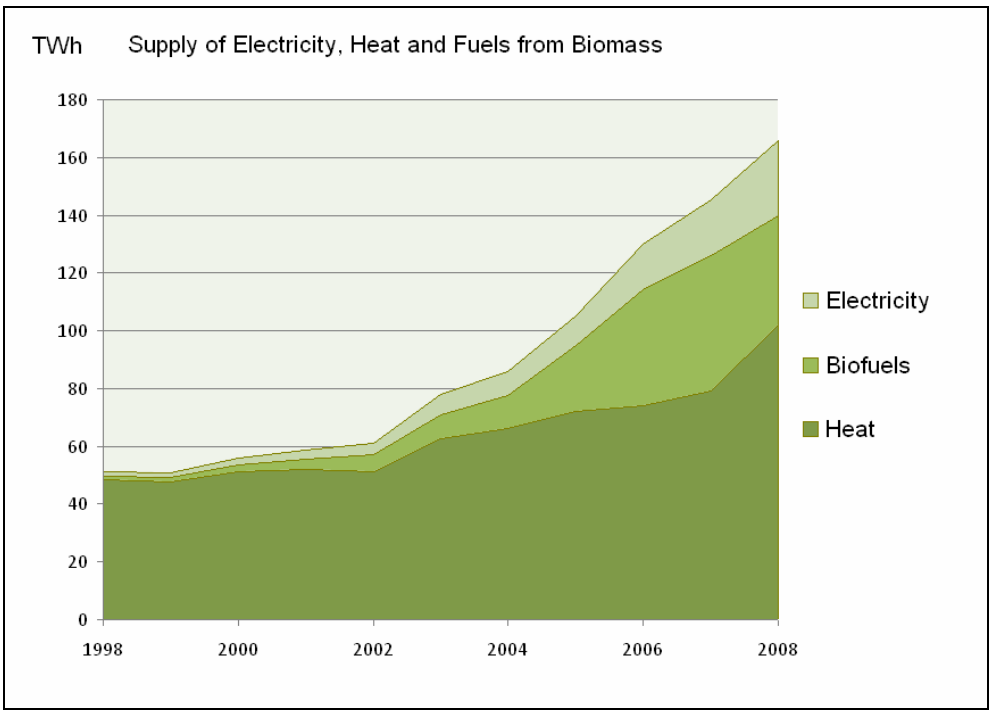



*Graph 2: The electricity generation from wind energy has increased by a factor of 10 over the last 10 years from 4 to 40 TWh[3].*

[2] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) 2008. German Renewable Energy Federation (BEE) 2008.
[3] ibid.

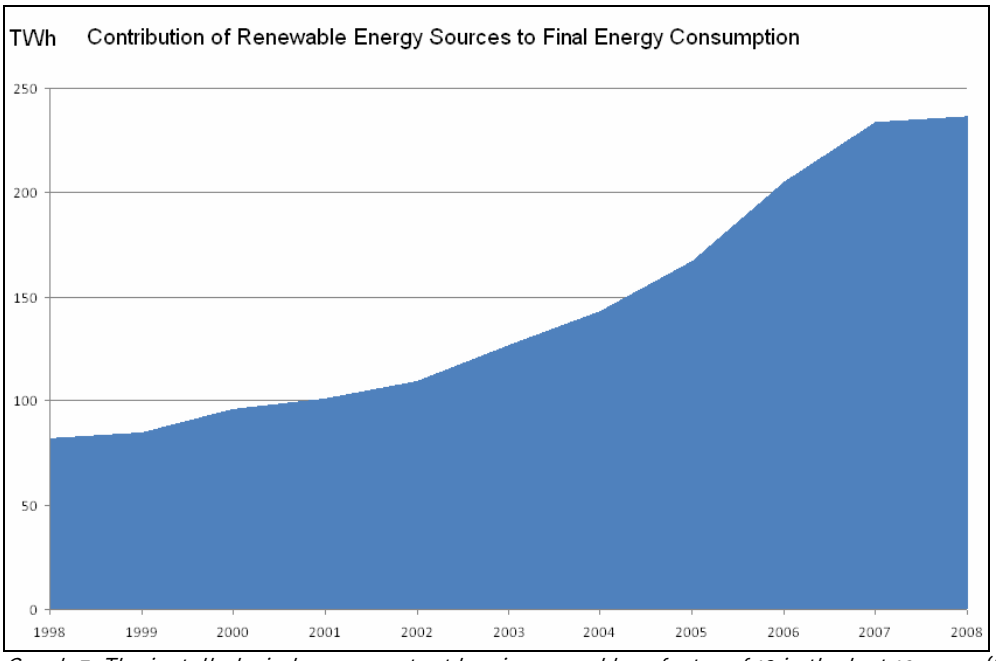



*Graph 3: The electricity generation from photovoltaic systems has increased by a factor of 100 in the last 10 years (from 0.03 to 4 TWh)[4].*




*Graph 4: The supply of electricity, heat and biofuels from bioenergy has tripled in the last 10 years from 51 to 166 TWh[5].*

[4] ibid.
[5] ibid.




*Graph 5: The installed wind energy output has increased by a factor of 12 in the last 10 years (from 9,700 to 122,000 MW)[6].*

# 3. The forecasts – development of renewable energy sources in Germany

## 3.1 Evaluation of scientific forecasts

The oil crisis in 1973 led to the world's first research and support programmes for renewable energy sources. Together with these research activities, the first forecasts on the development of renewable energy sources were also made at this time. With the exception of just a few studies, almost all forecasts in recent decades hugely under-estimated the development of renewable energy sources (see Table 1; Graph 4).

Of the 50 forecasts evaluated by this report, almost all predicted too small a contribution of renewable energy sources to the overall energy supply. The few studies that overestimated the future share of energy from renewable sources assumed an unrealistic rise in energy related prices until the year 2000 and stronger support by promotion

[6] World Wind Energy Association (WWEA) 2008. EurObserv'ER 2008: Wind Energy Barometer.

instruments. Since these assumptions did not materialise by the year 2000, the early optimistic scenarios from the 1980s did not come about.

The greatest differences between the forecasts and the reality of renewable energy development in Germany are from the studies by Prognos AG, carried out on behalf of the Federal Ministry of Economics and Technology. For example, the actual use of renewable energy sources in the year 2000 was nearly three times as high as the forecast made in 1998. Furthermore, the expected electricity supply from renewable energy sources in 2020 was already surpassed in 2007. But even the forecasts carried out on behalf of the Federal Ministry for the Environment and the German Federal Environment Agency in recent decades fell short of the mark concerning the actual development of renewable energy sources.

These forecasts not only underestimated the development potential of renewable energy sources, but also completely failed to take certain technologies into account. The Prognos study from 1985, for example, only saw development potential for hydro power, firewood, sewage sludge and waste and did not take into account the potential of "new" renewable energy technologies. Therefore, according to this forecast, wind energy, photovoltaic technology, biogas, geothermal energy, solar thermal energy and biofuels could not make any contribution to the energy supply.

The studies that followed only gradually started to take into account the breadth of the technology options available in terms of renewable energy sources. The differences between forecasts and the reality of "new" renewable energy sources are particularly striking. The Prognos study from 1998, for example, estimated that electricity generation from photovoltaic systems would be 0.44 TWh by 2020 - whereas photovoltaics were already generating ten times as much electricity in Germany by 2008.

The Prognos study from 2005 is also far removed from reality. The predicted values for 2030 regarding the generation of electricity from bioenergy and photovoltaics and for heat generation from renewable energies were already reached in 2007, just two years after the study was published. The predicted production of biofuels for 2020 was also already surpassed in 2007.

## Renewable energy forecasts for Germany

| Year of the forecast | Author/ Commissioning body | Energy type / reference parameters | Forecast target year[7] | Predicted terawatt hours | Actual energy supply in TWh for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|
| 1980 | Öko Institut: Energy Revolution: "Sun and coal" scenario | RE overall (PEC[8]) | 2010 | 516 | 377 (2008) | 2010 forecast will not be met |
| 1982 | Kernforschungsanstalt Jülich (KFA[9]) | RE overall (FEC[10]) | 2000 | 201 | 96 | -52% |
| 1984 | Prognos (upper variant)[11]; Commissioned by the Federal Ministry of Economics | RE overall (FEC) | 2000 | 35 | 96 | +174% |
| 1984 | Fraunhofer-Institut für Systemtechnik und Innovations- forschung (Fraunhofer ISI) / Deutsches Institut für Wirtschaftsforschung (DIW); Commissioned by the Federal Ministry of Economics[12] | RE overall (FEC) | 2000 | 118 | 96 | -18% |
| 1990 | Öko Institut: The green energy revolution scenario 2010[13]; Commissioned by Bündnis 90/die Grünen, Böll-Stiftung | RE - electricity | 2010 | 77 | 91 (2008) | 2010 forecast already surpassed in 2007 |
| 1993 | Deutsches Institut für Luft- und Raumfahrt (DLR): Geo-Studie | EE overall (FEC) | 2005 | 106 | 168 | +58% |
| 1995 | Verband der Elekrizitäts-wirtschaft (VDEW[14]) | RE - electricity (percentage of total electricity generation) | 2005 | Max. 6% | 10.40% | +73% |
| 1995 | Inquiry Commission "Schutz der Erdatmosphäre" ('Protecting the Earth's Atmosphere'); Reference scenario | RE overall (PEC, substitution method) | 2020 | 175 | 377 (2008) | 2020 forecast already surpassed in 2003 |
| 1995 | Inquiry Commission | RE overall (PEC, | 2020 | 196 | 377 (2008) | 2020 forecast |

[7] For long-term forecasts with several time periods, the prediction year is given which has already been exceeded by actual developments.
[8] Electricity, heat and fuels from renewable energy sources ('RE overall') measured in primary energy consumption (PEC).
[9] Kernforschungsanstalt Jülich – Atomic Research Center Jülich, 1982. Quoted in Fischer / Häckel 1987.
[10] Electricity, heat and fuels from renewable energy sources ('RE overall') measured in final energy consumption (FEC).
[11] The forecast from Prognos AG only takes into account the use of hydro power, fire wood, sewage sludge and waste.
[12] The "positive variant" scenario assumes a significant increase in energy prices (real increase of 2% until 1990, 4% per annum from 1990 onwards). However, real oil prices between 1980 and 2000 actually decreased significantly. Study: Fraunhofer Institute for Systems and Innovation Research / German Institute for Economic Research, 1984: Estimating the potential of renewable energy sources. Quoted in: Hauf 1986.
[13] The predicted electricity generation from renewable energy sources for 2010 was already surpassed by more than 10 TWh in 2007. Fritsche / Kohler 1990.
[14] Quoted in: *Die Welt*: *"Sanfte Energie gewünscht",* 23 August 1995.

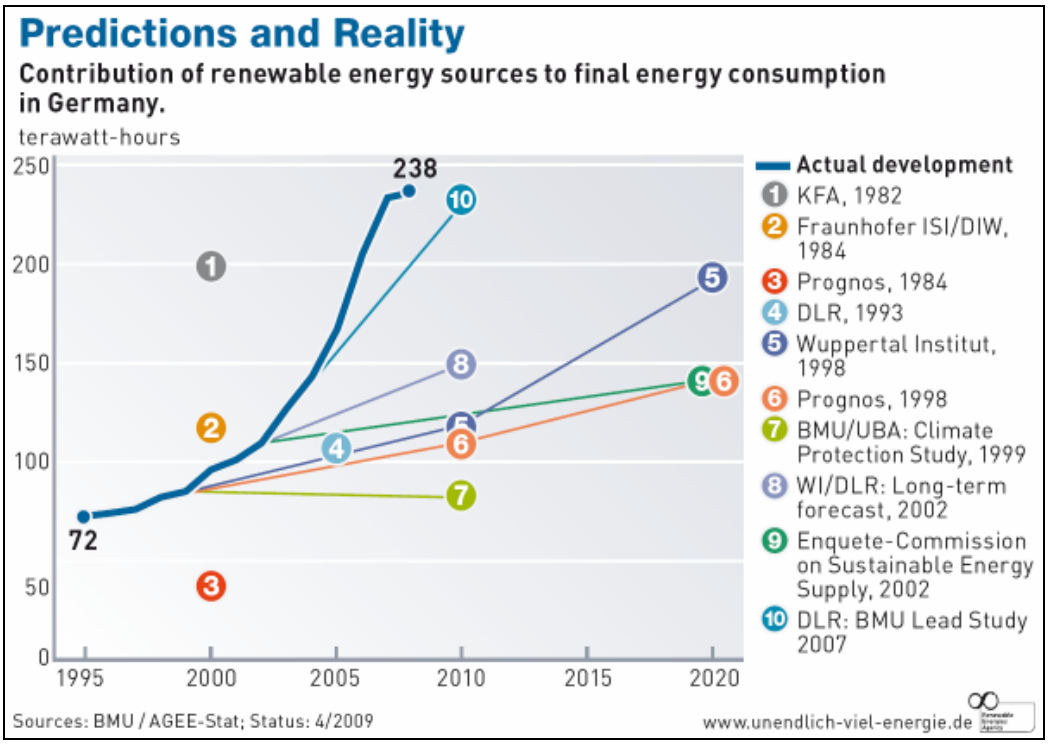
| Year of the forecast | Author/ Commissioning body | Energy type / reference parameters | Forecast target year[7] | Predicted terawatt hours | Actual energy supply in TWh for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|
| | "Schutz der Erdatmosphäre" ('Protecting the Earth's Atmosphere'); R1 scenario[15] | substitution method) | | | | already surpassed in 2004 |
| 1995 | Inquiry Commission "Schutz der Erdatmosphäre" ('Protecting the Earth's Atmosphere'); R2 scenario[16] | RE overall (PEC, substitution method) | 2020 | 300 | 377 (2008) | 2020 forecast already surpassed in 2006 |
| 1996 | Öko Institut: Energy revolution scenario 2020; Commissioned by Bündnis 90 / Die Grünen, Böll-Stiftung | RE overall (PEC, substitution method) | 2015 | 387 | 377 (2008) | 2015 forecast almost already met in 2008 |
| 1998 | Wuppertal Institut (WI); Contribution of the construction and housing sector to climate protection: KE-0 scenario[17] | RE overall (EEC) without import of electricity from solar installations | 2020 | 195 | 238 (2008) | 2020 forecast already surpassed in 2006 |
| 1998 | Nitsch / Luther et al: long-term solar scenario[18] | RE overall (PEC, substitution method) | 2010 | 216 | 377 (2008) | 2010 forecast already surpassed in 2004 |
| 1998 | Prognos: Possibilities for stimulating renewable energy sources; Commissioned by the Federal Ministry of Economics and Technology | Re overall (FEC) | 2020 | 144 | 238 (2008) | 2020 forecast already surpassed in 2005 |
| | | RE -electricity | 2020 | 85 | 91 (2008) | 2020 forecast already surpassed in 2007 |
| | | RE - heat | 2020 | 59 | 109 (2008) | 2020 forecast already surpassed in 2003 |
| 1998 | Fraunhofer ISI: Delphi survey; Commissioned by the Federal Ministry of Education, Science, Research and Technology | RE - electricity, without hydro power (share of renewables in electricity generation) | 2020 | 10% | 11.5% (2008) | In 2007, 10% of all electricity was generated by renewable sources (excluding hydro power) |
| 1999 | Federal Ministry for the Environment (BMU) / Federal Environment Agency (UBA): Climate protection study | RE overall (FEC) | 2010 | 82 | 238 (2008) | 2010 forecast already reached in 2003 |
| 2000 | Öko Institut: Energy Revolution 2020; scenario | RE - electricity | 2015 | 86 | 91 (2008) | 2015 forecast already reached |

[15] Assumption of scenario R1: $CO_2$ reduction by 45% compared to 1990. Quoted in DLR 2000.
[16] Assumption of scenario R2: Withdrawal from nuclear power by 2005, $CO_2$ reduction by 45% compared to 1990. Quoted in DLR 2000.
[17] Assumption of scenario KE-0: withdrawal from nuclear power by 2010 and a $CO_2$ reduction of 50% compared to 1990. Quoted in DLR 2000.
[18] Assumption of the scenario: $CO_2$ reduction of 80% by 2050.

| Year of the forecast | Author/ Commissioning body | Energy type / reference parameters | Forecast target year[7] | Predicted terawatt hours | Actual energy supply in TWh for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|
| | 'politics'; Commissioned by the Heinrich-Böll Stiftung | | | | | in 2006 |
| 2000 | Öko Institut: Energy Revolution 2020; scenario 'potential'; Commissioned by the Heinrich-Böll Stiftung | RE - electricity | 2015 | 97 | 91 (2008) | 2015 forecast is expected to be surpassed in 2009 |
| 2000 | Deutsches Institut für Luft- und Raumfahrt (DLR), Potential and perspectives; Commissioned by the Office of Technology Assessment at the German Parliament | RE - electricity | 2015 | 80 | 91 (2008) | 2015 forecast was already surpassed in 2007 |
| 2002 | Inquiry Commission "sustainable energy supply" Reference scenario | RE overall (FEC) | 2020 | 143 | 238 (2008) | 2020 forecast was already surpassed in 2005 |
| 2002 | Inquiry Commission "sustainable energy supply" scenario: REG-/REN offensive | RE overall (FEC) | 2010 | 181 | 238 (2008) | 2010 forecast already surpassed in 2006 |
| | | Electricity from photovoltaic systems | 2030 | 1.4 | 4 (2008) | 2030 forecast already surpassed in 2006 |
| 2002 | WI / DLR: Long-term scenarios; Commissioned by the Federal Environment Agency | RE overall (FEC) | 2010 | 150 | 238 (2008) | 2010 forecast already surpassed in 2005 |
| | | RE - electricity | 2015 | 108 | 91 (2008) | 2010 forecast is expected to be reached in 2010 |
| | | RE - heat | 2010 | 63 | 109 (2008) | 2010 forecast already surpassed in 2004 |
| 2004 | DLR, ifeu, WI: Ecologically optimised development of the use of renewable energy in Germany; Commissioned by the Federal Ministry for the Environment | RE overall (PEC) | 2010 | 181 | 276 (2008) | 2010 forecast already surpassed in 2005 |
| 2005 | Prognos IV; Commissioned by the Federal Ministry of Economics and Technology | RE overall (PEC) | 2015 | 265 | 276 (2008) | 2015 forecast already surpassed in 2007 |
| | | Electricity from bioenergy | 2030 | 22 | 23 (2007) | 2030 forecast already surpassed in 2007 |
| | | Electricity from photovoltaics | 2030 | 2.6 | 3.1 (2007) | 2030 forecast already surpassed in 2007 |
| | | RE - heat | 2030 | 103 | 100 (2007) | 2030 forecast |

| Year of the forecast | Author/ Commissioning body | Energy type / reference parameters | Forecast target year[7] | Predicted terawatt hours | Actual energy supply in TWh for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|
| | | | | | | already nearly reached in 2007 |
| | | Solar heat | 2030 | 5.3 | 5.3 (2008) | 2030 forecast already surpassed in 2008 |
| | | Biofuels | 2020 | 42 | 46.4 (2007) | 2020 forecast already surpassed in 2007 |
| 2005 | DLR, WI et al: Development of renewable energy sources in the electricity sector by 2020; Commissioned by the Federal Ministry for the Environment | RE - electricity | 2010 | 85 | 87 (2007) | 2010 forecast already surpassed in 2007 |
| 2006 | Bundesverband Erneuerbare Energie (BEE) ('Federal Association for Renewable Energy') | RE overall (share in FEC) | 2010 | 9% | 9.8% (2007) | 2010 forecast already surpassed in 2007 |
| 2007 | DLR: pilot study 2007; Commissioned by the Federal Ministry for the Environment | RE overall (FEC) | 2010 | 236 | 238 (2008) | 2010 forecast already surpassed in 2008 |

*Table 1: Selected forecasts on the development of renewable energy sources in Germany.*




*Graph 6: Contribution of renewable energy sources to final energy consumption in Germany.*

## 3.2 Statements on the development potential of renewable energy sources from the world of politics and the energy industry

Scientists are not the only ones who have significantly underestimated the development possibilities of renewable energy sources in recent decades. Politicians and industry associations from the energy sector have also done the same. It was claimed for a long time that renewable energy sources could only cover a small percentage of energy consumption. For example, the *Informationskreis Kernenergie* (Nuclear Power Forum) claimed in an advertisement in 1990 that wind energy could never provide more than one percent of the electricity supply in Germany because of the country's climatic conditions.

It is not only the development potential of renewable energy sources that has been significantly underestimated; the use of certain technologies such as the electricity generation from solar energy was even considered technically impossible. The most recent statements on solar electricity generation in Germany by a board member of *Energie Baden-Württemberg* (EnBW), Hans-Peter Villis, underestimate its development. In an

interview with the *Süddeutsche Zeitung,* he explains that solar electricity will only provide one percent of all electricity in 2020 because of insufficient sunlight. In 2008, however, solar power already provided a share of 0.7% of electricity consumption – and it is estimated that it will surpass the 1% mark in 2010[19].

Recently published forecasts on the development of renewable energy sources show just as well considerable divergences. The Federal Ministry of Economics presented a "vision for electricity supply" for 2030 in its brochure "A secure, affordable and environmentally friendly electricity supply in Germany – can this be done without nuclear power?". In this scenario, renewable energy sources will provide a share of 33% of electricity consumption until 2030. This view stands in stark contrast to the mid-term forecast of the *Bundesverband der Energie- und Wasser-Wirtschaft BDEW* ('Federal Association of the Energy and Water Industries'), which expects renewable energy sources to supply more than 28% of electricity consumption as early as 2014[20]. If increased efficiency causes consumption to decrease by 2030, 33% of electricity consumption being met by renewable energy sources would mean a stagnation in their development after 2014.

| Year of the forecast | Author/ Commissioning body | Energy type / reference parameters | Forecast target year | Predicted value | Current situation |
|---|---|---|---|---|---|
| 2008 | Federal Ministry for Economics and Technology (BMWi) | RE - electricity (share of overall electricity generation) | 2030 | 33% | 91,4 TWh or 15% (2008) |
| 2008 | Bundesverband der Energie- und Wasser- Wirtschaft BDEW ('Federal Association of the Energy and Water Industries'): Erneuerbare-Energien-Gesetz ('Renewable Energy Sources Act') mid-term forecast. | RE - electricity (share of electricity consumption) | 2014 | 156 TWh - only electricity pursuant to the Erneuerbare-Energien-Gesetz ('Renewable Energy Sources Act') | 91.4 TWh or 15 % (2008) |
| 2009 | Bundesverband Erneuerbare Energie ('German Renewable Energy Federation'): Industry forecast: Power supply 2020 | RE - electricity (share of electricity consumption) | 2020 | 278 TWh (47%) | 91.4 TWh (15 %) (2008) |

*Table 2: Forecasts published in 2008 and 2009 on the development of renewables in Germany*

[19] Süddeutsche Zeitung: "Solartechnik wird uns nicht weiterhelfen" ('Solar technology won't get us any further'). EnBW CEO Hans-Peter Villis on brand strategies, the future of the power grid and renewable energy sources. 15 March 2009

[20] By 2014, the BDEW expects 156 TWh of electricity from renewable energy sources to be paid pursuant to the Erneuerbare-Energien-Gesetz (EEG/ 'Renewable Energy Sources Act'). A further 20 TWh of electricity is expected which does not fall under the Renewable Energy Sources Act (hydro power facilities with an output of more than 5 MW, biomass facilities with more than 10 MW output, proportion of biogenic waste in waste incinerators). With a marginal increase in electricity consumption until 2014 (620 TWh compared to 617 TWh in 2008), the percentage of renewable energy sources will have reached a share of 28%.

Past forecasts from the renewable energy associations have also underestimated their growing contribution to energy supply. For example, the forecast for 2010 from the *Bundesverband Erneuerbare Energie (BEE)* ('Federal Association for Renewable Energy') concerning the share in total final energy consumption provided by renewable energy sources was already surpassed in 2007, one year after publication. In an analysis from 2009, the *Bundesverband Erneuerbare Energie* and the *Agentur für Erneuerbare Energien* ('Renewable Energies Agency') are predicting that 47% of electricity will be supplied by renewable energy sources by 2020.

## Selected quotes

### 1976: Interview with Hans Matthöfer, then Federal Minister for Research (SPD)

"The generation of electricity from the sun's energy in the Federal Republic of Germany has thus far been described by reputable specialists as 'not yet economically and ecologically possible."
*Die Zeit*, No. 37, 3 September 1976
(http://www.zeit.de/1976/37/Ich-glaube-nicht)

### 1977: Interview with Professor Hans Karl Schneider, then head of the Institute for Energy Economics at the University of Cologne (EWI) and former chairman of the Scientific Advisory Council of the Federal Ministry of Economics as well as the German Council of Economic Experts.

*Die Zeit* – Question: "In your scenario, what percentage could be reached by alternative energy sources which are not based on fossil fuels or nuclear energy?

Schneider: "I hope a very high percentage. 'Very high', however, realistically means two to three percent of total energy requirements in the 1980s – perhaps a little bit more by the year 2000. Solar energy, wind energy, geothermal energy and other 'exotic' energy sources simply cannot provide more than five percent."

*Die Zeit*, No. 25, 10 June 1977

## 1977: CDU policy document excerpts

"New technologies: they need to be ready on time before fossil fuels become scarce. Solar energy can only be used for heating. Wind energy can make a small contribution to the power supply. Geothermal energy can only cover about one percent of overall energy consumption."[21]

*Die Zeit*, No. 42, 7 October 1977

## 1990: Advert from *Informationskreis Kernenergie* ('Nuclear Power Forum')

"'Electricity from Wind' – Yes, but...

The Danes are the European front-runners in the use of wind energy: in 1988, nearly one in every hundred kilowatt hours was generated by wind energy – that corresponds to 0.9% of overall electricity consumption. Such an intensive use of wind power is not possible in Germany due to its climatic conditions. In 1989, wind energy only covered 0.03% of overall electricity consumption. We therefore continue to be dependent on other environmentally friendly forms of electricity generation, such as nuclear energy, which currently makes up 40% of electricity generation. Questions on nuclear energy will be gladly answered by: *Informationskreis Kernenergie*, Heussallee 10, 5300 Bonn 1, 0228/507226"

*Die Zeit*, No. 26, 22 June 1990

[21] The Office of Technology Assessment (TAB) at the German Parliament identified a technical overall potential for geothermal electricity generation of 300,000 TWh, which corresponds to about 600 times Germany's annual electricity consumption. The additional potential of thermal energy (heat in cogeneration – combined heat and power) amounts to 600 times Germany's annual heat requirements if heat pumps are used. TAB 2003.

## 1993: Advertisement "Your Electricity Providers"

**Wer kritisch fragt, ist noch längst kein Kernkraftgegner.**

Viele junge Leute empfinden Kernkraftwerke als bedrohlich. Wir, die deutschen Stromversorger, haben Ihre Kritik nie leichtfertig abgetan. Im Gegenteil: Wir stellen uns dieselben Fragen, die sie bewegen.

Kann Deutschland aus der Kernenergie aussteigen? Ja. Die Folge wäre allerdings eine enorme Steigerung der Kohleverbrennung, mithin der Emissionen des Treibhausgases $CO_2$. Denn regenerative Energien wie Sonne, Wasser oder Wind können auch langfristig nicht mehr als 4 % unseres Strombedarfs decken.

Können wir ein solches Vorgehen verantworten? Nein. Der steigende Energiebedarf der dritten Welt verpflichtet die reichen Staaten, ihre $CO_2$-Emissionen zu mindern.

Schaffen wir das ohne Kernkraft, allein durch Energiesparen? Nein. Kernkraftwerke liefern 34 % des deutschen Stroms und ersparen der Atmosphäre jährlich 160 Mio. Tonnen $CO_2$ – bei einem international vorbildlichen Sicherheitsstandard. Also: Treibhaus oder Kernkraft? Das ist hier die Frage!

Viele junge Leute stellen kritische Fragen. Wir auch. Denn unsere schärfsten Kritiker sind wir selbst.

Ihre Stromversorger

Badenwerk Karlsruhe · Bayernwerk München · EVS Stuttgart · Isar-Amperwerke München · Neckar-werke Esslingen · PreussenElektra Hannover · RWE Energie Essen · TWS Stuttgart · VEW Dortmund

"Those who ask critical questions are not automatically against nuclear energy.

Many young people feel threatened by nuclear energy. We, the German electricity providers, have never simply dismissed your criticisms. On the contrary: we ask ourselves the same questions that concern you. Can Germany phase out of nuclear energy? Yes. The consequences would, however, be an enormous rise in the burning of coal, along with the emission of the greenhouse gas $CO_2$. This is because renewable energy sources such as solar power, hydro power or wind energy cannot provide more than 4% of our electricity requirements in the long-term. Can we take responsibility for such a course of action? No. The rising energy requirements of the third world obligate rich countries to reduce their $CO_2$ emissions. Can we do that without nuclear power, just by reducing energy consumption? No. Nuclear power stations provide 34% of German electricity and prevent 160 million tonnes of $CO_2$ from being emitted into the atmosphere every year – with internationally exemplary safety standards. So, should we be choosing greenhouse gases or nuclear

power? That is the question! Many young people ask critical questions. We do too, because we are our own fiercest critics. Your electricity providers.

26 June 1993

**1995: *Verband der Elektrititätswirtschaft (VDEW)* ('Association of the Electricity Industry') – forecasts up to the year 2005**

"Bonn/Bochum – The percentage of German electricity generation from renewable energy will increase from 4.7% (1994) to a maximum of 6% by 2005."

*Die Welt*: *Sanfte Energie gewünscht* ('Gentle Energy Wanted'), 23 August 1995.

**2000: Dr. Rolf Linkohr, Member of the European Parliament**

"The conditions vary from country to country. In Sweden, Austria and Finland, renewables have a share of over 20%, whereas in Belgium and Britain they make up less than 3%. Even Germany, with just 2.3%, has an astoundingly low rate. This will increase to 4.4% by 2020 when the measures that the Federal government has now taken come into effect. That is nice, but nothing more."

Dr. Rolf Linkohr MEP: What consequences does the Kyoto obligation have for the transport sector? Conference "*Erneuerbare Energien 2000*" ('Renewable Energy Sources 2000'), Böblingen, 18 February 2000.

**2004: Energy programme of the FDP parliamentary group in the German Parliament**

"Renewable energy sources still play a small role today. Nevertheless, their use in regions with suitable climate conditions is particularly sensible."

Resolution of the Bundestag parliamentary group of 10 February 2004 (http://files.liberale.de/wechsellexikon_liberale-Umwelt-und-Energiepolitik.pdf)

**2005: Dr. Angela Merkel, Federal Chancellor, then chairperson of the *CDU/CSU* parliamentary group in the *Bundestag***

"Increasing the share of electricity consumption covered by renewable energy sources to 20% is unrealistic. I believe it is unrealistic to expect renewable energy sources to be able to fill a gap such as the one that would be made by the early exit from nuclear power."

Dr. Angela Merkel, Speech on VDEW Congress, Berlin, 8 May 2005

# 4. Forecasts concerning Europe and the World

Even in Europe and around the world, renewable energy sources have grown considerably faster than predicted. The forecasts of the European Union (EU) and the International Energy Agency (IEA) deviate considerably from actual developments. A particularly clear example of this is the "PRIMES" forecast up to 2020, which was made in 1994. The energy generation by renewable energy sources in 2008 is already significantly higher than the predicted values for 2020. Wind energy is 36% above the predicted value, with bioenergy 26% higher, and solar energy even 15 times higher. In the "PRIMES" forecast there is no mention of solar power or biofuels production in the year 2020. However, the installed output of photovoltaic systems in Europe was 10 Gigawatts in 2008, and biofuel production stood at 7.7 million tonnes in 2007.

Further studies demonstrate similarly large deviations. For example, in 2004 the wind energy use in Europe was already higher than the value predicted for 2020 in the "Advanced Scenario" forecast by the European Union in 1996. But even the European Wind Energy Association (EWEA) considerably underestimated the speed of wind energy development (see Graph 8).

The forecasts have not become more reliable even as the significance of renewable energy sources has increased. The global development of wind energy has been growing by an average of 30% a year for more than ten years. These huge growth rates nevertheless fail to be reflected in the IEA forecasts. In the World Energy Outlook in 2002 the IEA expected an increase in wind energy capacity to 100,000 MW by 2020. Actual installed capacity already surpassed this value by 20 % in 2008, just a few years after the forecast was published.

## Renewable energy forecasts for Europe

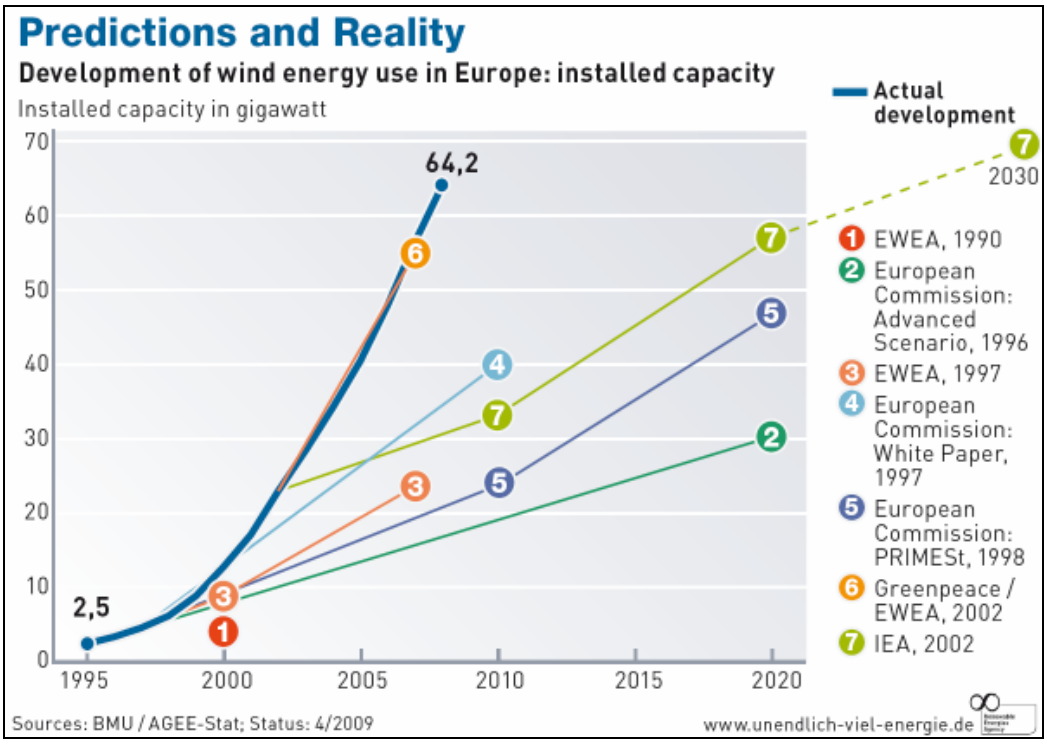
| Year of the forecast | Author/ Commissioning body | Geographical scope of the forecast | Energy type | Forecast target year | Fore-cast | Actual result for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|---|
| 1990 | European Wind Energy Association (EWEA) | EU-15 | Wind | 2000 | 4,089 MW | 12,887 MW | +215% |
| 1996 | European Commission: Baseline scenario[22] | EU-15 | Wind | 2007 | 6,799 MW | 56,535 MW | +732% |
| 1996 | European Commission: Advanced scenario | EU-15 | Wind / solar (electricity) | 2020 | 30,280 MW | 73,504 MW (2008) | 2020 forecast already reached at the beginning of 2004 |
| 1997 | EWEA[23] | EU-15 | Wind | 2000 | 8,000 MW | 12,887 MW | +61% |
| | | EU-15 | Wind | 2007 | 23,709 MW | 56,535 MW | +138 % |
| 1997 | European Commission White Paper[24] | EU-15 | Wind | 2010 | 40,000 MW | 64, 173 MW (2008) | 2010 forecast already reached in 2005 |
| | | EU-15 | Photovoltaics | 2010 | 3,000 MW | 9,331 MW (2008) | 2010 forecast already reached by 2007 in Germany alone |
| | | EU-15 | Solar heat | 2010 | 100 million $m^2$ | 22,33 million $m^2$ (2007) | 2010 forecast will not be met |
| | | EU-15 | Geothermal (electricity) | 2010 | 1,000 MW | 856.8 MW (2007) | 2010 forecast will nearly be met[25] |
| | | EU-15 | Geothermal (heat pumps) | 2010 | 2,500 MWth | 7,064 MWth (2006) | 2010 forecast already surpassed twice over by 2005 |
| 1998 | EWEA[26] | EU-15 | Wind | 2007 | 36,378 MW | 56,535 MW | +55% |
| 1998 | European Commission: PRIMES[27] | EU-15 | Wind | 2010 | 22,600 MW | 64,173 MW (2008) | 2010 forecast already reached in 2002 |
| | | EU-15 | Wind | 2020 | 47,100 MW | 64,173 MW (2008) | 2020 forecast already reached in 2007 |
| | | EU-15 | Solar heat | 2020 | 10,440 MWth | 10,110 MWth (2007) | 2020 forecast already nearly reached in 2007 |
| | | EU-15 | Biomass | 2010 | 609 TWh | 833 TWh (2006) | 2010 forecast already reached in 2001 |
| | | EU-15 | Biomass | 2020 | 657 TWh | 833 TWh | 2020 forecast |

[22] Quoted in: EWEA 2008: Pure Power. Wind Energy Scenarios up to 2030. p. 25
[23] Quoted in EWEA 2003.
[24] European Commission: Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan. November 1997. p. 41
[25] In Italy, the development of installed output is planned to be approx. 100 MW in 2010. EurObserv'ER 2008: The State of Renewable Energies in Europe.
[26] Quoted in: EWEA 2003.
[27] PRIMES: quoted in EWEA, Response to the European Commission's Green Paper: Towards a European strategy for the security of energy supply. November 2001.

| Year of the forecast | Author/ Commissioning body | Geographical scope of the forecast | Energy type | Forecast target year | Fore-cast | Actual result for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|---|
| | | | | | | (2006) | already reached in 2003 |
| 1999 | European Commission[28] | EU-15 | Wind | 2007 | 17,886 MW | 56,535 MW | +216% |
| 2002 | Greenpeace / EWEA: Windforce 12 | EU-15 | Wind | 2007 | 55,703 MW | 56,535 MW | +1% |
| 2002 | International Energy Agency (IEA): World Energy Outlook | EU-15 | Wind | 2010 | 33,000 MW | 64,173 MW (2008) | 2010 forecast already reached in 2004 |
| | | EU-15 | Wind | 2020 | 57,000 MW | 64,173 MW (2008) | 2020 forecast already surpassed in 2008 |
| | | EU-15 | Wind | 2030 | 71,000 MW | 64,173 MW (2008) | 2030 forecast almost already reached in 2008 |
| | | EU-15 | Geothermal (electricity) | 2010 | 1,000 MW | 856.8 MW (2007) | 2010 forecast will probably be met[29] |
| | | EU-15 | Geothermal (electricity) | 2020 | 1,000 MW | 856.8 MW (2007) | 2020 forecast will probably be surpassed[30] |
| | | EU-15 | Photovoltaics | 2010 | 2,000 MW | 9,331 MW (2008) | 2010 forecast already reached in 2005 |
| | | EU-15 | Photovoltaics | 2020 | 4,000 MW | 9,331 MW (2008) | 2020 forecast already surpassed in 2007 |
| 2003 | EWEA[31] | EU-15 | Wind | 2007 | 48,286 MW | 56,535 MW | +17% |
| | | EU-15 | Wind | 2010 | 75,000 MW | 64,173 MW (2008) | 2010 forecast will probably be surpassed.[32] |
| 2004 | IEA: Alternative Policy | EU-25 | Biomass | 2020 | 882 TWh | 971 TWh (2006) | 2020 forecast already surpassed in 2005 |

*Table 3: Forecasts for renewable energy sources in Europe*

[28] Cf. EWEA 2008
[29] In Italy the development of installed output is planned to be around 100 MW by 2010. EurObserv'ER 2008: The State of Renewable Energies in Europe.
[30] A stagnation in the use of geothermal power in Europe after 2010 is not likely.
[31] Cf. EWEA 2008
[32] It is very likely that the annual growth rates in the development of wind energy in Europe will continue until 2010.




*Graph 7: Development of installed wind energy capacity in Europe*

## Renewable energy forecasts worldwide

| Year of the forecast | Author/ Commissioning body | Geographical scope of the forecast | Energy type | Forecast target year | Forecast | Actual result for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|---|
| 1976 | Lovins[33] | USA | RE overall | 2000 | 26% | 7% | -370% |
| 1995 | International Energy Agency: World Energy Outlook, Energy Savings (electricity) | OECD countries | Geothermal | 2010 | 105.4 TWh | 38.76 TWh (2007) | 2010 forecast will not be met |
| | | OECD countries | Solar | 2010 | 13.9 TWh | 10 TWh world (2008) | 2010 forecast will probably be surpassed |
| | | OECD countries | Wind/tidal /other | 2010 | 70.4 TWh | 260 TWh (2008), only wind power | 2010 forecast already reached in 2004 |
| | | OECD countries | Biomass | 2010 | 173.7 TWh | 171.19 TWh (2006) | 2010 forecast already reached in 2007 |
| 1996 | Department of Energy (DOE) / Energy Information Administration (EIA): Annual Energy Outlook | USA | Wind | 2010 | 5,000 MW | 25,170 MW (2008) | 2010 forecast already reached in 2003 |
| | | USA | Wind | 2015 | 12,000 MW | 25,170 MW (2008) | 2015 forecast already surpassed in 2007 |
| 1998 | IEA: World Energy Outlook | OECD countries | Wind | 2020 | 45,000 MW | 97,304 MW (2008) | 2020 forecast already surpassed in 2005 |
| | | OECD countries | Geothermal | 2010 | 15,000 MW | 6,157 MW (2007) | 2010 forecast will not be reached |
| | | OECD countries | Photovoltaics / tidal / other | 2010 | 2,800 MW | Photovoltaic: 14,184 MW Tidal power: 260 MW (2008) | 2010 forecast already reached in 2004 |
| | | OECD countries | Photovoltaics / tidal / other | 2020 | 6,300 MW | Photovoltaic: 14,184 MW Tidal power: 260 MW (2008) | 2020 forecast already reached in 2007 |
| 2000 | IEA: World Energy Outlook[34] | World | Wind | 2007 | 26,614 MW | 93,881 MW (2007) | +253% |
| 2000 | DOE /EIA: Annual Energy Outlook | USA | Wind | 2010 | 3,260 MW | 25,170 MW (2008) | 2010 forecast already surpassed in 2002 |
| 2002 | IEA: World Energy Outlook[35] | World | Wind | 2007 | 41,952 MW | 93,881 MW | +124% |
| | | World | Wind | 2020 | 100,000 MW | 121,188 MW (2008) | 2020 forecast already surpassed in 2008 |
| 2004 | IEA: World Energy Outlook; Reference[36] | World | Wind | 2007 | 66.136 MW | 93,881 MW | +42% |
| 2004 | IEA: World Energy Outlook; | World | Wind | 2007 | 76,454 MW | 93,881 MW | +23% |

[33] Lovins A. 1976. The Road Not Taken. Foreign Affairs
[34] Quoted in: Rechsteiner 2008: Wind Power in Context. A Clean Revolution in the Energy Sector. p. 85.
[35] ibid.
[36] ibid.

| Year of the forecast | Author/ Commissioning body | Geographical scope of the forecast | Energy type | Forecast target year | Forecast | Actual result for the forecast year | Deviation between reality and the forecast |
|---|---|---|---|---|---|---|---|
| | Alternative | | | | | | |
| 2004 | IEA: World Energy Outlook; Reference[37] | World | Wind | 2007 | 73,031 MW | 93,881 MW | +29% |
| 2004 | IEA: World Energy Outlook; Alternative | World | Wind | 2007 | 73,559 MW | 93,881 MW | +28% |

*Table 4: Forecasts on the development of renewable energy sources worldwide*

## 5. Summary

This report evaluates German, European and global energy forecasts from the last few decades and compares the predicted levels with the actual development of renewable energy sources. The majority of the 50 forecasts examined underestimated the proportion of energy provided by renewable energy sources. Renewable energy sources often reached the predicted values several years in advance and surpassed these values by several hundred percent.

[37] ibid.

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