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VGB PowerTech

Figures and Facts about

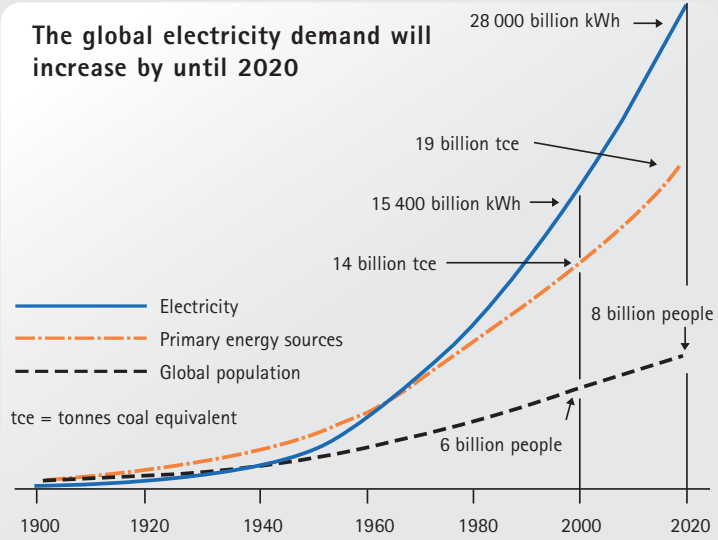
Electricity Generation

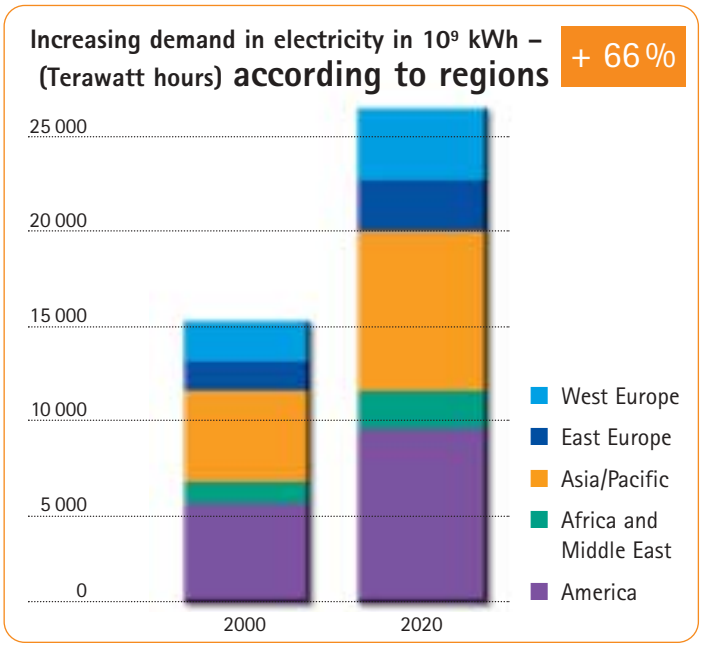
2003

Development of the Global Electricity Demand

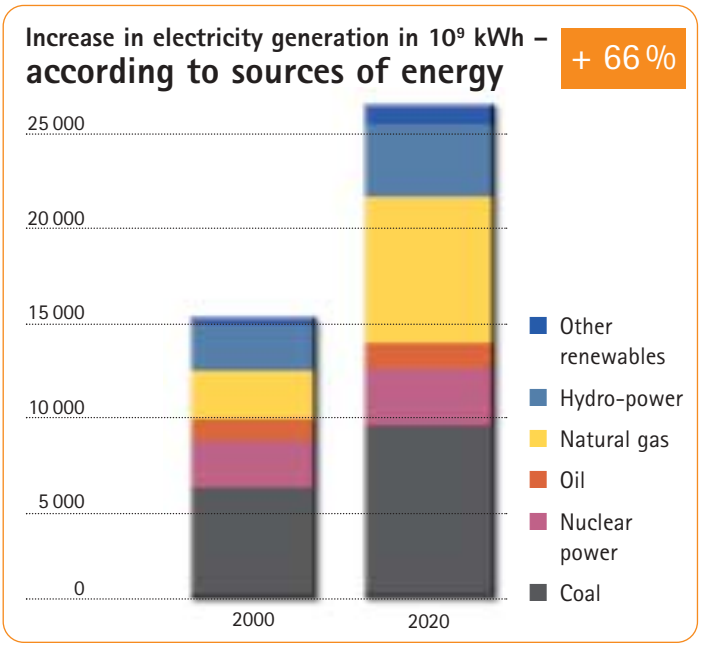
The strongly growing global population will consume more electricity in the next 25 years than in the entire period since the beginning of electrical power generation. Electricity consumption will increase more rapidly than any other kind of energy consumption: "The trend towards electricity is unbroken." Currently more than one quarter of the world population still has no access to electricity. This share will only change slightly in the coming years. The largest increase in electricity generation growth will occur in the threshold countries in South America and Asia.
Fossil fuels will remain the most important sources of energy and will cover more than 90 % of the consumption growth. The demand in natural gas, which is the primary energy source with the smallest range, for electricity generation will triplicate until 2020 due to the lack of other alternatives. Coal consumption will also rise, however, more slowly than the oil and gas consumption. Renewables will play an increasing part in the global structure of primary energy consumption.

Source: UN, IEA, WEC, Siemens





Source: UN, IEA, WEC, Siemens



Source: UN, IEA, WEC, Siemens

Development of the Electricity Demand in the EU and in Germany

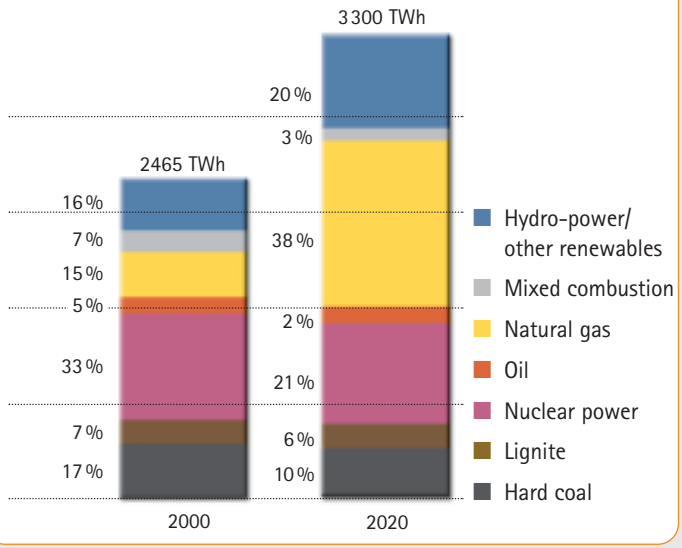
The electricity generation will increase in Europe by some 34 % until 2020. The high dependency of the European Union on energy imports will further increase up to a share of more than 70 %. The gas-based electricity generation will increase from 15 % to 38 %. The share of nuclear power will decrease from 33 % to 21 %. A decisive increase is expected for renewables.

Until 2020 the electricity generation in Germany will increase by some 9 %. Imported hard coal will drive out domestic hard coal. Nuclear power-based electricity generation will decrease from 30 % to 6 % by 2020 due to the political decision to phase out nuclear power. Lignite will remain the only domestic source of energy with a noteworthy contribution to electricity generation.

Source: EURELECTRIC, Eurprog 2002

Development of electricity generation in the EU from 2000 to 2020

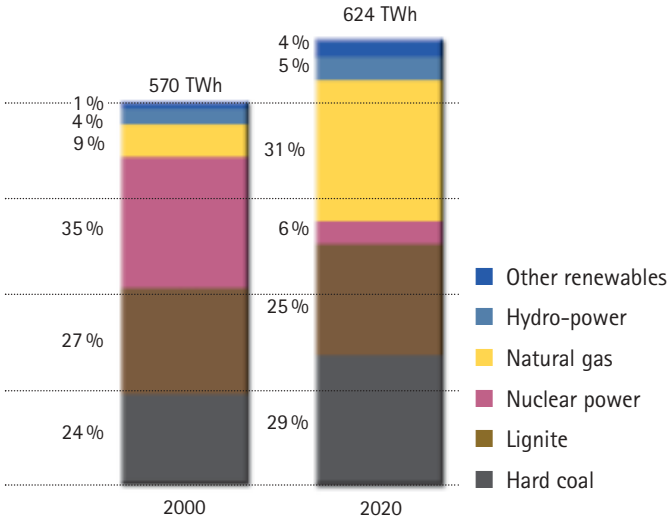
+ 34 %



Source: ESSO-Prognose (state 02/2002)

Development of electricity generation in Germany from 2000 to 2020

+ 9 %



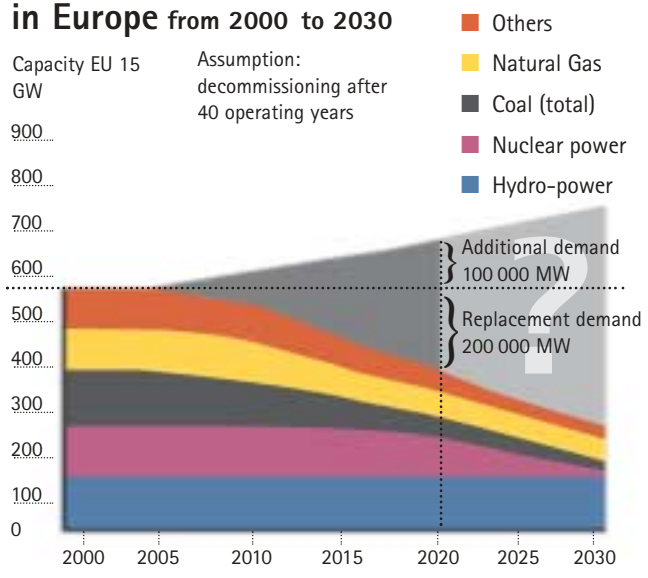
Development of the Power Plant Portfolio in the EU and in Germany

An estimated power plant capacity of 200 000 MW will have to be replaced in Europe (EU 15) until 2020 due to ageing and political decisions (e. g. phasing out of nuclear power). These figures are based on the assumption that plants will have to be decommissioned after 40 operating years. Additionally, the EU Commission is expecting an increase in electricity demand of approximately 100 000 MW.

The enlargement of the EU to 25 countries will further increase the demand in new plants in the EU 25, since the power plant park in the acceding countries mainly comprises older plants with an average efficiency of 35 %.

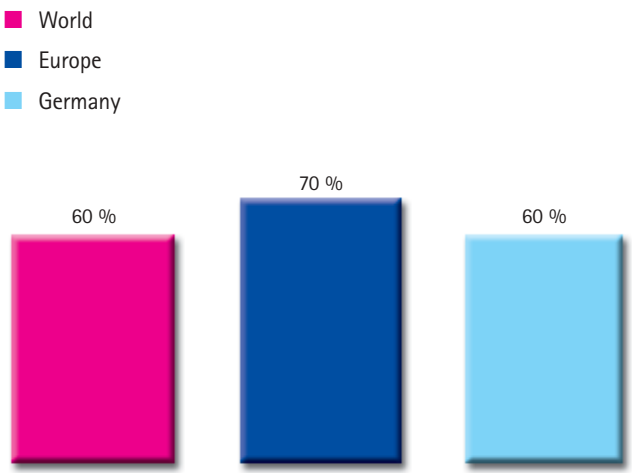
Until 2020 power plants in Germany with an installed capacity of approximately 40 000 MW will have achieved their technical lifetime of 40 years. The decision to phase out nuclear energy will result in an additional capacity of 21 700 MW that will be decommissioned until 2025. It is uncertain how to cover this gap in the long term. But also in the short term there is need to act. **On the day with the maximum load (10th December 2002) the remaining reserve only amounted to 1700 MW** (this equals 1.6 % of the total installed capacity).

Development of the power plant portfolio in Europe from 2000 to 2030

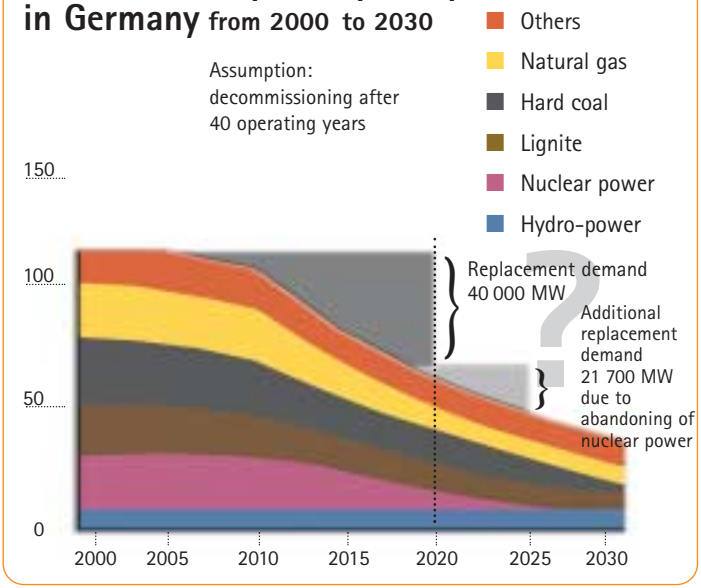


Share of coal-fired power plants older than 20 years (state: 2000)

Source: RWE



Development of the power plant portfolio in Germany from 2000 to 2030



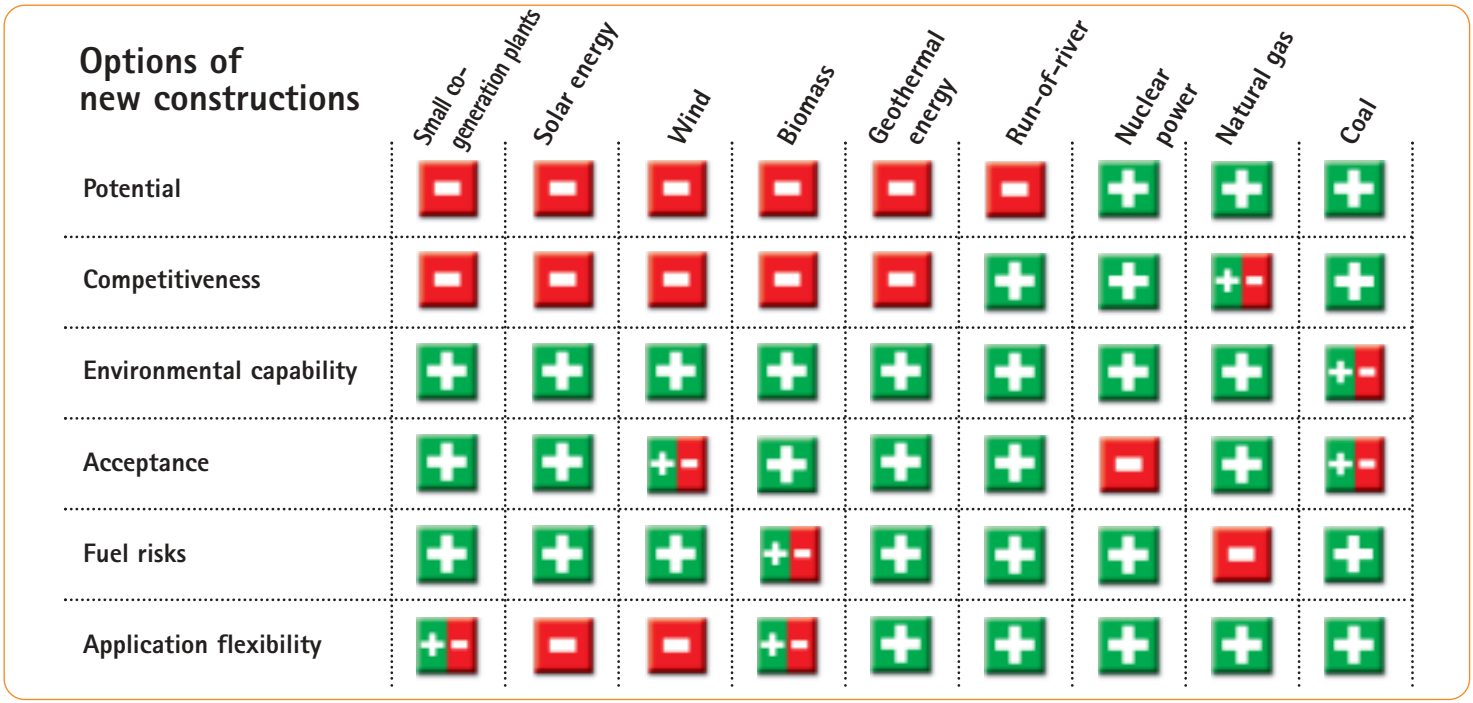
Options of Future Power Generation

Competitiveness, amongst other requirements, is in the foreground in the liberalised electricity markets Currently, renewables (wind, biomass, geothermal energy, solar energy) as well as electricity generation in small plants for co-generation are still not competitive. Therefore, these techniques are backed within the scope of government support schemes. Among renewables, hydro-power plants are the only renewable-based stations that are operated profitably. However, its technical potential is nearly depleted, thus, no noteworthy increase in hydro-power can be expected. Besides, the General EU Directives and their implementation into national law are bearing uncertainties for hydro-power plant operators.

Nuclear power offers an option for economic and CO_2-free electricity generation, but is not widely accepted by politics and public in numerous European countries.

The use of natural gas in combined gas and steam power plants is an attractive option due to its high efficiencies, favourable investment costs and short construction periods, however, the development of the gas price is connected with high risks. This applies in particular when the forecasted application of combined cycle plants as base load stations is resulting in increased demands in imported gas.

With realisable capacities of up to 1000 MW and a high reliability, coal-fired power plants offer a large potential to overcome the future supply bottleneck. The long-term secured and competitive power generation is guaranteed by globally distributed coal reserves. Comprehensive R&D efforts in "Clean Coal Technologies" are aiming at the market introduction of state-of-the-art coal-fired power plants with higher efficiencies and even less emissions. These modern techniques can also open economic CO_2-reduction potentials.



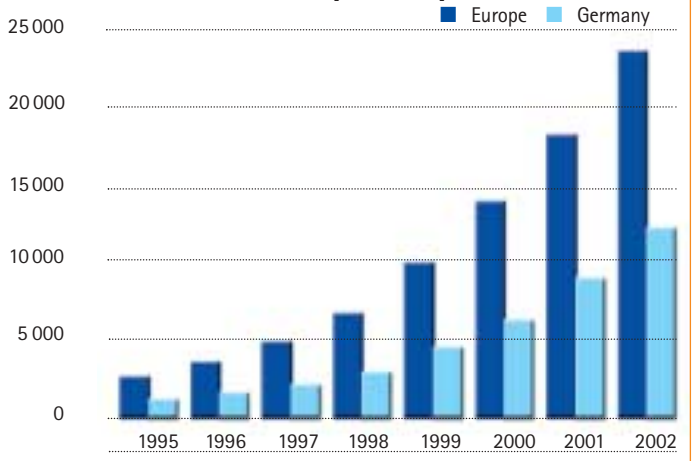
Challenge Wind Energy – Effects of Increased Extension

The main growth in renewables will occur in the field of wind energy. In Europe as well as in Germany wind power increased with an installed capacity of approximately 23 050 MW and 12 000 MW, respectively (state end of 2002).

The main difference of wind-based power generation to conventional conversion processes is the fluctuation in generation. The weather-related fluctuation and not reliably available supply of energy is making high demands on the existing power plant park, i. e. conventional thermal power plants have to be available in order to cover the electricity demand when wind parks do not produce any power due to weak winds or have to be shut down because of storm. Therefore, wind parks cannot provide reliable capacities. This also applies when the plants are distributed over large areas. The increasing amount of wind-based electricity generation has considerable effects on the remaining power plants. It can be assumed that the thermal power plants designed for base- and medium load are increasingly driven out of their original operation into unfavourable load-following operation with poor efficiencies. The already high demand in primary control reserve will further rise due to the supported extension of wind energy. Therefore, large wind parks not only have to meet the requirements of reliable system operation but also have to provide grid-supporting functions.

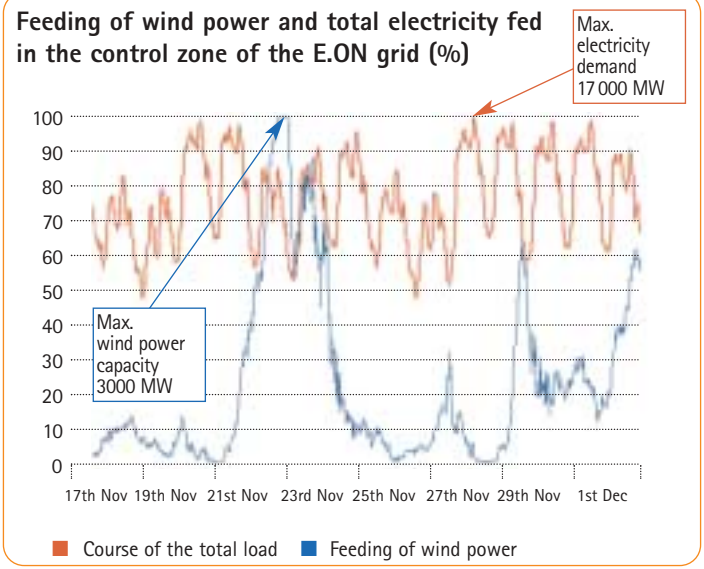
A decisive criterion for the extension of wind energy – this is also a general requirement to be met by the other renewables – is the maximum efficiency of the energy conversion technique, a high availability as well as the optimum harmonisation of the entire power plant park.

Installed capacity of wind power plants in MW



	1995	1996	1997	1998	1999	2000	2001	2002
Europe	2 531	3 496	4 794	6 553	9 739	13 631	17 813	23 056
Germany	1 132	1 552	2 081	2 874	4 442	6 095	8 754	12 001

Feeding of wind power and total electricity fed in the control zone of the E.ON grid (%)



Challenge Decentral Small Plants
– A Viable Future Vision?

A trend in electricity generation is the extension of decentral systems (small block heating plants, micro gas turbine, fuel cells and others). Especially the fuel cell can contribute to environmentally compatible energy supply, if the technical and economic conditions are met. Since the fuel cell is in competition with other conversion systems and measured at the cost structure of conventional energy conversion plants, the following technical general conditions are given for the successful broad introduction on the electricity and heat generation market:

- Competing technologies are existing heating techniques and the electricity supply via the grid as well as efficient and already mature technologies of decentral electricity and heat generation.
- Fuel cell plants have to achieve efficiencies of > 90 % and have to be operated for a minimum lifetime of 40 000 operating hours without any restriction.
- The special investment costs are not to exceed 1000 €/kW, el. for industrial applications.
- The system cost for smaller household plants (up to 5 kW, el.) have to be below 10 000 €.

In future, fuel cells with an electrical capacity of approximately 1 to 10 kW are to provide households with electricity. For distributed electricity and heat supply fuel cell block heating plants with an output of approximately 500 kW are envisaged. Mainly hydrogen and hydrogen-rich gases are to be used as fuel. This also comprises fossil fuels like natural gas, which can be converted efficiently with low pollution into electrical energy. It is expected that in the year 2020 the contribution of the fuel cell in the energy supply is probably less than 3 %.

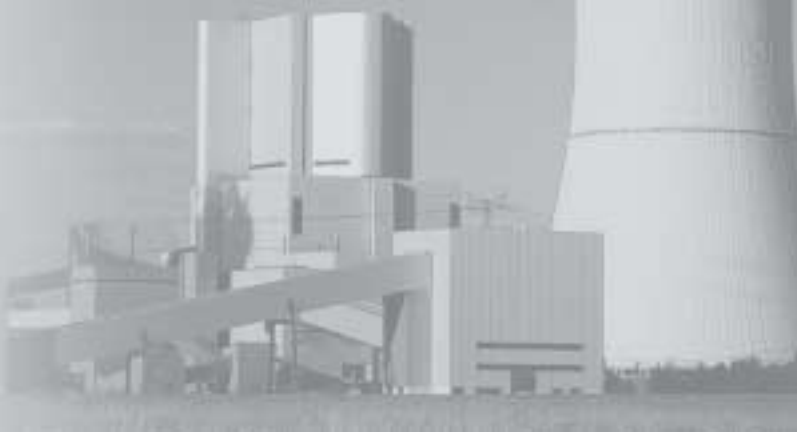
Abbr.	English
AFC	Alkaline Fuel Cell
PAFC	Phosphoric Acid Fuel Cell
PEMFC	Proton Exchange Fuel Cell
MCFC	Molten Carbonate Fuel Cell
SOFC	Solid Oxide Fuel Cell

Design of fuel cell	Development status	Efficiency (electrical), single operation	Efficiency (electrical) combined operation with micro gas turbine	Remarks
AFC	Available for special applications	Approx. 65 % (up to around 70 % with mere O_2, related to lower calorific value of H_2)	——	For H_2 only
PAFC	Commercially available, but expensive; no development potential	Approx. 40 %	——	Waste heat utilisation possible: fuel utilisation degrees > 80 %
PEMFC	Demonstration for mobile and stationary (also small plants) applications; cost reduction necessary	State: 30 %; objective: 40 % objective with H_2: 55 %	——	Waste heat utilisation possible: fuel utilisation degrees > 80 %
MCFC	Demonstration for stationary applications > 250 kW; cost reduction necessary; commercial offers for decentral applications as of 2005	State: 48 %, objective 55 %	——	Waste heat utilisation possible (also process heat): fuel utilisation degree > 80 %; other primary sources of energy possible, e. g. coal, biomass
SOFC	Demonstration for stationary applications > 100 kW and small plants; cost reduction necessary; designed for applications with wast heat utilisation, also for small plants	State: 47 % (at nominal capacity); objective 55 %	Pressurised SOFC with micro gas turbine: state: 53 % objective: 60 % (< 500 kW) > 65 % (< 10 MW)	Waste heat utilisation possible (also process heat): fuel utilisation degree > 80 %; other primary sources of energy possible, e. g. coal, biomass

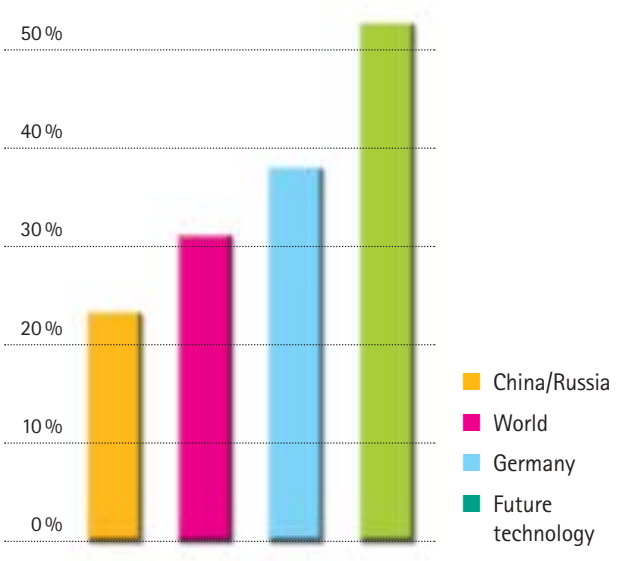
Challenge Coal-fired Power Plants –
Chances through Advanced Technologies

Today, 60 % of the electricity generated worldwide is based on fossil fuels. This share is likely to rise until 2020. Under these conditions, the advancement and further development of existing power plants to achieve higher and maximum efficiencies upon the conversion of fossil primary energy sources is one of the greatest challenges. Besides it is also possible to consequently employ these new technologies when having to replace the existing power plant portfolio in the foreseeable future. At the end of such a replacement process about $^1/_3$ of the global CO_2 emissions of coal-fired power plants could be avoided (approximately 1.8 billion tonnes of CO_2). This equals to around 7.5 % of the current global anthropogenic CO_2 emission, i. e. 2.5 times as much as the CO_2 reduction commitment to be met by the industrialised countries according to the Kyoto Protocol.

New technologies for fossil-fired plants only have a chance in the long term, if environmental goals and total cost minimisation will be harmonised. This also includes possible burdens from the EU Directive "Emission Trading" for the relevant emissions. The technological further advancement of fossil-fired power plants with improvement of efficiencies is offering a large potential, because on the one hand low specific CO_2 avoidance cost and on the other high CO_2 reductions are possible.

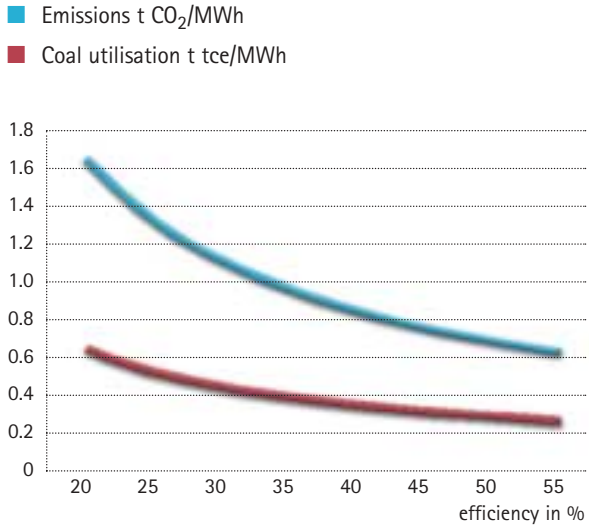


Efficiency of coal-fired power plants



Source: BMWA-Bericht COORETEC 2003

Emission reduction
through improved efficiencies



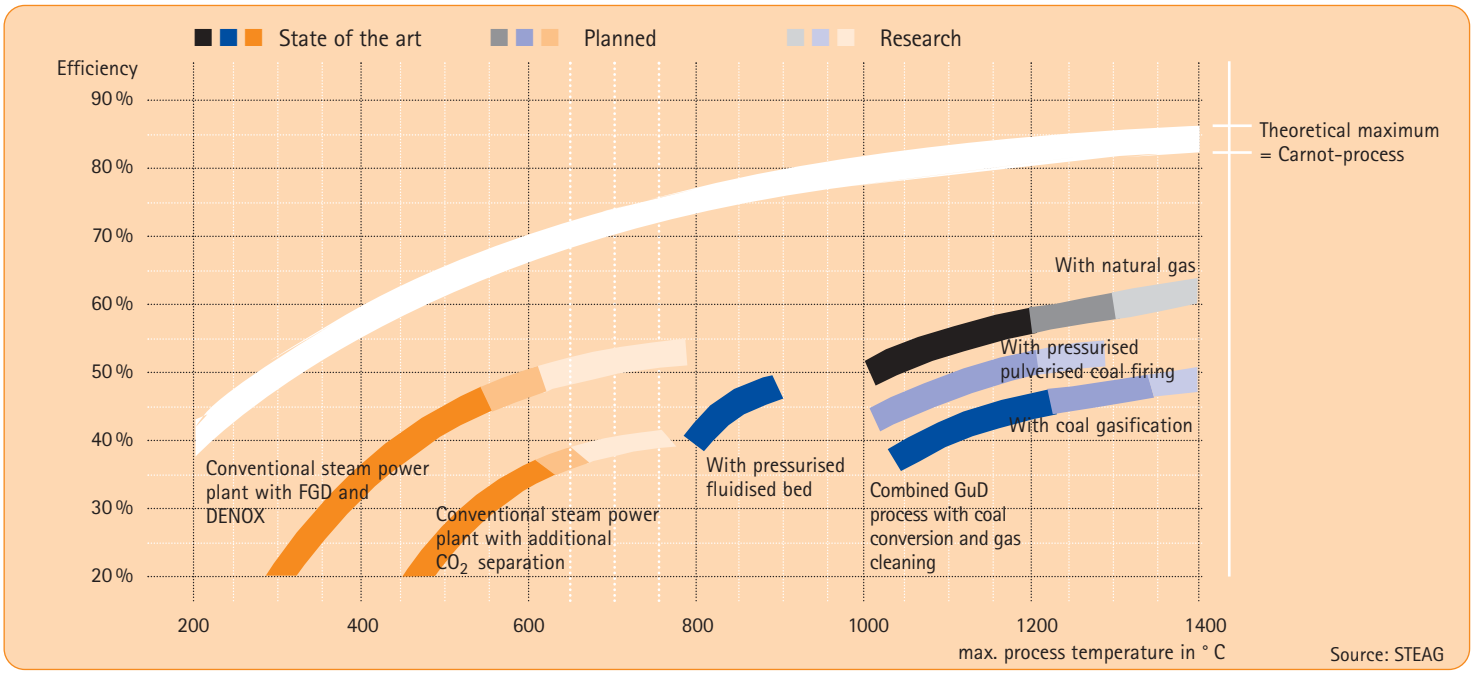
Source: BMWA-Bericht COORETEC 2003

R&D Activities – For Low-emission, Fossil-fired Power Plants

Coal- and gas-based power plant processes bear high development potentials for even better efficiencies and emission values. Thanks to CO_2 removal and disposal electricity from carbon-containing fuels can be generated in the future with zero emissions. However, CO_2 removal results in decreased plant efficiencies and thus in increased resource consumption. The electricity generation cost also rise clearly. Staged comprehensive R&D activities into this field are necessary.

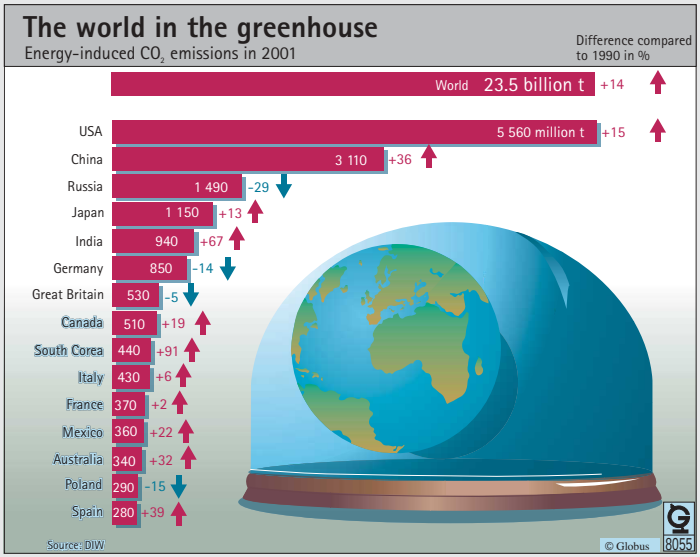
On behalf of the Federal Ministry of Economics and Labour (BMWA = Bundesministerium für Wirtschaft und Arbeit) VGB has established jointly with operators, manufacturers and science the so-called COORETEC Study. Main stages of the development are:

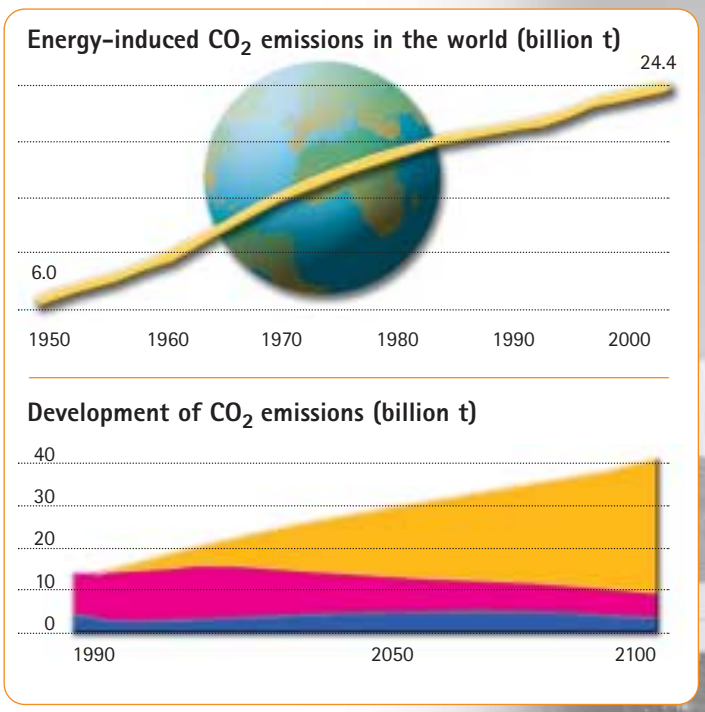
- North-Rhine Westfalia (NRW) reference power plant (620 °C),
- E_{max}/AD 700 component test plant (700 °C),
- Development of innovative CO_2 removal techniques and the systematic investigation of complete process chains, including secured CO_2 storage.



Challenges of Climate Policy

The global development of the energy industry has to take into account the challenges of climate policy. According to the Kyoto goals it has been agreed that the industrialised countries will decrease their energy-related climate emissions until 2008/2012 by an average of 5.2 %. Although the effects of CO_2 are not yet proven according to the current state of climate research, the reduction of emissions and the careful consumption of scarce energy resources remain an important goal also for precautionary reasons. However, this goal can only be achieved globally, since the major portion of CO_2 emissions will stem from the developing countries. The energy-related emission of CO_2 between 1990 and 2001 has developed very differently in the world. The largest emitters, i. e. the USA and China, have increased their emissions by 15 % and 36 %, respectively. In comparison, the emissions in Russia and Germany have decreased by 29 % and 14 %, respectively, however, for different reasons. In total, the worldwide CO_2 emissions increased during this period by 14 %.





Source: World Energy Council/IIASA, 1998

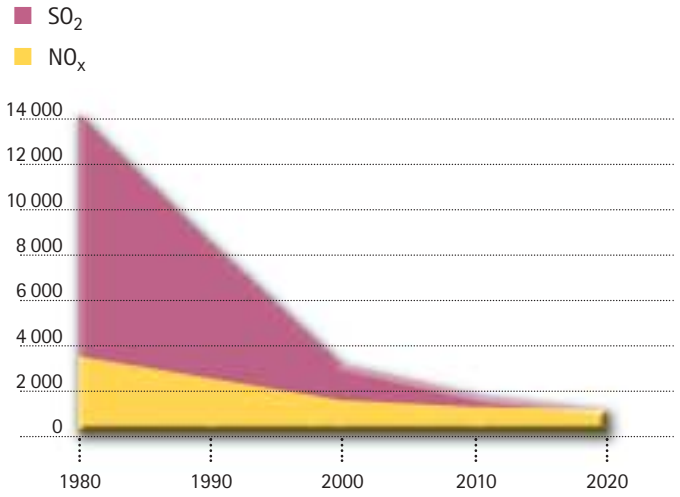
Environment and Climate

The abatement of the common emission values for dust, SO_2, NO_x and other pollutants has been so successful in the past years that these substances hardly play any part in today's public discussion. The limit values for large plants are becoming even fiercer on European level through the EU Directive "Large Combustion Plants". Here the top priority, i. e. the harmonisation of the European limit values, has to be borne in mind when converting the Directive into national law.

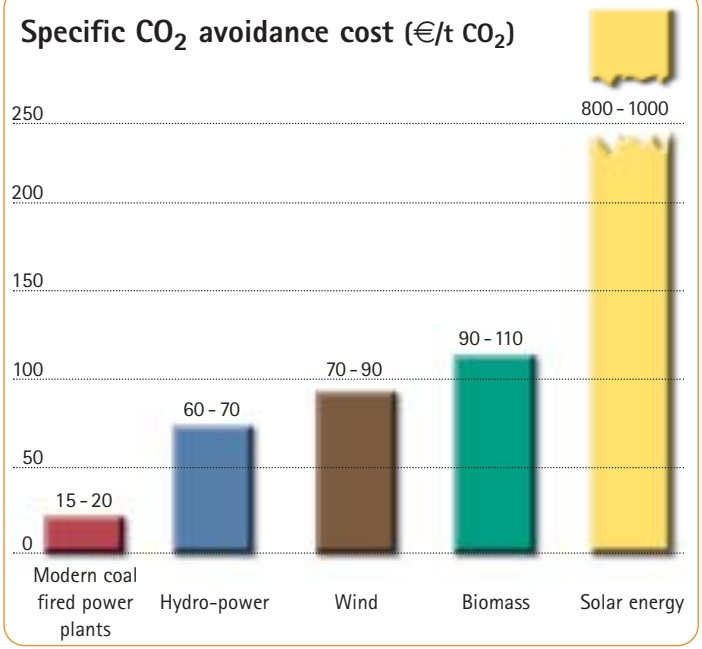
The new challenge of CO_2 reduction also has to take into account economic aspects. The specific CO_2 avoidance costs are a good orientation. Today, around 60 % of the globally generated electricity is based on fossil fuels. Therefore, upgrading of plants and the new construction of fossil-fired power plants are a very favourable variant to reduce the CO_2 emissions in the short- and medium term.

Source: EURELECTRIC, Eurprog 2003

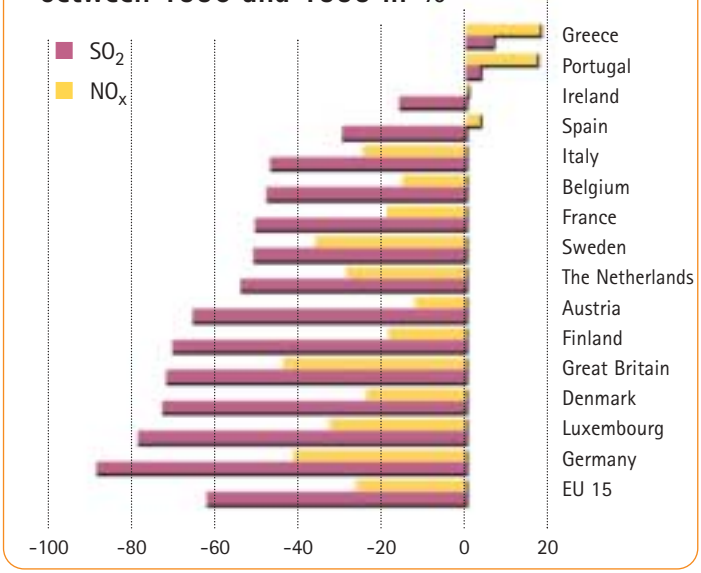
Emissions of electricity generation in Europe (EU 15) in 1000 t



Specific CO_2 avoidance cost (€/t CO_2)



Development of energy-induced emissions between 1990 and 1999 in %

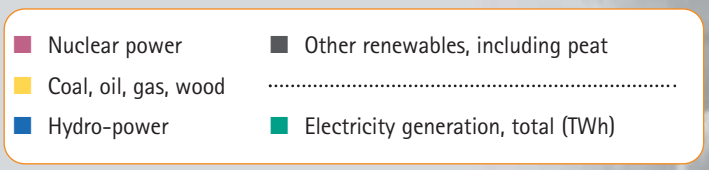


Source: EEA, Report No 31, 2002

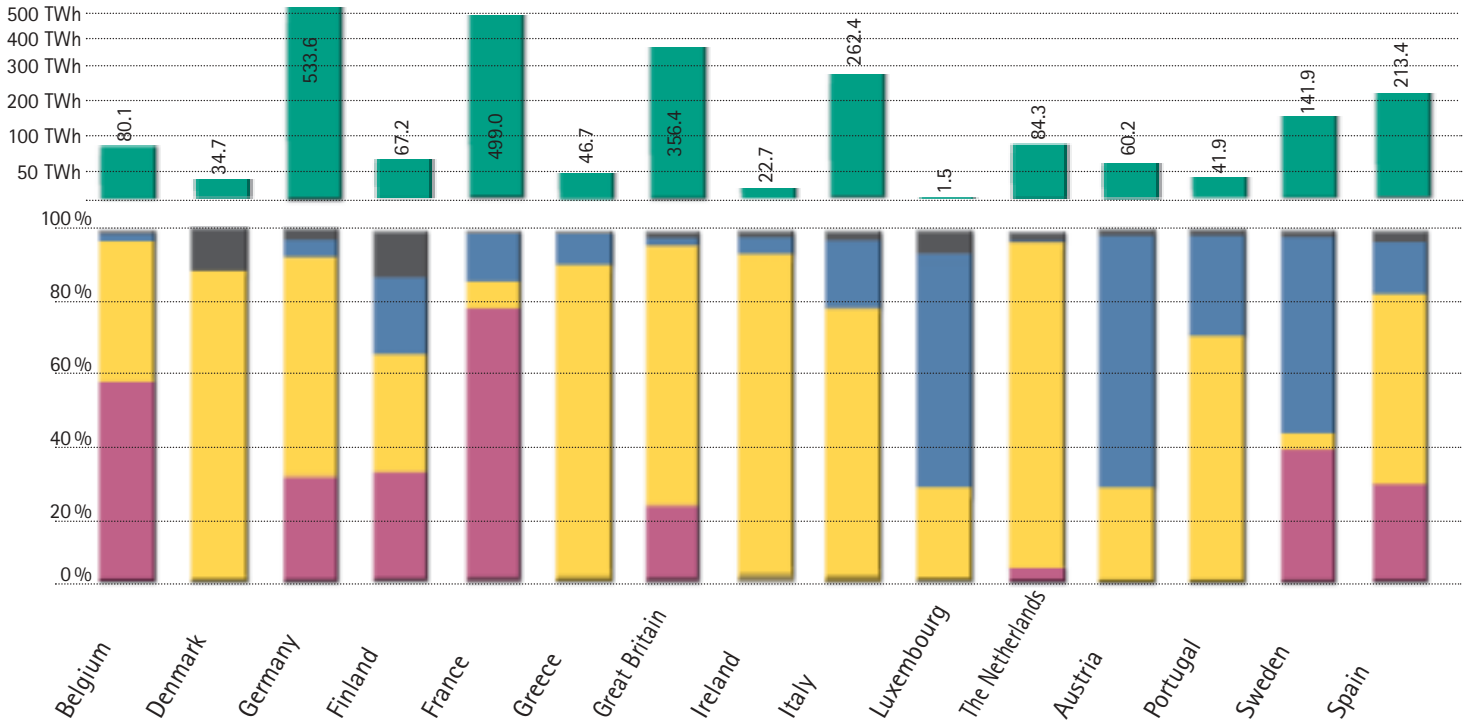
Electricity Generation in the EU

Electricity generation in Europe is dominated by nuclear power and coal with a total share of 57 % (in the year 2000). The portion of nuclear power amounted to 33.3 % and coal contributed with 24.1 %. 13.8 % of the European electricity was generated in hydro-power plants. The remaining renewables yielded 2.3 %.
It is expected that that the consumption of fossil fuels, i.e. coal, gas and oil, will increase in the next two centuries in Europe.

Electricity sources in Europe (EU 15), share of energy sources in the total electricity generation in percent (state 2000)



Source: VDEW, 2002



Availability of Nuclear Power Plants in 2002

For a number of years VGB has been recording the statistic parameters of nuclear power plants in Germany, Finland, The Netherlands, Switzerland and Spain. Besides, VGB is co-operating with all nuclear power plants worldwide via international organisations like e. g. WANO and IAEA.

The 28 plants listed in the bottom table are an impressive proof for the high state of the art. In 2002 these plants have generated approximately 219 billion kWh of electricity. Record values have been achieved in several units concerning the generated operating energy as well as the time- and energy availability since commissioning of these units. The average availability of these nuclear power plants amounted to 7739 hours out of 8760 annual hours. This equals to more than 88 % of the total time. 20 of the plants listed have an energy availability of more than 90 % for the period reviewed. The comparison between energy availability and energy utilisation clearly demonstrates the competitiveness of nuclear power-based electricity in the liberalised market.

Nuclear power plant	Country	Type	Nominal capacity (gross) MW	Operating energy (gross) GWh	Time availability in %	Energy availability in %	Energy utilisation in %
KWO Obrigheim	D	DWR	357	2995.7	96.0	95.8	95.4
KKS Stade	D	DWR	672	4947.7	86.3	86.1	84.0
Biblis A	D	DWR	1225	6558.3	68.3	68.1	60.3
Biblis B	D	DWR	1300	10744.6	95.6	95.2	93.7
GKN-I Neckar	D	DWR	840	6672.3	94.1	92.7	90.7
GKN-II Neckar	D	DWR	1365	10488.9	88.8	88.7	88.0
KKB Brunsbüttel	D	SWR	806	897.4	13.3	13.1	12.7
KKI-1 Isar	D	SWR	912	7870.5	99.7	98.6	98.5
KKI-2 Isar	D	DWR	1475	12165.8	95.3	95.1	94.0
KKU Unterweser	D	DWR	1410	7114.3	60.6	60.5	57.5
KKP-1 Philippsburg	D	SWR	926	6896.0	90.0	89.4	84.2
KKP-2 Philippsburg	D	DWR	1458	11650.3	92.9	92.4	90.6
KKG Grafenrheinfeld	D	DWR	1345	10432.5	91.1	91.0	88.7
KKK Krümmel	D	SWR	1316	8854.1	80.7	78.0	76.9
KRB-B Gundremmingen	D	SWR	1344	10503.1	92.9	92.1	88.7
KRB-C Gundremmingen	D	SWR	1344	10825.0	94.8	93.4	91.6
KWG Grohnde	D	DWR	1430	11428.8	94.0	93.8	90.6
KBR Brokdorf	D	DWR	1440	11921.9	95.9	95.8	94.5
KKE Emsland	D	DWR	1400	11861.8	97.0	96.9	96.6
OL1 Olkiluoto	FIN	SWR	870	7261.9	95.8	95.3	95.1
OL2 Olkiluoto	FIN	SWR	870	7364.3	97.4	96.9	96.6
KCB Borssele	NL	DWR	478	3914.6	94.6	94.3	93.7
KKB 1 Beznau	CH	DWR	380	3034.2	91.6	91.3	91.1
KKB 2 Beznau	CH	DWR	380	3138.0	95.0	94.6	94.3
KKG Gösgen	CH	DWR	1020	8316.0	93.1	92.9	93.1
KKL Leibstadt	CH	SWR	1200	9635.3	94.2	92.8	91.7
KKM Mühleberg	CH	SWR	372	2950.4	94.7	90.7	90.5
CNT-I Trillo	E	DWR	1066	8352.3	89.9	89.6	89.3

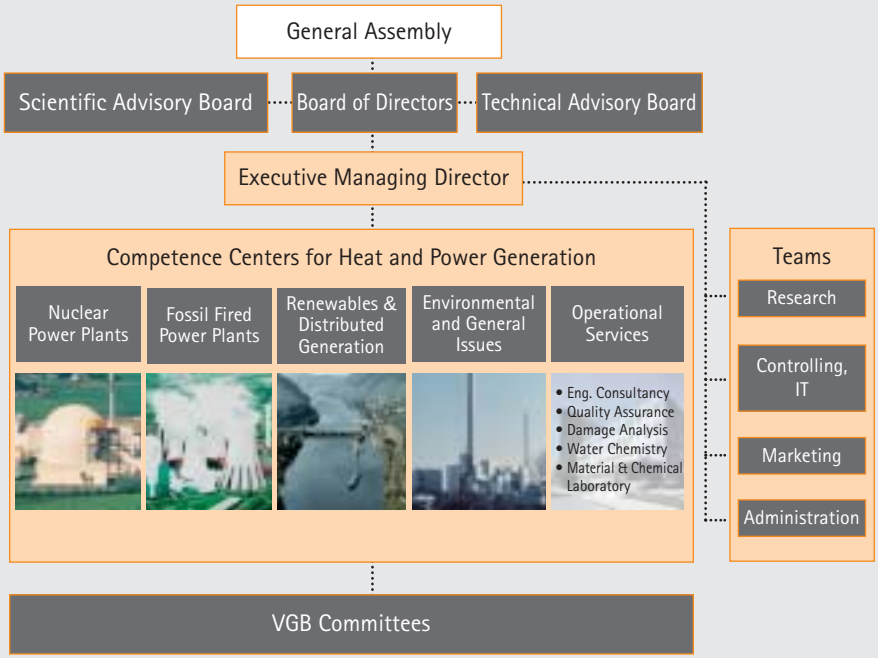
Tasks of VGB Offices

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 & 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 424 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 424 companies from 29 countries are members in our association:

Fossil-fired power plants	:	294 800	MW
Nuclear power plants	:	114 600	MW
Hydro-power plants	:	62 300	MW
Total	:	471 700	MW

EU 15: 383 members in 15 countries
Belgium, Denmark, Germany, Finland, France, Greece, Great Britain, Ireland, Italy, Luxembourg, The Netherlands, Austria, Portugal, Sweden, Spain

Europe: 32 members in 10 countries
Iceland, Croatia, Poland, Romania, Russia, Switzerland, Slovenia, Czech Republic, Turkey, Hungary

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

Total: 424 members in 29 countries