The global population is increasing by 80 million people per year. Consequently, the number of people has doubled between 1960 and today – i.e. within roughly five decades. At present, approximately one quarter of the global population of 6.9 billion people does not yet have access to electricity. Electricity consumption will grow faster than any other form of energy consumption. The increase might be decelerated in the short term due to the current worldwide economic crisis, however, in the medium term the above-mentioned factors will again dominate the development. It is expected that today’s electricity consumption of 18,921 billion kWh will increase by roughly 75% to 33,265 billion kWh worldwide by 2030. In 2008 about one-fifth of the electricity generated globally – roughly 3,374 billion kWh – was provided in the European Union (EU). A 25% rise in demand is alone expected there by 2030.

Experts estimate that fossil fuels will continue to cover most of the extra demand. Fossil fuels will still account for about 70% of electricity generated worldwide in 2030. About half of the electricity generated in the EU will come from fossil fuels by that time. Renewable energy sources will play a growing role in the global primary energy consumption structure. Likewise, nuclear power will – despite the political discussion about nuclear phase-out in Germany – maintain an important position in global electricity generation and will even grow in some countries.

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Expected growth in electricity generation in billion (10^9) kWh worldwide

+75 %

Source: IEA

Expected growth in electricity generation in billion (10^9) kWh in the EU

+25 %

Source: Eurostat, IEA, VGB
Existing primary energy reserves and resources, in particular when including unconventional sources, are still sufficient in terms of fossil fuels and uranium around the world. Hard coal and lignite as well as uranium are the most widespread.

However, energy sources have an uneven geographical distribution, which means that some countries and regions, including the European Union, are becoming increasingly dependent on imports. The EU’s fossil fuel reserves amount to approx. 75,000 million tonnes of coal equivalent (tce), accounting for only 5% of the known reserves worldwide, and consist mainly of lignite and hard coal. The natural gas and oil reserves amount to approximately 5 billion tonnes of coal equivalent.

Europe’s dependency on imported coal will grow from approx. 35% today to more than 60% by 2030. An import dependency of 81% is expected for natural gas and of as much as 88% for oil. Overall, the share of imported energy will increase from approx. 50% today to roughly 70% by 2030. Underlying causes are the decreasing European energy reserves that can be produced at competitive prices. Lignite remains the only fuel that can still be mined from open cast mines at competitive costs in some countries in the long term.

### Static Range of Energy Sources Worldwide

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Conventional</th>
<th>Conventional + Non-Conv.</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>41</td>
<td>64</td>
<td>760</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>60</td>
<td>135</td>
<td>760</td>
</tr>
<tr>
<td>Hard Coal</td>
<td>64</td>
<td>127</td>
<td>2,840</td>
</tr>
<tr>
<td>Lignite</td>
<td>50</td>
<td>143</td>
<td>4,280</td>
</tr>
<tr>
<td>Uranium (≤ 260 $/kg)</td>
<td>143</td>
<td>315</td>
<td>&gt;5,000*</td>
</tr>
</tbody>
</table>

Source: BGR, OECD-NEA, VGB

**Reserves:** Known and with today’s technology economically recoverable sources.

**Resources:** Documented but with today’s technology economically not recoverable sources.
Regional distribution of the worldwide energy reserves for hard coal, lignite, oil, natural gas and uranium/thorium

North America
(290 billion t TCE)

Middle- and South America
(53 billion t TCE)

Africa
(72 billion t TCE)

Europe
(57 billion t TCE)

Middle East
(240 billion TCE)

Asia, Oceania, Australia
(332 billion t TCE)

CIS
(288 billion TCE)

The area of the circles corresponds to the scope of regional energy reserves; the area of the circle segments corresponds to the regional share of each source of energy.

TCE: tonne of coal equivalent
TOE: tonne of oil equivalent
1 TCE = 0.7 TOE

Source: BGR 2010
Demand for New Power Plant Capacity

According to current estimations, the electricity demand in the EU-27 is to rise to roughly 3,700 billion kWh in 2030.

Due to the age structure of the power generation portfolio and the parallel envisaged climate protection targets of minus 21 % greenhouse gas emissions within the EU-27 emissions trading scheme (period considered 2005 to 2020), a total of some 476,000 MW of new generation capacity will have to be erected by 2020. Fossil-fired power plants will have to make the largest contribution to emission reduction. This will have to be achieved through consequent replacement of existing power plants by highly-efficient state-of-the-art plants which calls for new capacities amounting to some 170,000 MW.

The desired share of renewables is to amount to 34 % requiring additional renewables-based capacities of some 295,000 MW in the field of wind and hydro power, photovoltaics, biomass, biogas, geothermal energy, solar power plants and marine energy. At the same time comprehensive investments are also needed for extending the European electricity grid in order to cope with the in-feed of fluctuating renewables-based electricity. However, the ambitious European climate protection targets will only be met if some 11,000 MW of nuclear power will also be erected anew.
Primary Energy Saving through Efficient Use of Electricity

Over the last years many developed countries have been able to separate growth of gross domestic product from primary energy consumption. This can especially be attributed to the increased use of the particularly most flexible and efficient form of energy, electricity.

On the one hand, this development is reflected by the trend towards a service society. On the other hand, advances in energy conversion and use have also played an important role. These were achieved, for example, through more efficient power plants and improved energy efficiency on the end-use sector, e.g. via electronic control systems.

Against the background of drastic price spikes for oil and gas, we can expect to see new areas of application in the transport and heating sectors in future. Innovative electric vehicles (e.g. plug-in hybrid concepts) are being developed by car manufacturers while electrically operated heat pumps using geothermal heat are also gaining ground.

To summarise: More electricity is needed to save energy. Otherwise, with prescribed or forced electricity savings there is a risk that primary energy- and emission balances will deteriorate unnecessarily.

Source: Eurostat 2008
New Power Plant Projects in Europe

The need to replace older power plants and the increase in electricity consumption in Europe have led many companies to plan new construction projects. Also, against the backdrop of CO₂ emissions trading and the worldwide increase in energy demand, coal, natural gas and nuclear power remain the most important primary energies for electricity generation. Since highly efficient new plants are to replace older, less-efficient plants, not only CO₂ emissions will be reduced but also all other emissions related to fossil energy conversion will be clearly decreased.

The pie chart points out that the generation gap that is developing in Europe can partly be closed through the consequent realisation of new construction plans announced that amount to some 252,490 MW. However, since last year’s survey, planned new construction capacities of some 19,000 MW were cancelled. Currently about 94,000 MW are being licensed, 70,000 MW are under construction and about 88,000 MW are in the pre-planning stage. Natural gas, hard coal and wind power continue to be the main sources of energy in the new construction programmes.

Whether all the new projects that have been announced will actually be built will depend largely on future developments of prices for primary sources of energy and particularly on the underlying political conditions.

Source: Data base VGB, June 2010

Projected and announced power plant capacities in Europe

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Capacity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>93,293 MW</td>
<td>36.9 %</td>
</tr>
<tr>
<td>Oil</td>
<td>500 MW</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Hard coal</td>
<td>42,185 MW</td>
<td>16.7 %</td>
</tr>
<tr>
<td>Lignite and peat</td>
<td>7,590 MW</td>
<td>3.0 %</td>
</tr>
<tr>
<td>Nuclear</td>
<td>27,980 MW</td>
<td>11.0 %</td>
</tr>
<tr>
<td>Hydro power</td>
<td>11,873 MW</td>
<td>4.7 %</td>
</tr>
<tr>
<td>Biomass</td>
<td>1,153 MW</td>
<td>0.5 %</td>
</tr>
<tr>
<td>Residues and Waste</td>
<td>380 MW</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Other Renewables</td>
<td>2,110 MW</td>
<td>0.8 %</td>
</tr>
</tbody>
</table>

Total: 252,490 MW

Share of energy source (2007 to 2020)
Total capacity of projected and announced new power plant projects in Europe (from 2007 by 2020)

- Gas
- Oil
- Lignite and peat
- Hard coal
- Nuclear
- Hydro power
- Wind
- Biomass
- Residues and waste
- Other renewables

Source: Data base VGB, June 2010
Renewable Energies – EU's Ambitious Targets for 2020

It is an ambitious target of the EU energy and environmental protection policy to increase the share of renewable energy sources (renewables, RES). According to the EU Directive 2009/28/EC the share of renewables of total energy consumption in the European is to amount to 20% by 2020 in addition to binding national targets of individual member states. To meet these extremely ambitious objectives, the share of renewable energy sources used in electricity generation in the European Union must rise from about 16.8% in 2008 to approx. 34% in 2020. The Directive allows for a certain flexibility in order to make advantage of members’ different potentials through their national support schemes. Members can also invest in other member states and have these investments added to their own national targets.

The action plans published show that 8 out of 27 EU member states will probably exceed their national targets for renewables and another 13 members will achieve their objectives with domestic resources. According to current estimations only 6 member states are likely not to achieve their targets with domestic sources.

<table>
<thead>
<tr>
<th>EU-27 total</th>
<th>8.5</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>✓</td>
<td>2.2</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>✓</td>
<td>9.4</td>
</tr>
<tr>
<td>Denmark</td>
<td>✓</td>
<td>17.0</td>
</tr>
<tr>
<td>Germany</td>
<td>✓</td>
<td>5.8</td>
</tr>
<tr>
<td>Estonia</td>
<td>✓</td>
<td>18.0</td>
</tr>
<tr>
<td>Finland</td>
<td>✓</td>
<td>28.5</td>
</tr>
<tr>
<td>France</td>
<td>✓</td>
<td>10.3</td>
</tr>
<tr>
<td>Greece</td>
<td>✓</td>
<td>6.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>✓</td>
<td>1.3</td>
</tr>
<tr>
<td>Ireland</td>
<td>✓</td>
<td>3.1</td>
</tr>
<tr>
<td>Italy</td>
<td>✓</td>
<td>5.2</td>
</tr>
<tr>
<td>Latvia</td>
<td>✓</td>
<td>32.6</td>
</tr>
<tr>
<td>Lithuania</td>
<td>✓</td>
<td>15</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>✓</td>
<td>0.9</td>
</tr>
<tr>
<td>Malta</td>
<td>✓</td>
<td>0.0</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>✓</td>
<td>2.4</td>
</tr>
<tr>
<td>Austria</td>
<td>✓</td>
<td>23.3</td>
</tr>
<tr>
<td>Poland</td>
<td>✓</td>
<td>7.2</td>
</tr>
<tr>
<td>Portugal</td>
<td>✓</td>
<td>20.5</td>
</tr>
<tr>
<td>Romania</td>
<td>✓</td>
<td>17.8</td>
</tr>
<tr>
<td>Sweden</td>
<td>✓</td>
<td>39.8</td>
</tr>
<tr>
<td>Slovakia</td>
<td>✓</td>
<td>6.7</td>
</tr>
<tr>
<td>Slovenia</td>
<td>✓</td>
<td>16.0</td>
</tr>
<tr>
<td>Spain</td>
<td>✓</td>
<td>8.7</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>✓</td>
<td>6.1</td>
</tr>
<tr>
<td>Hungary</td>
<td>✓</td>
<td>4.3</td>
</tr>
<tr>
<td>Cyprus</td>
<td>✓</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Source: European Commission
Hydro power is still a reliable renewable source of energy. Pumped storage plant also play a very important role in the provision of reserve power/peak load and network control through pumped storage plants.

Numerous new hydro power projects as well as expansions and retrofits are being implemented or are being planned for the near future, for example, in Austria, Switzerland, France, Germany and Portugal. Essentially, these deal with the utilisation of more supplementary generation or (pumped) storage capacities by expanding or optimising the plants at existing sites. An important step is also increasing plant efficiencies by replacing older machines and/or components by new, high-performance designs, thereby meeting the envisaged environmental protection requirements.

Utilisation of wind power is playing an important role in order to meet the targets of the European Union within the Climate and Energy Package by 2020. However, this should be done mainly at very favourable "wind locations" by taking into account power plant-specific criteria.

The weather-related fluctuation and unreliable electricity generation of wind turbines places considerable demands on existing and future power plants, for example, in terms of providing reserve power. At the end of
2009 in Germany there were around 21,164 wind power plants with a capacity of 25,777 MW in operation. At this time the installed capacity in Europe was 76,152 MW and worldwide 157,899 MW.

The existing offshore wind farms in Denmark and the UK show that the design of offshore wind parks still needs to be improved to match the offshore environment. Besides numerous questions have not been settled yet concerning safety and maintenance. A lot of valuable experience is expected from the alpha ventus wind farm, which was commissioned in April 2010. It is the first wind park that was erected in the German North Sea territorial waters. Alpha ventus comprises 12 plants of the 5 MW range.

Apart from wind energy, biomass, the share of which has been increased in recent years in electricity generation, will have to play an important part in the European Union to meet the 2020 targets.

In February 2010 the European Commission set the requirements to be met in connection with the use of solid and gaseous biomass fuels in heating, electricity generation and cooling in order to guarantee sustainable utilisation of biomass.

The report comprises recommendations for sustainability criteria that are to be applied by member states that want to introduce regulations on na-
tional level. It is planned to check the regulations in 18 months to see whether modifications are required. This could also result in binding standards. Binding sustainability criteria have already been introduced in 2009 for bio fuels and bio combustibles.

Co-combustion of biomass has become an important carbon-neutral way of generating electricity across Europe. Co-combustion of biomass in fossil-fired pants is continuously extended. The main advantages of co-combustion are the shared use of existing equipment, a wide range of fuels and the achievement of higher levels of efficiency in biomass-based electricity generation.

Decentralised small plants – fuel cells, micro gas turbines and Stirling engines – could open up new areas of application for combined heat and power (CHP) generation. Within the scope of contracting models, block heating stations fuelled with natural gas and small biomass-fired plants for providing heat, steam and cooling will be employed. Such contracting services cover all stages of the value chain from first consultancy and demand analysis up to plant operation, maintenance and repair including different financing and operator models. Economically-efficient pant operation is always the decisive factor for project realisation.

Biomass:
Development of electricity generation in the EU

Source: Eurostat, Pöyry
In 2009, net electricity generation from nuclear power was around 2,550 billion kWh worldwide. The share of nuclear power in worldwide electricity generation has been roughly 13%.

On a cumulated basis since the first commercial nuclear power plant was commissioned in Calder Hall in England in 1956 around 60,000 billion kWh of electricity have been produced. This corresponds to about three times the current annual global electricity demand.

Experience in operating nuclear power plants has grown to 13,650 reactor years.

The growth of nuclear electricity generation in the 1980s is remarkable. During this time the large power plant projects with unit outputs in excess of 1,000 MW, which were started in the 1970s due to the pressure of the first oil price crisis, went into operation and provided considerable generation capacity. In the 1990s through to the present there was a smaller increase, mainly in threshold countries and in Asia's industrialised countries, where demand for electricity has grown considerably.
Currently 439 nuclear power plants with a total capacity of 393,000 MW are being operated in 31 countries, another 61 are being built, while roughly 202 plants are being planned to be commissioned by 2030.

Long-term planable perspectives in terms of electricity generation costs and nuclear fuel supply motivate investors all over the world to launch new construction programmes.

After limitations and reversals in the decisions to phase out nuclear power in Sweden, Belgium and Spain, Germany is the only country in the world committed to phasing out nuclear power.

In the next few years another 4 plants will be shut down in the UK and 1 plant in Armenia due to aging.
In the energy mix of the future nuclear power and large hydro power plants will offer one important option to provide CO₂-free base load electricity at reasonable prices.

Consequently, worldwide and also in Europe, where nearly half of the worldwide nuclear capacity is located (191 units), countries are once more increasing their development of nuclear power. In 13 of the 19 European countries using nuclear power, new nuclear power plants are currently being constructed or are in the planning phase. The UK, Switzerland and Italy have also announced extensive programmes to build new plants.

Over the last years the development of sophisticated reactors has been advanced worldwide. The focus of this work is to further optimise safety, resource conservation and economic efficiency. These Generation III+ nuclear power plants are ready for the market and are the basis for the new plants that will be built in coming years. As a consistent further development of today’s nuclear power plants they combine experience and innovation.
Today, international power plant manufacturers are offering several reactor types with different technology and sizes of Generation III+.

These reactors are evolutionary developments of current plants in operation and are based among others on operating experience amounting to about 13,650 reactor years.

All types integrate a far-reaching safety concept and technical principles from quality control, diversity, redundancy, fail-safe, separation, automatic safety control as well as conservative design aiming at maximum plant safety.

Optimised plant design as well as advanced fuel management guarantee stable electricity generation costs over the entire plant operating period of about 60 years. The EPR by Areva, AP1000 by Westinghouse, WWER-1000/V-491 by Atomenergoexport and Kerena by Areva are concrete European projects.
Efficient Coal and Gas Power Plants are Still Indispensable

**Technological development**

CO$_2$ emissions can be reduced gradually through technological development. The volume of CO$_2$ produced from hard coal electricity generation alone could be reduced clearly worldwide if low-efficiency power plants (the average global efficiency currently stands at 30%) were replaced by power plants with a 45% to 50% efficiency (current state of the art). Therefore the gradual reduction of CO$_2$ emissions by technological development is the first option.

It would result in multiple profit:

- Resource protection, as less fuel is required for generating the same amount of electricity
- Substantial reduction of CO$_2$ emissions
- Clear reduction of other emissions
- Increased electricity generation from the same fuel amount

In the long term, fossil-based electricity generation could take place with very low CO$_2$ emissions through capture and subsequent underground storage of CO$_2$.

Ideas are developed and turn into innovations offering key technologies for future coal-and gas-fired power plants leading to higher efficiencies and environmental and climate protection.

All fossil-fired power plant need higher temperatures and pressures to increase efficiency.

Thus, research and development in all fields of power plant engineering is being carried out. All components of the new power plant generation have to be designed to meet the new requirements, to be tested and need to be fit for permanent operation. This means among others

- Qualification of new materials,
- Proving availability of components and of the entire power plant and
- Increasing the flexibility of power plant operation.

The way to new power plants starts with component test plants and then via pilot plants to demonstration plants and finally – after having collected sufficient operating experience – to power plants that are ready for the market.
## CO₂ Reduction Potential of Coal-Fired Power Plants

### CO₂ Reduction Potential

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ Emissions per kWh (g CO₂/kWh)</th>
<th>CO₂ Emissions per kWh (g CO₂/kWh)</th>
<th>Fuel Consumption (g Coal/kWh)</th>
<th>CO₂ Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Average worldwide: 1,116</td>
<td>EU: 38 %</td>
<td>480 g Coal/kWh</td>
<td>-21 %</td>
</tr>
<tr>
<td></td>
<td>379 g Coal/kWh</td>
<td>38 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>881 g CO₂/kWh</td>
<td>30 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>State-of-the-art technology:</td>
<td>45 %</td>
<td>743 g CO₂/kWh</td>
<td>-33 %</td>
</tr>
<tr>
<td></td>
<td>320 g Coal/kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steam power plant 700 °C technology:</td>
<td>about 50 %</td>
<td>669 g CO₂/kWh</td>
<td>-40 %</td>
</tr>
<tr>
<td></td>
<td>288 g Coal/kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCS technology</td>
<td>But: Efficiency loss 7 to 12 % points</td>
<td></td>
<td>-90 %</td>
</tr>
</tbody>
</table>

### Notes:
- Average data for hard coal-fired power plants
- Efficiency 1)
- CO₂ emissions
- Fuel consumption
- CCS: Carbon Capture and Storage. Source: VGB
Carbon Capture and Storage (CCS)

Fossil Fuel Power Plants with low CO\textsubscript{2} Emissions in Europe from 2020

Limitation of the global temperature increase to 2 degrees is inevitable according to the UN Intergovernmental Panel on Climate Change (IPCC) if irreversible climate changes are to be avoided. Experts agree that CO\textsubscript{2} Capture and Storage (CCS) technology is a solution which could massively reduce CO\textsubscript{2} emissions thus helping to mitigate climate change.

The “Zero Emission Fossil Fuel Power Plants” (ZEP) European technology platform has developed a research and market launch strategy in order to realise the vision of CO\textsubscript{2}-free electricity generation from demands. An EU–CCS demonstration programme is to test CCS technologies on a large scale in order to reduce technical and commercial risks. The ZEP proposal for an EU demonstration programme, that has already been presented by the end of 2008, deals with issues of practical implementation, necessary subsidies and criteria of project selection. Industry has to make considerable endeavours to meet the time schedule 2015, however, the schedule is feasible with political support if the general conditions will be defined within 2010.

Since CCS is not yet economically efficient, additional public funding is necessary to accelerate the programme. In December 2009 a total of 1 billion Euros of the funds of the European Energy Programme for Recovery (EEPR) were granted to 6 CCS demonstration projects in different member states.

The Emissions Trading Directive also provides for the allocation of emission rights (300 million t of CO\textsubscript{2}) from the New Entrant Reserve (NER) for supporting CCS demonstration projects. The first part of the registration is to be made in the third quarter of 2010 and the funds are to be granted by the end of 2011. A second generation of CCS technology must be researched and developed by 2020 and a third generation until 2030. The exchange of knowledge and experience made with the demonstration programme should speed up technological development.

Within the scope of the European network of CCS demonstration projects the exchange of experience between projects and of information for potential project developers is supported. In addition the European CCS industry initiative (CCS EII) was launched in Madrid in June 2010. Project partners are the industry, member states, the European Commission as well as research and environmental protection organisations. The initiative is aiming at the utilisation of synergies and the accelerated implementation of necessary changes in politics, technology and financing across Europe.

Public relations and information about CCS are important to reach public acceptance, thus, ZEP is concentrating on opinion leaders from media, environmental protection organisations and politics on European level.
CCS – Bridge to a Sustainable Energy System

As a safe and efficient method for capturing and underground storing several billion tonnes of CO$_2$ for thousands of years, CCS could form a bridge to a sustainable energy system.

The underground storage of CO$_2$ must not pose any risk to health, safety or the environment – neither in the short- nor in the long term.

According to the 2009-CCS Technology Roadmap of the International Energy Agency (IEA) CCS can contribute – together with efficiency increases on the side of consumers and utilities, renewable sources of energy and nuclear power – by 2050 some 20% to the 50% cut in CO$_2$ emissions compared to the reference values of 2005. CCS is indispensable in the IEA portfolio with worldwide about 100 CCS projects running until 2020 and more than 3,000 projects until 2050. Without CCS the costs for achieving the same emission reduction targets would be by 70% higher.

However, the work will all be in vain without the authorisation and approval of licensing authorities and the general public. Therefore it will be essential to make clear in the public that CCS involves safe and reliable technology.

Source: www.co2captureproject.org
In a lot of countries grid operators are obliged to take on renewables-based electricity with priority. The feed-in of wind- and solar-based power fluctuates according to offer between 10 and 90%. Therefore either the remaining power plant park or direct (e.g. battery systems) or indirect (pumped-storage plants) electricity storage systems have to compensate for the balance between grid load and renewables-based feed-in.

At the end of 2009 this meant for Germany as one of the leading countries using renewable sources of energy:

- Installed wind capacity: 25,777 MW (annual utilisation degree 20%)
- Installed capacity of photovoltaics: 9,800 MW (annual utilisation degree 10%)

These values have to be compared to the utilisation degrees of coal- and biomass-fired, nuclear and pumped-storage plants which have annual utilisation degrees of 60 to 100%.

The following model consideration clearly illustrates the necessary extension of storage systems (see diagram):

Assuming a capacity of 10,000 MW, a strong wind phase would then require storing of 300,000 MWh over a period of 30 hours. If at that time of excess wind power, the basins of all German pumped storage plants were only filled to their minimum level – an unrealistic assumption – these plants could only take on energy amounting to 50,000 MW for pump operation. In the most ideal case this would equal to only about 17% of the 300,000 MWh provided by wind. If pumped-storage capacity would be further extended in Germany in the next years, a maximum increase of 3% of storage capacity could be achieved. Noteworthy extension potentials exist in the Alpine countries. Only a minor share of the storage facilities available in Scandinavia can be utilised as pumped-storage plants.

However, if fluctuating wind and solar power are to be extended, storage capacities urgently have to be enlarged in parallel since otherwise the reserve capacities of conventional power plants will have to be increased. This meant among others more part load operation of conventional plants with decreasing efficiencies. From the technical point of view conventional power plants can be operated without any problems in load-following operation with considerable regulation potential, as shown in the diagram. Nuclear power plants have a very high regulation potential within short term.
Example of a one-week load profile in the German high-voltage grid in 2008 and flexibility of conventional power plants
Between 1990 and 2008 total greenhouse gas emissions (CO₂) in the European Union (EU-27) decreased by 11.3%; for the EU-15 the decline is 2.7%. These figures were given in the latest annual report from the EU on the inventory of greenhouse gas emissions in the EU.

In accordance with the Kyoto Protocol the EU is committed to reduce greenhouse gas emissions by 8% for the period 1990 to 2008/2012. The European Council has also set an ambitious target of a 20% reduction by 2020.

In addition a global approach is needed: To stabilise and reduce CO₂ emissions worldwide action based on the principle of effectiveness and cost efficiency has to be taken.

Cost-efficient measures such as insulation of buildings, fossil-fired power plants with higher efficiencies, expanded use of renewables at the right locations or further use of nuclear energy, etc. must be applied with priority and without prejudice.

The International Energy Agency (IEA) has developed a stabilisation concept with which a reduction to 14 billion t (BLUE MAP scenario) is to be achieved in comparison to the reference scenario (“Baseline emissions”: 62 billion t CO₂ in 2050).
CO₂ emissions total and per capita from fossil fuel combustion for selected regions

Source: IEA, 2009
VGB PowerTech e.V.

We are a voluntary association of companies who focus on power plant operation and related technologies, i.e. these fields are an important basis of the entrepreneurial activities of our members. The offices of the association are located in Essen.

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

Currently we have 478 members in total, comprising operators, manufacturers and institutions connected with energy engineering. Our members come from 34 countries worldwide and represent an installed power plant capacity of 520,000 MW, 461,000 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.

The structure of the VGB membership is shown below:

<table>
<thead>
<tr>
<th>Type of Power Station</th>
<th>Capacity [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fired power plants</td>
<td>306,000</td>
</tr>
<tr>
<td>Nuclear power plants</td>
<td>130,000</td>
</tr>
<tr>
<td>Hydro power plants and other renewables</td>
<td>84,000</td>
</tr>
<tr>
<td>Total</td>
<td>520,000</td>
</tr>
</tbody>
</table>

EU: 443 members in 20 countries
- Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden, United Kingdom,

Other Europe: 20 members in 5 countries
- Croatia, Norway, Russia, Switzerland, Turkey

Outside Europe: 15 members in 9 countries
- Argentina, Brazil, India, Israel, Japan, Libya, Mongolia, South Africa, USA

Total: 478 members in 34 countries
Tasks of the European Technical Association VGB

VGB PowerTech e.V., abbreviated VGB, is the European technical association for electricity and heat generation. According to its tasks, the VGB Secretariat is divided into the Competence Centres:

- Nuclear Power Plants,
- Fossil-fired Power Plants,
- Renewables and Distributed Generation,
- Environmental Technology, Chemistry, Safety and Health
- Operational Services.

These competence centres are dealing with all issues of power and heat generation and related environmental topics in close cooperation with EURELECTRIC at European level and BDEW and other associations at national level.

To perform its duties the VGB Board has opted for honorary committees. The VGB Technical Advisory Board is responsible for appointing the members and fixing the tasks. The work of the VGB Committees is supported by activities of the Operational Services, R&D projects, databases and VGB Standards.