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VGB PowerTech

Figures and Facts about

2004

Electricity Generation

Development of Global Demand for Electricity

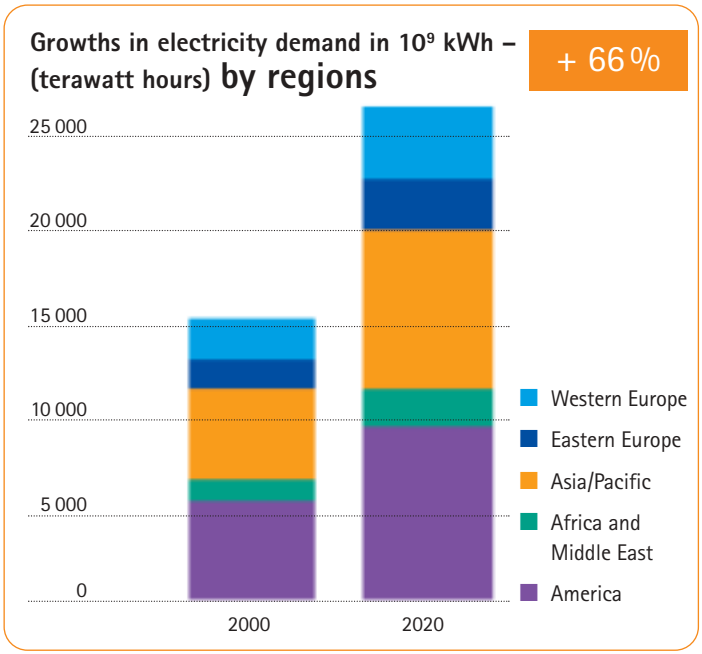
The world population is growing by 78 million people every year. The total world population has doubled since 1960. By the year 2020, the world's energy consumption for what will then be 8 billion people will have grown by approx. 35 %. Over the coming 25 years alone, the world's population will consume more electricity than it has in the entire period since electricity was first generated. Around one quarter of the world's population currently has no access to electricity. Consumption of electricity will grow more quickly than all other types of energy use. For example, IEA anticipates a rise of 66 % by 2020. Growth will be highest in the emerging markets of South America and Asia.

According to expert estimates, fossil energy sources will account for the major part of this growth, contributing more than 90 % of total consumption. The demand for natural gas for generating electricity will accordingly increase approximately three-fold by 2020. Consumption of coal is also set to grow, although somewhat more slowly than oil and gas consumption. Renewable energies will also play an increasingly important role in the world's primary energy supply structure.

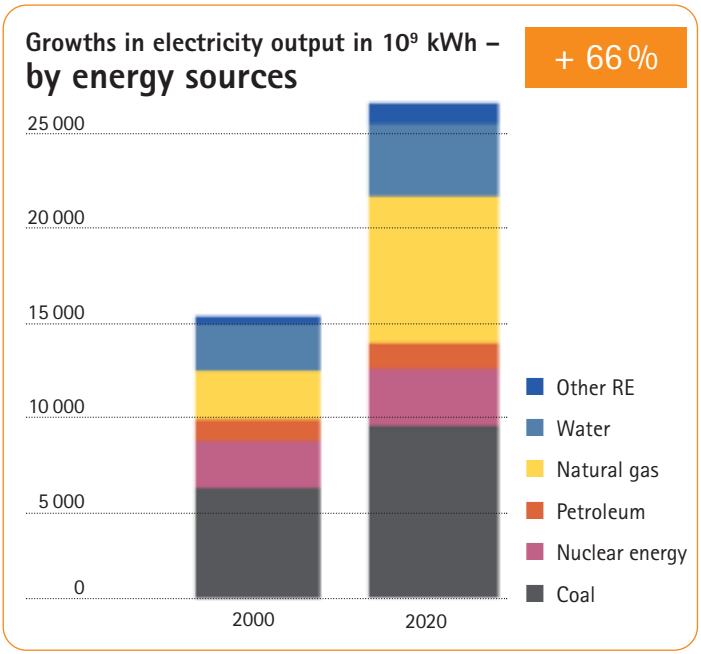
Source: UN, IEA, WEC

Contents

- Global Electricity Demand 2–3
- Electricity Demand in Europe 4–5
- Electricity Generation in Europe 6–7
- Energy Mix and CO_2 8–9
- Energy Prices 10–11
- Utilization 12–13
- Costs of Electricity Generation 14–15
- Modern Coal-fired and Gas-fired Power Plants 16–17
- Nuclear Energy 18–19
- Renewable Energies 20–21
- Research and Development 22–23
- Climate Policy 24–25
- VGB Activities 26–27



Source: UN, IEA, WEC



Source: UN, IEA, WEC

Electricity Demand and Energy Imports

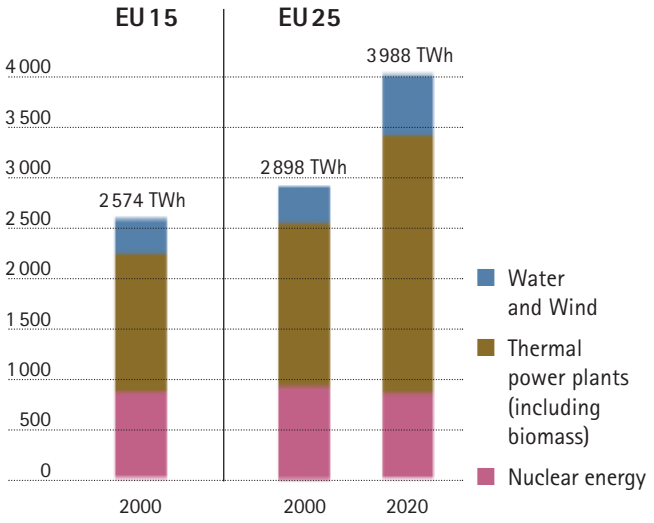
A quarter of all the electricity generated in the world, approx. 3 000 TWh, is consumed in the enlarged European Union (EU 25). The "European Energy and Transport Outlook" forecasts growth rates averaging 1.3 % per annum in the 15 "old" EU states and 2.2 % per annum in the 10 new EU members in the coming years. This will lead to an extra demand of 1000 TWh by the year 2020. In 2020, the main burden of electricity generation will continue to be borne by thermal power plants operating on the basis of coal, gas, biomass and nuclear energy.

Europe's dependence on imported primary energy will grow from today's rate of approx. 50 % to over 70 %, in the case of oil even to almost 90 %. This increased dependence is due not least to a decision by certain countries to phase out nuclear energy as well as to the depletion of economically recoverable reserves in Europe. Only lignite can be produced at competitive prices from opencast mines in several European countries in the long run. The portion of electricity generated from nuclear energy will drop from the current rate of approx. 32 % to 20 %. By contrast, the portion generated from renewable energy sources is supposed to double to around 20 %.

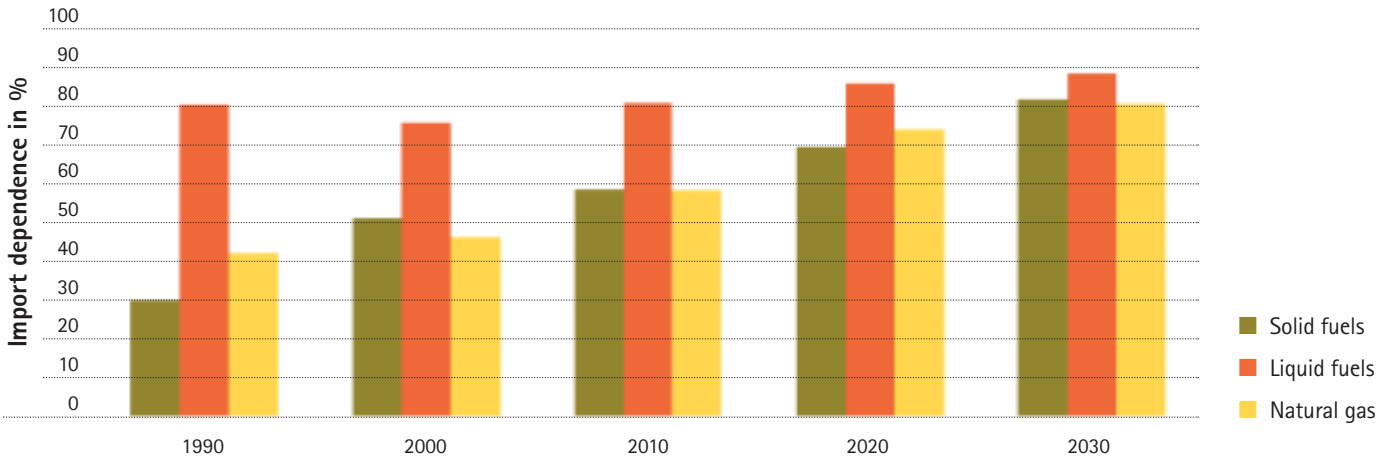
Source: Eurelectric, EU - Energy and Transport Outlook

Development of electricity demand in the EU from 2000 to 2020

+ 38 %



Import dependence of the EU on primary energy sources between 1990 and 2030



Source: EU - Energy and Transport Outlook

Portfolio of Power Plants and Generation Options

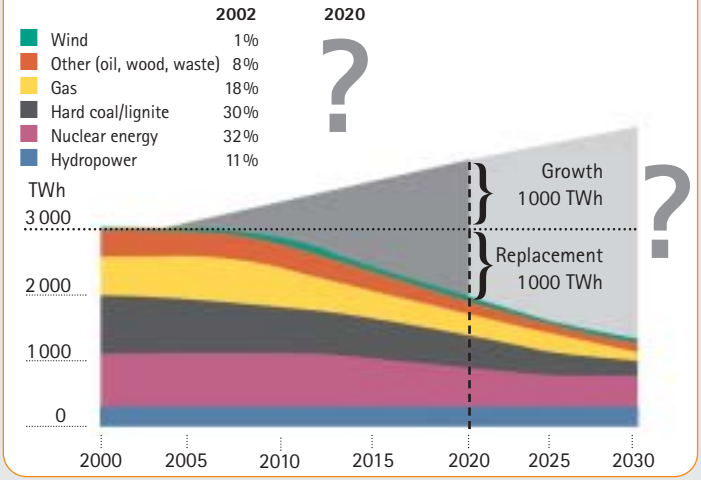
Demand for electricity will rise from the current volume of approx. 3 000 TWh to approx. 4 000 TWh in 2020. The age structure of European power plants and the phase-out of nuclear energy in Germany will lead to a shortage of supply of approx. 2 000 TWh - half of which comes from the need for replacement and half from extra demand. This raises the question as to how this gap can be closed. Given a technically feasible average utilization of 7 500 hours per annum for thermal power plants and 3 000 hours per annum for wind energy systems (onshore and offshore installations), the requirement can be calculated as follows:

- 167 nuclear power plant units at 1 600 MW each, or
- 266 lignite-fired units at 1 000 MW each, or
- 444 hard coal-fired units at 600 MW each, or
- 666 CCGT plants at 400 MW each, or
- 133 000 wind energy systems at 5 MW each (+ reserve power plants (80%) e.g. 355 hard coal-fired units or 532 CCGT plants)

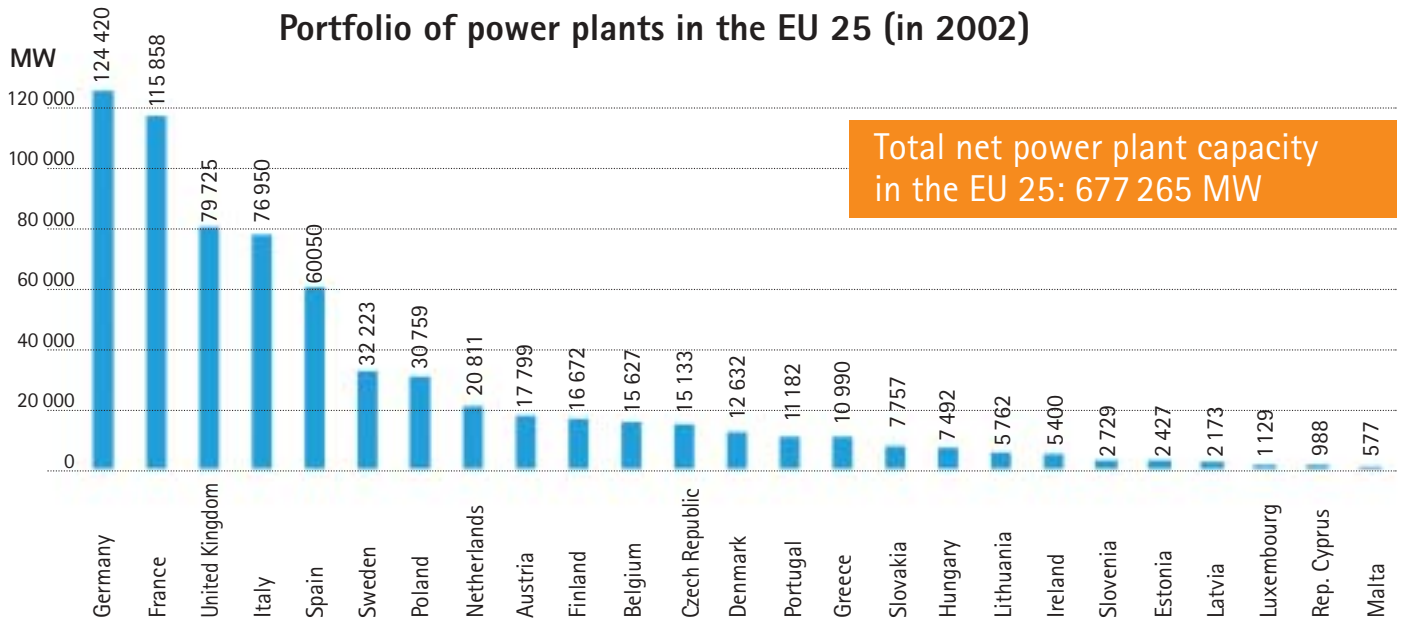
These figures alone show clearly that an energy mix will remain necessary in the future if reliable generation of electricity is to be secured.

Source: EU - Energy and Transport Outlook

Development of electricity generation in the EU 25 between 2000 and 2020



Portfolio of power plants in the EU 25 (in 2002)



Source: Eurelectric, Eurostat

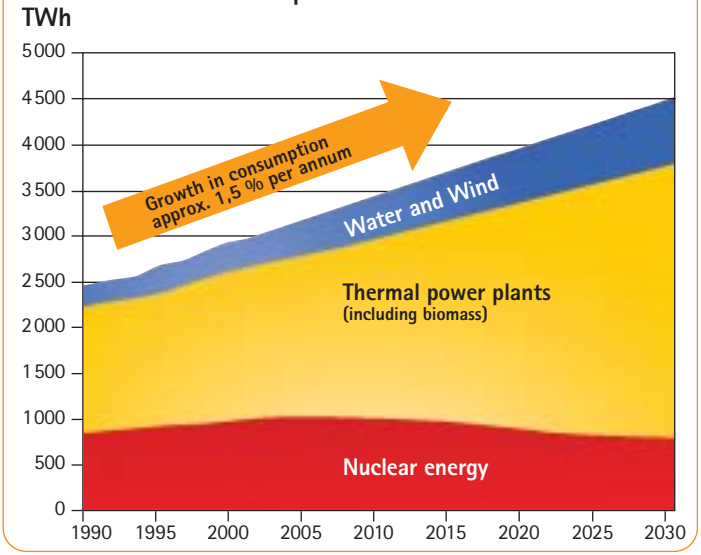
Energy Mix and CO_2

According to the EU study "European Energy and Transport Trends to 2030", the basic scenario shows that an overall increase in CO_2 emissions in Europe can be anticipated due to the continuous increase in electricity consumption (approx. 1.5 % per year) from 3 000 TWh today to up to 4 000 TWh in 2020. The chart also shows that decommissioned nuclear generation capacities are expected to be replaced primarily by thermal power plants. It is also anticipated that the electricity which has hitherto been generated almost without CO_2 emissions in nuclear power plants will in the future be provided by a mix of coal-fired and gas-fired power plants and biomass plants. This will lead to higher CO_2 emissions starting in 2015.

The EU forecast anticipates no significant portion of electricity needs to be met by photovoltaic plants in the period up to 2030. The share of renewable energies will thus essentially be covered by hydroelectric, wind power and biomass plants.

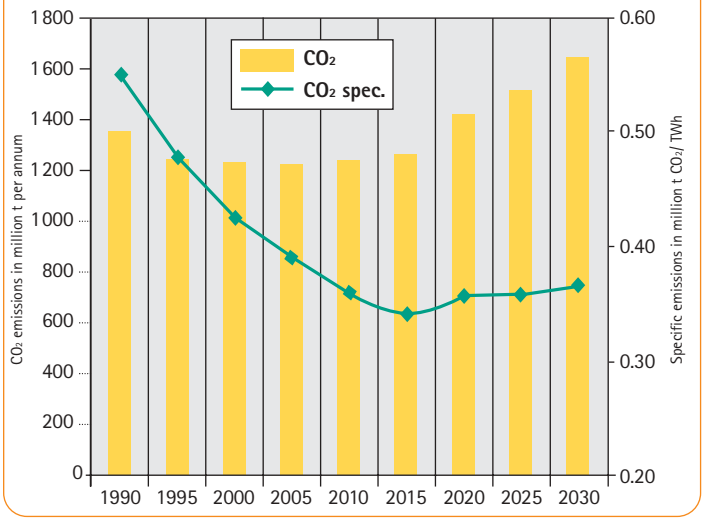
The significant rise in efficiency of thermal power plants and an increased volume of electricity generated by biomass power plants will lead to a reduction of specific CO_2 emissions from approx. 0.4 million tonnes CO_2/TWh to around 0.36 million tonnes CO_2/TWh.

Electricity generation options in the EU 25 up to 2030



Source: EU - Energy and Transport Outlook

Development of energy-related CO_2 emissions in the EU 25



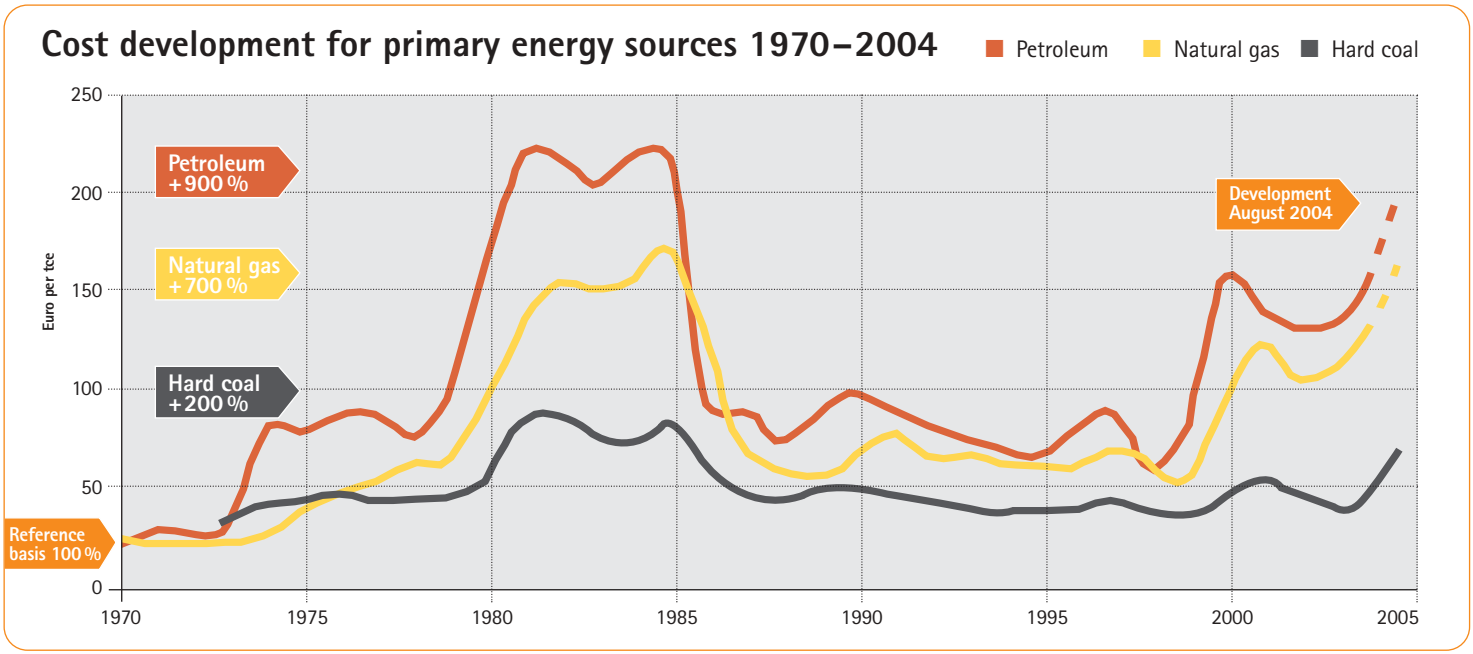
Source: EU - Energy and Transport Outlook

Price Risks for Primary Energy Sources

Growth, prosperity and social security depend on a reliable electricity supply. Reasonably priced electricity supplies are necessary if products are to be manufactured at competitive prices.

An analysis of import prices for petroleum, natural gas and coal shows that over the past 30 years petroleum has seen price fluctuations of approx. 900 %, natural gas of approx. 700 % and hard coal of merely 200 %. In addition, many countries have reserves of reasonably priced lignite for direct use in local electricity generation. The high price fluctuations for natural gas indicate the price risks for generating electricity from natural gas. A balanced energy mix will therefore remain necessary if electricity is to be generated at favorable cost in the future.

The cost of electricity generation essentially results from the fuel costs and the capital and staff costs. The share of costs contributed by the fuel to the total cost of electricity generation is also of importance. In gas-fired power plants, the fuel cost accounts for approx. 65 % of the total cost of electricity generation. In hard coal-fired power plants, by contrast, the fuel share accounts for only around 45 %, and is even lower in lignite-fired power plants. In addition to the price fluctuations for natural gas, which are significantly higher than for hard coal anyway, the increased fuel cost in gas-fired power plants gives rise to further economic risks. Natural gas-fired power plants are thus preferably used for the simultaneous generation of electricity and process heat because the fuel price risk can then be spread over the combined products of electricity and heat.



Source: Statistik der Kohlenwirtschaft e. V.

Utilization of Power Plants

The utilization period indicates how many operating hours a plant has run in any given calendar year. From a technical perspective, a high utilization will result from the ability to deploy a power plant as scheduled. The plant and the energy source must therefore always be available as planned. Thermal power plants operated with biomass, lignite, hard coal, natural gas or nuclear energy meet these requirements.

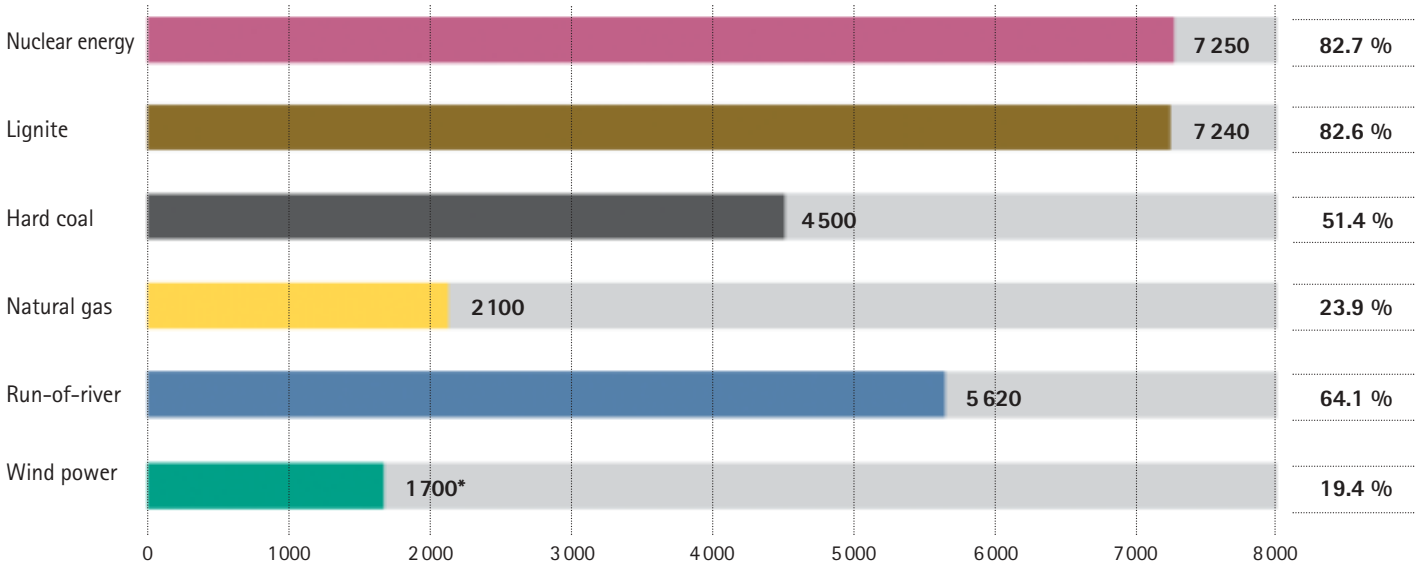
Fluctuating energy from the sun, wind and hydropower can, by contrast, be used only depending on their supply. In the least favorable case, electricity will be generated precisely at times when there is no demand in the power market, or conversely, no electricity will be produced when demand is highest. Such systems (with the exception of pumped-storage power plants) are therefore not utilized according to a plan but stochastically.

From an economic point of view, the utilization of a power plant should be as high as possible to spread operating costs over a broad product volume (kWh) and achieve low costs of electricity generation.[1] Power plants generating electricity from renewable energy sources above the wholesale price level (with the exception of hydropower) do not participate in the competitive market. This is why specific subsidization schemes are in place for power from renewables fed into the system.

In the German energy market, nuclear power plants, lignite-fired power plants and run-of-river power stations achieve a utilization of 6 500 to 8 000 hours in base-load operation. Hard coal-fired power plants achieve a utilization of approx. 4 500 hours in mid-merit load operation. They compensate for the fluctuations between electricity generation and electricity consumption. Peaks in electricity consumption are covered by so-called peak-load power plants (e.g. gas-turbine plants).

[1] This requires, of course, a level of fuel costs enabling electricity to be generated at competitive terms. This is not always the case with natural gas-fired plants.

Average utilization of power plants in hours per annum (example Germany, 2001)



* Values from 2002, own calculations

Source: VDEW electricity data

Costs of Electricity Generation in New Power Plants

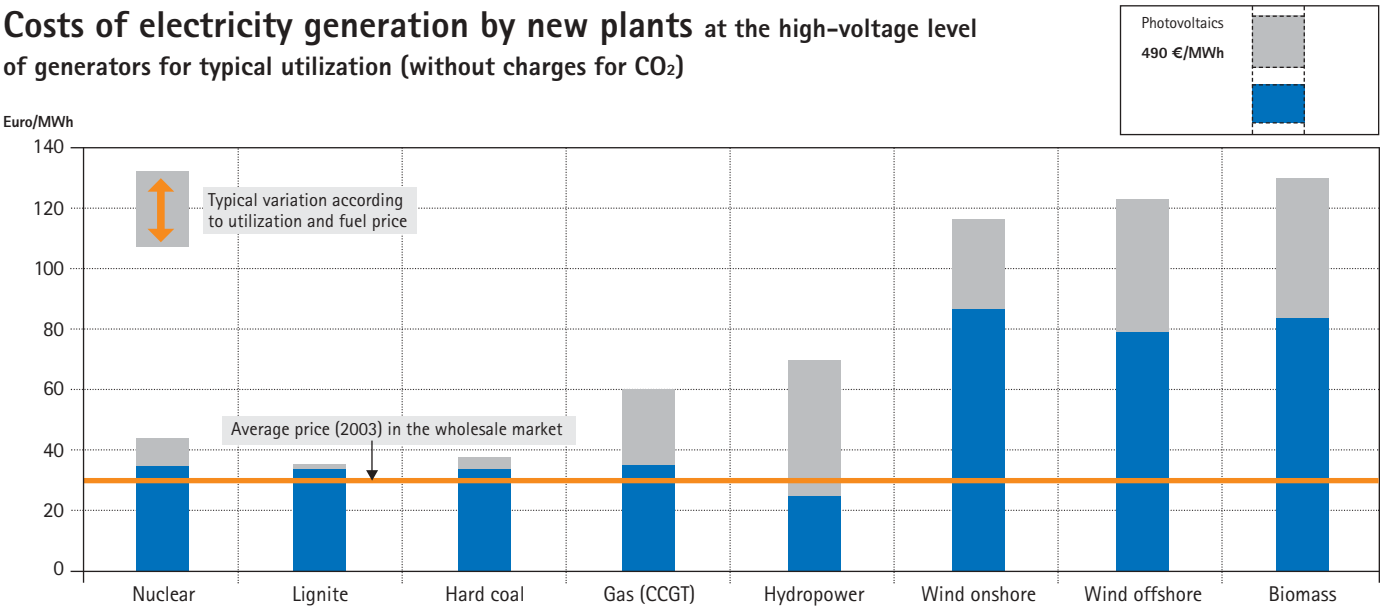
The use of renewable energies (with the exception of existing hydroelectric stations), such as wind power, biomass, geothermal energy and photovoltaics, as well as electricity generation from small cogeneration plants are currently not yet competitive. This is why these technologies are subsidized by the government. Among the plants using renewable energies, only the existing, partly depreciated hydropower plants are economically viable. Their potential for expansion, however, is largely exhausted, so that no significant growth can be expected.

In today's liberalized power market, lignite-fired power plants compete with hard coal-fired power stations, gas-fired power plants and nuclear power plants. Electricity from these plants can be sold in the wholesale market only if it is generated at competitive terms. In 2003, the average price for electricity at the wholesale level was Euro 30/MWh. The decision to build and operate a power plant will depend on the expected revenue. If costs of electricity generation are higher than the revenue, the plant will not be economically viable.

If a base-load or mid-merit power plant cannot operate for the scheduled number of hours because electricity is fed into the system primarily from regenerative plants, this will lead to higher costs of electricity generation. Trading with CO_2 emission certificates due to be introduced in 2005 may impose additional costs on electricity generation.

End consumer prices are significantly higher than the costs of electricity generation (e.g. in Germany) due to further costs incurred by electricity transmission, concession levies and other statutory levies resulting from the German Renewable Energy and Cogeneration Acts. End consumer prices furthermore also include other costs caused by ecotax and value-added tax.

Costs of electricity generation by new plants at the high-voltage level of generators for typical utilization (without charges for CO_2)



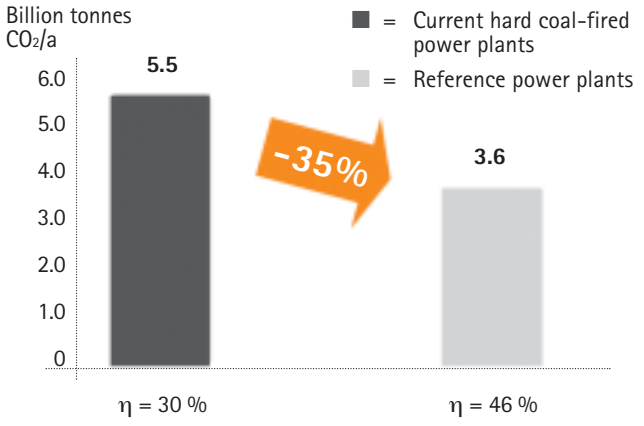
Source: Own calculations, Bremer Energieinstitut, TVO, EURELECTRIC, Study RKW NRW

CO_2 Reduction by Efficient Coal-fired and Gas-fired Power Plants

Modern fossil-fuelled power plants fired by lignite, hard coal and gas can make a major contribution to reducing CO_2 emissions worldwide. Efficiencies of > 43 % are already technically feasible for lignite-fired power plants and > 58 % for CCGT power stations. The technical-commercial analysis presented in the concept study "Reference power plant North Rhine-Westphalia" showed that hard coal-fired power plants can today achieve efficiencies of approx. 46 % at inland sites. If the cooling tower of such a plant is replaced by fresh-water cooling (e.g. on the coast), the net efficiency can be increased even to approx. 47 %. Further cost-intensive measures also allow efficiencies of 48 %. The general economic conditions on the deregulated European energy market, however, do currently not permit such increased investment.

A simple calculation reveals that a total replacement of the hard coal-fired power plants existing in the world (average efficiency approx. 30 %) by this new technology (efficiency 46 %) would lead to a reduction in CO_2 emissions by 35 %. In this way, global CO_2 emissions of 5.5 billion tonnes would be reduced to 3.6 billion tonnes - equivalent to a contribution 1.5 times the entire Kyoto CO_2 commitment up to 2008/2012.

Worldwide replacement of existing hard coal-fired power plants by modern reference power plants



Ready for use: Modern coal-fired and gas-fired power plant technology

Lignite

BoA Niederaußem

> 43 %

Hard coal

Reference power plant NRW

46 %

Gas

CCGT Köln-Niehl

> 58 %

Nuclear Energy Potential

The European Union is world leader in generating electricity from nuclear energy, accounting for a share of 32 %. No other region produces a larger portion of its energy from this source. In this way, approx. 650 million tonnes of CO_2 are avoided each year. Various European countries are continuing the development of nuclear energy to meet growing demands for electricity free of CO_2 in the future. It was agreed with the new EU members to close down all nuclear power plants that do not comply with western safety standards. Under the European "Phare" program, among others, safety reviews were conducted from which improvements were derived and implemented for plants which can be backfitted. A total nuclear power capacity of 3 500 MW, which cannot be backfitted according to the EU, is affected by these closures. The EU enlargement has therefore led to improvements in plant safety.

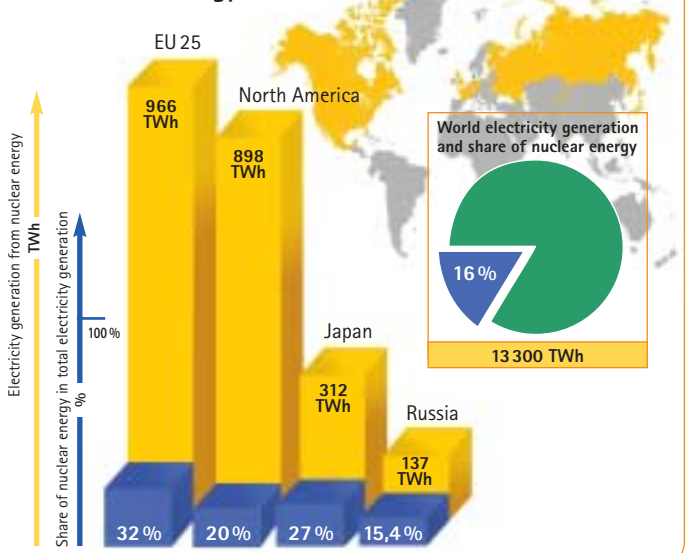
The probabilistic safety analysis (PSA) is a proven standard method for assessing the safety of technical plants, and specifically of nuclear power plants. The analysis is always applied specifically to each plant and is updated for the most nuclear power plants every ten years.

The evaluation shows a continuous improvement in PSA results over more than 35 years. This is due both to more refined verification methods and plant improvements (backfitting). There are currently 442 nuclear power plant units in operation throughout the world, which on 1 July 2004 had an accumulated operating experience of over 11 500 years of reactor operation.

The integral safety of all these nuclear power plants has, on average, increased ten-fold every 10 years, while it took 20 years for the accumulated reactor years of operation to increase by the same amount.

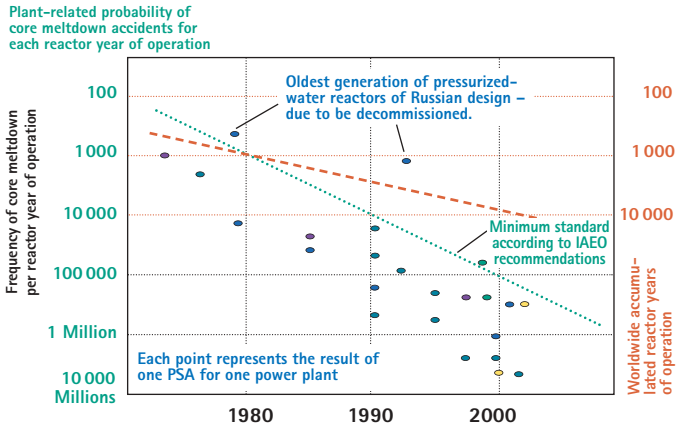
The improvement in plant safety therefore continues faster than the increase in reactor years of operation. This means that even with a faster expansion of nuclear energy, the probability of an accident occurring with significant radioactive discharges would continue to decrease. In addition, modern reactor designs such as the EPR (European Pressurized Reactor) are equipped with sophisticated safety systems for preventing core meltdown.

EU 25: No. 1 in the electricity generation from nuclear energy



Source: IEA 2002

Results of probabilitstic safety analyses (PSA), for NPP worldwide



The actual radiation hazard for the public is again much more remote, as only every tenth to one hundredth core meltdown accident leads to a significant release of radioactivity.

The individual results cannot be directly compared to each other due to the different methods and boundary conditions.

Source: International Atomic Energy Agency IAEO, VGB

Renewable Energy Sources and Distributed Small Power Plants

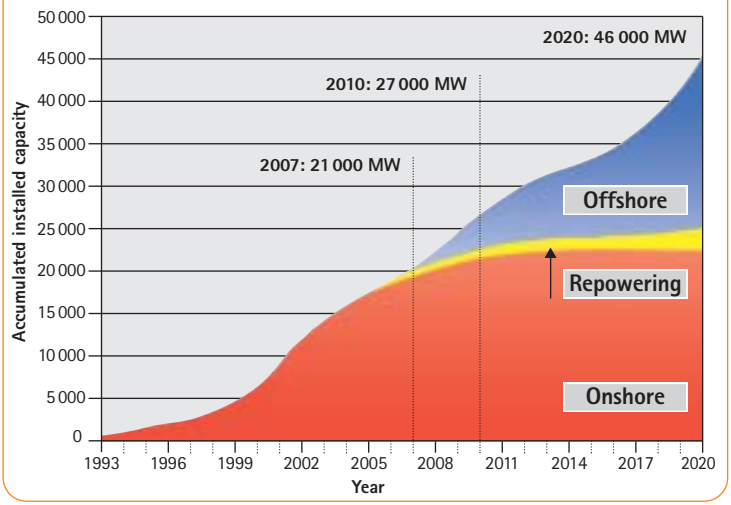
Electricity generation from renewable energy sources enjoys high priority in the European Union due to the associated security and diversification of energy supply, environmental protection and social and economic cohesion. However, using renewable energies is often in conflict with the aims of deregulated energy markets, as the cost of electricity generation from such sources still cannot compete with conventional energy generation. If renewable energies are to be integrated favorably into the liberalized energy market, energy conversion will therefore have to be highly efficient. Minimizing distortions of competition in the European Single Market requires uniform regimes for the support of renewable energies to be introduced. These regimes should be based on market-economy criteria.

Among all the plants operated on the basis of renewable energy sources, only the existing hydropower plants are economically viable. However, their technical potential is largely exhausted. Both in Europe and in Germany, an intensive expansion of wind power plants can be witnessed, with a currently installed capacity of 28 706 MW and 14 609 MW respectively (end of 2003). Deutsche Energie-Agentur (German Energy Agency - DENA) expects this trend to continue (see forecast below).

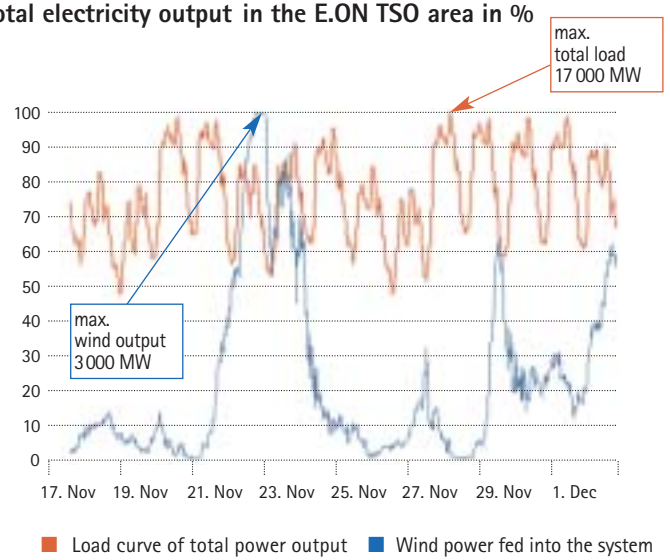
The main difference between generation of electricity from wind energy and in conventional thermal power plants is, however, the unsteadiness of supply from the former source. Energy supply depends on the climate and weather and is never completely reliable, which puts heavy demands on the existing portfolio of power plants. Conventional thermal power plants must, for example, be kept on standby to guarantee that electricity requirements can be met even at times when wind farms are unable to produce any electricity due to weak winds or storms.

Besides wind energy, using biomass can also make a significant contribution to the supply of electricity. In the field of distributed small power plants, a bright future is being predicted for fuel cells, which can also contribute to an environment-friendly supply of power. This will require, however, a drastic reduction in system costs if economically viable operation is to be guaranteed.

Forecast for trends in wind energy
in Germany up to 2020



Wind power fed into the system and
total electricity output in the E.ON TSO area in %



Source: DEWI (rounded forecast values)

Research and Development

Additional power plant capacities, estimated at approx. 2 000 GW by the year 2020, will be required to meet the world's growing electricity demand. The challenges posed by climate policy must also be met. Against this background, electricity supplies that are reliable, economical and environment-friendly in the long run can best be achieved in liberalized electricity markets by a balanced mix of energy sources. In addition to continued expansion of CO_2-free energy sources, the use of fossil energies will remain indispensable in this regard.

The development of new power plant concepts with high and maximum efficiencies for the energy conversion of fossil fuels represent a major challenge and opportunity at the same time. This challenge can be met with a staged approach.

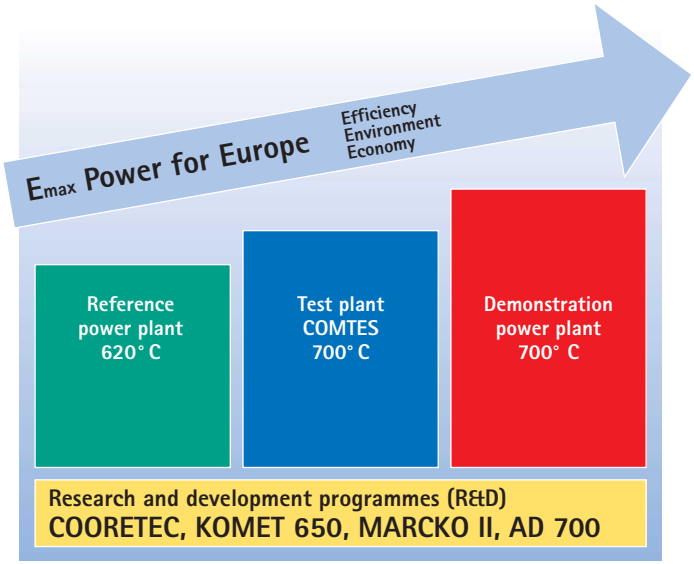
In the short and medium term, the development of plants fired by fossil fuels (materials, components, process management) should be continued consistently on the basis of existing technologies. This approach should realize those potentials of CO_2 reduction that can most easily be exploited under the general conditions of electricity generation necessary from an overall economic point of view (availability and competitiveness). Such CO_2 reduction measures are furthermore to be pursued, and supported, for all options of power plant technology as a "no-regret strategy", as, on the one hand, low specific CO_2 avoidance costs and, on the other hand, a significant reduction of CO_2 emissions are possible.

The VGB-Emax power plant initiative is a first step for the continued development of modern environment-friendly hard-coal and lignite-fired power plants.

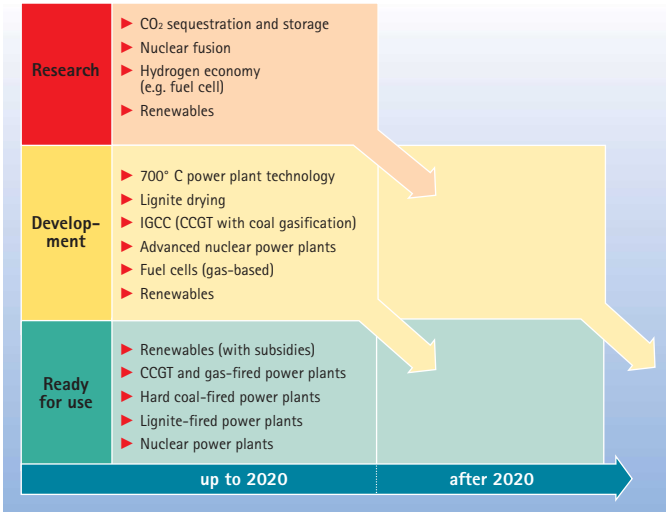
At the same time, additional R&D activities for innovative power plant concepts are also to be stepped up with which further efficiency increases and reductions in CO_2, including the option for CO_2 sequestration, can be achieved in the medium and long term. Such long-term R&D activities must address, among other things, the development of innovative CO_2 sequestration techniques and the systematic investigation of complete process chains including reliable CO_2 storage.

The situation as described above will generally require a consistent and thorough technology offensive, which can be realized only with a comprehensive national and European research program. Public acceptance of sustainable energy supply also needs to be improved as a supplementary step.

Emax power plant initiative



R&D electricity generation technologies: Today – Tomorrow – The Future



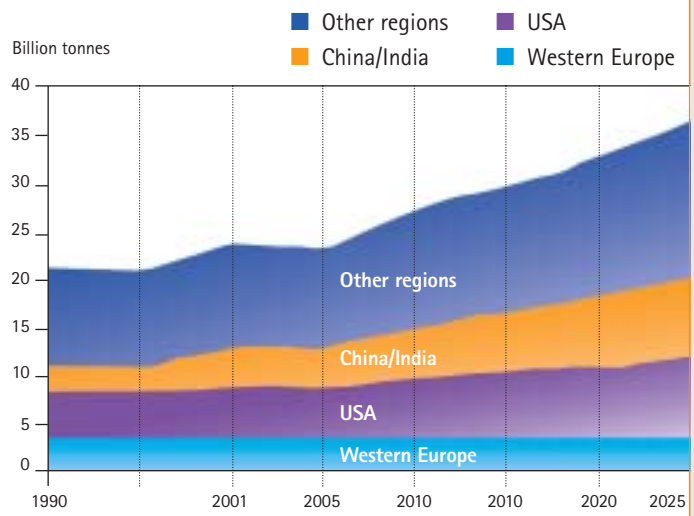
Climate Balance in the EU 25/World

Even without human influence, the world climate is changing due to geological processes and changes in cosmic radiation activity. Although there is no scientific evidence of any correlation between incidents of heavy rainfall and changes in the global climate, the reduction of emissions and careful use of energy resources remain important goals, if only as a precaution.

Worldwide CO_2 emissions will rise from 24.5 billion tonnes (in 2000) by around 1.8 % each year. The share of emissions attributable to electricity generation will increase, according to forecasts, from 5.6 billion tonnes to 9.1 billion tonnes up to 2020. As the increase in CO_2 emissions will occur for the most part in developing countries and the USA, a global climate prevention program will lead to a sustained reduction in emissions only if these countries subscribe to the obligations to reduce emissions. Today, only approx. 30 % of global CO_2 emissions come under the voluntary obligations of the Kyoto Protocol.

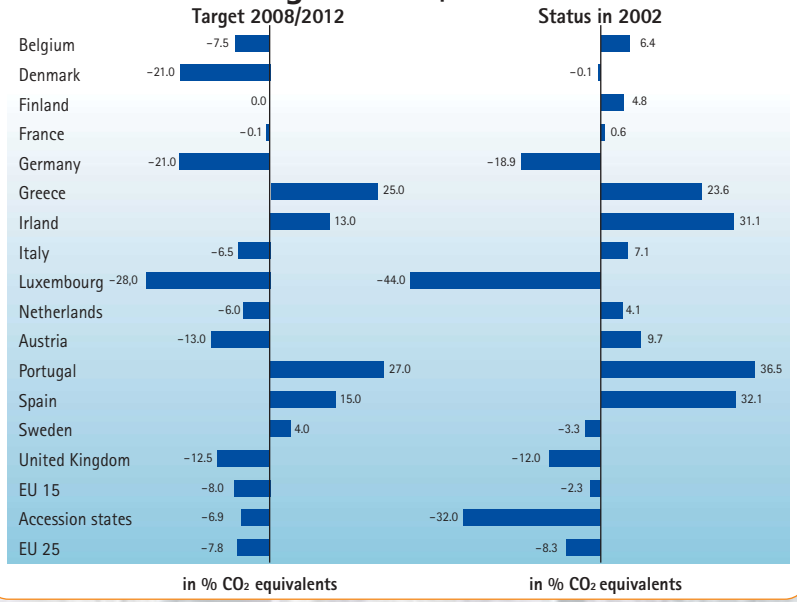
Source: WEC, SV GUA, IEA

Development of worldwide CO_2 emissions 1990 to 2025

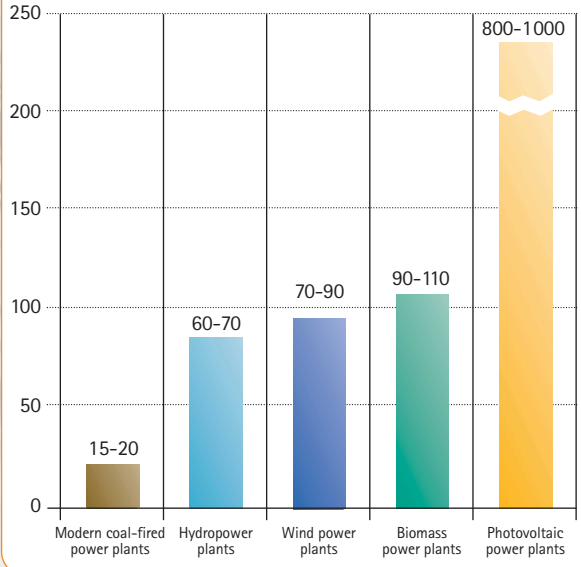


Source: Energy Information Administration/International Energy Outlook 2004

CO_2 reduction targets in Europe



Specific CO_2 reduction costs in €/t CO_2



Source: European Environment Agency (EEA)

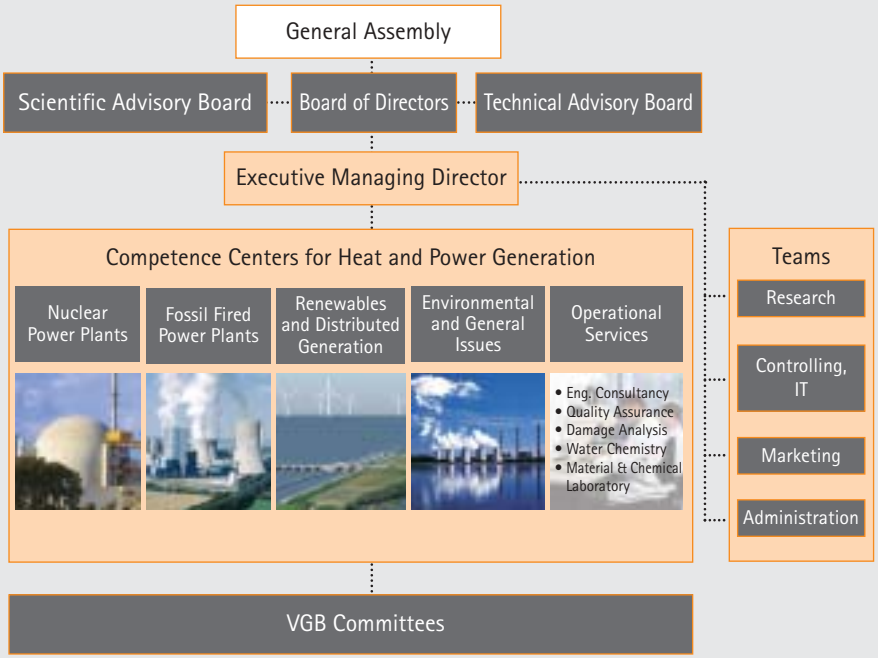
Tasks of VGB Offices

VGB PowerTech e.V. is the European technical association of electricity and heat producers. According to its tasks, VGB Offices are divided into the competence centres:

- Nuclear Power Plants,
- Fossil Fired Power Plants,
- Renewables and Distributed Generation,
- Environmental and General Issues,
- Operational Services.

These competence centres are dealing with all issues of power and heat generation and related environmental topics in close co-operation with VDEW at national level and with EURELECTRIC at European level.

For performing its duties according to the articles of association, the VGB Board has opted for honorary committees. The VGB Technical Supervisory Board is responsible for appointing the members. Currently four general committees are active with their numerous technical and special committees as well as working panels.



VGB PowerTech e.V.

We are a voluntary association of companies that focus on power plant operation and related technologies, i.e. these fields are an important basis of the entrepreneurial activities of our members. The domicile of the association is Essen with liaison offices in Brussels and Berlin.

Our objective is the support and improvement of

- the operating safety and environmental compatibility as well as
- the availability and efficiency of power plants for electricity and heat generation, either in operation or under construction.

Currently we have 423 members in total, comprising operators, manufacturers and institutions connected with energy engineering. Our members come from 29 countries worldwide and represent an installed power plant capacity of 471 700 MW, 394 000 MW of which are in Europe.

Our tasks are to

- utilise and bundle international experience,
- offer expertise for current tasks and tomorrow's challenges,
- represent our members' interests.

Currently 423 companies from 29 countries are members in our association:

Fossil-fired power plants	:	295 000	MW
Nuclear power plants	:	114 600	MW
Hydro-power plants	:	62 100	MW
Total	:	471 700	MW

EU 25: 394 members in 19 countries
Austria, Belgium, Czech Republic, Denmark, Germany, Finland, France, Greece, Great Britain, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Poland, Portugal, Slovenia, Spain, Sweden

Europe: 20 members in 6 countries
Iceland, Croatia, Romania, Russia, Switzerland, Turkey

Outside Europe: 9 members in 4 countries
Brazil, India, Israel, South Africa

Gesamt: 423 members in 29 countries