THE BOA 2&3 PROJECT

Hi-tech climate protection
In our business, we rely on a diversified primary energy mix of lignite and hard coal, nuclear power, gas and hydropower to produce electricity in the base, intermediate and peak load ranges.

RWE Power operates in a market characterized by fierce competition. Our aim is to remain a leading national power producer and expand our international position, making a crucial contribution toward shaping future energy supplies.

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In June 2005, the Düsseldorf regional government gave its approval for the construction and operation of two lignite-fired power stations with optimized plant technology (BoA) at the Neurath location. After the Niederaussem-based firstborn, which went on stream in 2003, the new units will be 2 and 3 (BoA 2 & 3) with this modern design.

The construction work began along the Neurath-Vanikum/Romerskirchen road (Rhein county Neuss) in early 2006. Commercial operation is set to start in 2011. At peak times during the construction phase, there are up to 4,000 people a day working on the site; the new plant is securing and creating jobs in the supplier industry. This is one of the biggest construction sites in Europe. Each BoA unit will account for some 1,000 jobs and training places in opencast mines, power plants and administration. In addition, one BoA plant also helps secure some 2,000 indirect jobs in the region.

The two power plant units will have a gross capacity of 1,100 MW each and an efficiency of over 43%. The most striking components are the two buildings for the steam generators (boilers), which will look much like the Niederaussem unit, and the two cooling towers. The structures will be some 170 m high.

The operational area of the two new units comprises just under 37 hectares (ha). Of this, less than 50% is built on. As an ecological offset for the erection of the two new power plant units, incl rail track hookup and overhead lines, RWE Power will reforest some 23 ha of farmland in the area of Neurath, Sinsteden and Vanikum in accordance with a concept reviewed with the municipalities affected and with the landscape authorities. To this must be added about 10 ha of cultivated land which, thanks to a special farming method, will offer open-land animal species in particular refuge and space for development. Prior to the commissioning of the first new BoA unit, RWE Power will finally shut down six 150-MW units in the Frimmersdorf power plant: the first 150-MW unit was closed already as early as 2005, another three 150-MW units were taken off-line in mid-2009. Following the commissioning of the second BoA unit in Neurath, RWE Power will take a further six 150-MW units in Frimmersdorf and Niederaussem out of service. These six 150-MW units can then merely be used as stand-by reserve for the BoA units in Neurath. Along with the other units that were announced to be decommissioned, all sixteen 150-MW units in the Rhenish lignite mining area will gradually be shut down by late 2012.

RWE Power continues to renew its power plant portfolio with ultra-modern and environmentally sound technology, investing more than € 2.2 billion – an investment in the future of the Rhenish lignite mining area as well.
The new BoA power plant units, too, will generally produce electricity on the same principle as the existing units, but with significant improvements in the various plant parts and process steps. Combustion of the lignite in the steam generator converts the energy chemically bound in the fuel into thermal energy. This energy is used to evaporate water under high pressure and at high temperatures. The steam drives a turbine. The connected generator converts the rotational energy of the turbine shaft into electric energy.

**THE BoA UNITS F AND G**

Following on from the designation of the existing power plant units at the Neurath location, the BoA units will be named "F" and "G". The two new units will be erected on the site east of the existing Neurath power plant and partially connected to the supply and disposal facilities of the existing plants, which must in part be retrofitted or extended for this purpose.

For lignite supplies, a new coalyard in the form of a subterranean slot-bottom bin is being built. The raw lignite is delivered to the new bin using the Company’s own north-south railway from the Garzweiler and Hambach opencast mines. From there, the lignite is transported by a new conveyor belt system to the day bins in the boiler houses.
LIGNITE BECOMES FUEL
From the Hambach and Garzweiler opencast mines the raw lignite is transported by rail to the slot-bottom bin to be newly built. A new conveyor belt system transports the lignite via a new iron separation unit and crusher to the eight bins in the boiler houses.

There, it is placed on an intermediate stockpile and fed into each of the allocated lignite mills via feeder belts and chutes.

FUEL BECOMES HEAT
The lignite mills pulverize the lignite and, to lower its high moisture content of 48 to 60%, dry it by applying hot flue gases taken from the furnace. Next, together with the air heated by the flue-gas air heater, it is blown into the combustion chamber of the steam generator and burnt. Combustion is subject to constant monitoring and adjustment of the lignite and air feed, so that it takes an optimized course, and the emergence of nitrogen oxides (NOₓ) is confined to a minimum at this stage already. The legally prescribed emission limit values for NOₓ of 200 milligrams per cubic metre of flue gas can be safely adhered to in this way even without additional catalysts.

The lignite is burnt at temperatures of about 1,200 °C. The hot flue gas that emerges during combustion flows through the steam generator from bottom to top. In the process, it transfers heat to the outer walls formed by tubes and to the tube banks suspended in the flue-gas flow. Heated feedwater flows through these tube systems of the steam generator and is evaporated and superheated by this heat absorption.

Behind the topmost bank of heating surfaces, the flue gas is redirected to the downward open-pass duct and distributed across the two flue-gas air heaters. After flowing through these heat exchangers, the flue gases – cooled to approx. 160 °C – are conducted in two parallel lines to the cleaning system (dust collection and desulphurization).
The heat is converted into kinetic energy in the turbine. The main steam produced in the steam generator has a pressure of 272 bar and a temperature of 600°C and is initially expanded to 55.5 bar in the turbine’s high-pressure section, and the temperature falls to 356°C. This steam is conducted back to the steam generator and superheated again to 605°C. This is referred to as reheating. In the intermediate- and low-pressure sections, the steam expands to a pressure of 48 millibar prevailing in the condenser. In the condenser, the steam is then precipitated as water. The drop in steam pressure produces flow energy which is transferred via the turbine blades to the turbine shaft, setting it in rotation.
HEAT UTILIZATION

Heat-utilization systems ensure that the highest possible amount of the heat arising in the combustion of lignite is integrated into the process and exploited in power generation. The flue gas, for example, which leaves the steam generator at approx. 350 °C, is used to heat the combustion air in two parallel air heaters. The temperature of the flue gas after it has flowed through the air heaters is still some 160 °C.

A further portion of the remaining flue-gas heat is removed from the flue gas before it is fed into the desulphurization (FGD) plant via flue-gas coolers and transferred via a heat-transfer cycle to a part-flow of the condensate in the feedwater heating section. This lowers the flue-gas temperature to 125 °C before it enters the FGD.

KINETIC ENERGY BECOMES ELECTRICITY

The rotational energy of the turbine shaft is converted into electric energy in the connected generator. In a magnetic field between generator rotor and generator stator, electricity is produced on the induction principle. An unvarying speed of 3,000 revolutions per minute ensures the standard frequency of 50 Hertz. For connection, the generated electricity’s voltage is stepped up via transformers to 380 kV and fed into the interconnected grid.

THE COOLING CYCLE

The condenser precipitates the expanded steam as water. This releases physically related condensation heat which the cooling tower discharges into the atmosphere with the aid of the circulating cooling water. The cooling water re-cooled in the cooling tower flows through the pipes of the condenser, generating the desired pressure of 48 millibar.

The heat released in the condenser each second warms up more than 23 tons of cooling water by about 12 °C. The cooling water is re-cooled in the cooling tower by falling as rain and by continuous contact with the cooling air. The cooling air required for this on the energy-saving natural-draught principle requires the envisaged cooling-tower height of 170 m.

The cooling water that evaporates during re-cooling and the cooling water that must be discharged to avoid excess concentrations of salt must be replaced on a continuous basis. For this, use is made primarily of makeup water from the Frimmersdorf power plant which is treated there before it is deployed in Neurath. By way of alternative, the new units can also be supplied with treated water from Niederaussem.

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GAS AND DUST EMISSIONS

One crucial objective of the new power plant units is a reduction of CO₂ emissions in electricity generation. Since no industrial-scale and commercial solutions, like filters, separators and similar, are available as yet to retain CO₂, reductions can only be achieved at present by better utilization of the input fuel in the power plant process, i.e. by an increase in efficiency.

With an efficiency of more than 43% compared with about 31% for old systems to be shut down, the BoA units meet this goal. After the corresponding old plants are decommissioned, annual CO₂ emissions for the same amount of electricity generation will fall by some 6 million tons. Besides CO₂ emissions, the specific SO₂, NOₓ and dust emissions, too, will be reduced by some 31%.

To restrict the emission concentrations in the flue gas to at least the limit values prescribed by statute, viz.

SO₂ = 200 milligrams per cubic metre
NOₓ = 200 milligrams per cubic metre
CO = 200 milligrams per cubic metre
dust = 20 milligrams per cubic metre,
planning calls for various measures or process steps as regards units F and G. These limit values comply with the recently amended and tightened Large Combustion Plant Ordinance (13th BImschV).

ENVIRONMENTAL PROTECTION

Thanks to the use of specially designed lignite burners and optimally matched injection of fuel and combustion air, the formation of nitrogen oxide and carbon monoxide is limited in the furnace of the steam generator already. Ultra-modern filters working on the electrostatic principle separate more than 99.8% of the dust carried by the flue gas. Over 90% of the sulphur dioxide from the flue gas is separated by the FGD plant and turned into gypsum. For flue-gas desulphurization, planning calls for a wet limestone process which, besides sulphur dioxide, also scrubs hydrogen chloride and hydrogen fluoride from the flue gas.

Using FGD gypsum
ENVIROMENTAL PROTECTION

NOISE CONTROL
In principle, all mechanical equipment in the new power plant units is installed in enclosed rooms. Within the plants, selective sound-proofing is envisaged to ensure safe adherence to the permissible values in the workrooms. Primarily, low-noise machinery is used and, wherever this is not sufficient, additional sound-proofing enclosures or structural partitions are provided. For the air inlets and outlets of the buildings, silencers are employed. To limit the noise emissions from the cooling towers, which are mainly produced by the water raining into the bottom section, the erection of sound-control walls outside the cooling towers is envisaged. An expertise on the adherence to the permissible values in the workrooms.

WATER MANAGEMENT
The water needs of a power plant unit are determined mainly by the evaporation losses when the heat is discharged in the cooling tower. In addition, to avoid any critical salt concentrations, some of the cooling water must be continually removed from the cooling cycle and replaced. Some of the removed cooling water directly covers the needs of other water consumers (e.g. FGD), while excess amounts are directly discharged into the outfall ditch. For service water, the Company’s own purification plant with sufficient cleaning capacity is available. The purified water is released into the outfall ditch. Any surface water occurring is initially collected in a rainwater settling basin and then released into the outfall ditch.

WASTE
For process-related reasons, a power plant mainly produces dry and wet ash as well as gypsum in the way of waste.

Some of the gypsum is sold to the construction-material industry for further use. Due to the variations in gypsum quality owing to the strongly fluctuating ash composition, and due to insufficient demand, some of the gypsum is used together with lignite ash for backfilling in the mine.

For the other process-related substances that emerge, re-use in the process itself is planned. The calciferous sludge from water treatment, for example, is used to reduce pulverized-limestone needs in flue-gas desulphurization.

With the envisaged environmental measures for the new power plant units, all statutory requirements are safely met. All the same, the new units have implications for their immediate surroundings. This being so, experts at TÜV Anlagentechnik GmbH assessed the environmental compatibility of the project. Backed by individual expert opinions, the impact on natural assets worthy of protection, viz. air, climate, soil, water, flora and fauna and, ultimately, on humans, was ascertained. Also, the influence on the landscape, taking account of the various interactions, as well as cultural and other material assets, was investigated.

AIR, CLIMATE, SOIL, WATER
Comprehensive measurements made between December 2002 and June 2003 recorded, by way of precaution, the current air pollution levels for nitrogen dioxide and airborne particles (PM10) with an evaluation of the heavy metals in the airborne particles and dustfall at the location Rommerskirchen-Nettesheim. In the period December 2003 to June 2004 measurements of prior contamination were made for dioxins/furans. Further prior contamination data were obtained from the measuring points operated by the environment office of the state of North Rhine-Westphalia. Using the calculation procedures prescribed in Germany’s Technical
Instructions on Air-Quality Control (TA Luft) and supporting wind-tunnel trials, the additional air pollution from the F and G units was calculated and the total pollution to be expected established.

As outcome, it must be noted that the additional pollution from each individual air pollutant is no more than 3% of the air-quality values of TA Luft and that overall pollution undercuts the permissible air-quality values. These air-quality values were issued as protection against health risks, considerable disadvantages or serious nuisance.

Also, and by way of precaution, additional contamination from pollutants was established for which the TA Luft states no air-quality limit values. None of the additional contamination established exceeds the recognized effect and risk-threshold values, however.

The data on prior, additional and total air contamination apply to the most unfavourable situation in each case in the region being assessed. The additional contamination takes account of the max. admissible emissions from the new units; in normal operations, actual emissions are much lower.

Any air contamination from germs with a health-hazard effect can likewise be ruled out. This has been demonstrated by measurements of germ contamination of the cooling water and, based on this, chemical air investigations. Any odour nuisance within the meaning of Germany’s Guideline for Odour Concentrations (GIRL) can be ruled out as well.

The investigations of the implications for the climate showed that annual rain precipitation will not change. Neither will there be any additional fog. In any upcoming natural fog formation, the fog may emerge rather earlier or dissolve rather later. No soil contamination need be expected from heavy metals in the catchment of units F and G owing to the immaterial amounts of additional contamination.

Nor do the envisaged treatment and discharge of the rain and service water lead to any relevant impact on the environment.

FLORA, FAUNA AND HUMANS

Special attention is being paid to the plant’s possible implications for flora, fauna and humans. These can be both direct and via the assets worthy of protection discussed above.

The expertises and investigations show that the impairment of air, soil, climate and water is very low and, hence, quite negligible. This ensures that flora, fauna and humans, too, are not exposed to any relevant pollution either directly or indirectly via interaction.

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### Technical data per unit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rated operation</th>
<th>Max. rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace capacity</td>
<td>2,392 MW</td>
<td>2,800 MW</td>
</tr>
<tr>
<td>Raw lignite input (guarantee lignite)</td>
<td>1 t/h</td>
<td>1,326 MW</td>
</tr>
<tr>
<td>Gross capacity</td>
<td>1,100 MW</td>
<td>1,122 MW</td>
</tr>
<tr>
<td>Net efficiency</td>
<td>&gt; 43 %</td>
<td>&gt; 43 %</td>
</tr>
<tr>
<td>Steam output</td>
<td>2,870 t/h</td>
<td>2,960 t/h</td>
</tr>
<tr>
<td>Main-steam pressure/temperature*</td>
<td>272/600 Bar/°C</td>
<td>280.4/600 Bar/°C</td>
</tr>
<tr>
<td>Hot reheat pressure/temperature*</td>
<td>55.5/605 Bar/°C</td>
<td>56.7/605 Bar/°C</td>
</tr>
<tr>
<td>Condenser pressure</td>
<td>48 mbar</td>
<td>48 mbar</td>
</tr>
<tr>
<td>Feed heater</td>
<td>9 stages</td>
<td>9 stages</td>
</tr>
<tr>
<td>Feedwater inlet temperature</td>
<td>292 °C</td>
<td>294 °C</td>
</tr>
</tbody>
</table>

*Outlet steam generator.
The fossil energy sources hard coal and lignite, thanks to their availability and relatively low price and in view of growing world energy needs, will remain indispensable for power generation, and even gain in importance. This is the assumption of all prominent energy scientists. Against this background, though, industrialized countries in particular must not lose sight of the need for climate protection and must come up with long-term strategies for reducing CO₂. RWE, on the road toward lowering CO₂ levels in the generation of electricity from fossil energy sources, is pursuing three development lines:

first an increase in efficiency by spending billions of euros on newbuild plants and on the modernization of existing plants. Higher efficiencies mean lower emissions per kilowatt hour of electricity produced and, hence, savings in greenhouse gases;

second the development of new power plant technologies for even better utilization of coal as a resource;

third RWE is planning to build the world’s first lignite power plant with integrated gasification (IGCC), carbon capture, transport and storage (CCS); moreover, the Company is researching CO₂ flue gas scrubbing techniques.

INCREASING EFFICIENCY

The best example of this is the first lignite-fired power station with optimized plant technology (BoA), which started continuous commercial operations at Niederaussem in 2003 – with a max. efficiency of more than 43 % at that time. With unchanged power generation, it emits up to 3 million tons of CO₂ less than old lignite-based power plants. One comparable plant will be BoA 2&3 at Neurath, though as a twin unit there.

NEW POWER PLANT TECHNOLOGIES

At the same time, RWE Power is working on the next generation of lignite-fired power plants, which are expected to boast all of four percentage points more in the way of efficiency. To do so, they work with dry and not – like all of today’s units – with run-of-mine lignite. RWE Power is perfecting the drying technique required for this purpose in a plant for so-called fluidized-bed drying with internal waste heat utilization (WTA) which has been installed upstream of the BoA unit since 2009 and will help save up to 30 % of the otherwise needed raw lignite. This will trial the technology for the first time in an interaction with a large-scale power plant. RWE Power will be investing some € 50 million in the project.

With the Niederaussem plant, the Company wishes to demonstrate that WTA drying in continuous operations will prove itself both technically and financially in generating electricity from lignite. WTA is a proprietary development of RWE Power that is protected by numerous patents.

At the Westfalen power plant location in Hamm, RWE Power is erecting a hard coal-fired twin unit with a ground-breaking efficiency of 46 %, the worldwide average being 30 %. In addition, RWE Power is engaged in a series of further research projects: in the steam generators of the power plants Esbjerg (DK, hard coal) and Weisweiler (D, lignite), test facilities have been installed in which superheater tubes are being trialled to check their powers of resistance under real conditions. So far, the highest main-steam temperatures are around 600 °C. The COMTES-700 project is researching materials and weld joints that are designed to withstand temperatures of 700°C. Higher temperatures are one road to even higher efficiencies in coal-based power generation. One further issue to be clarified is whether such power plants can work profitably.

CARBON CAPTURE AND STORAGE

Is it possible for coal-based power plants – of all systems – to work without producing any major amounts of carbon dioxide, i.e. to have power stations in which the undesired CO₂ is either scrubbed from the flue-gas flow after combustion of the coal, or is separated before the combustion of a fuel gas produced from coal?

<table>
<thead>
<tr>
<th>BoA concept</th>
<th>BoA concept with predried lignite (dry lignite-fired power plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated milling</td>
<td>Integrated milling</td>
</tr>
<tr>
<td>1,000 °C hot flue gas</td>
<td>1,000 °C hot flue gas</td>
</tr>
<tr>
<td>Predrying (WTA)</td>
<td>Fluidized bed dryer</td>
</tr>
<tr>
<td>Heating steam from turbine bleeding</td>
<td>Heating steam from turbine bleeding</td>
</tr>
<tr>
<td>Vapour for boiler feedwater heating</td>
<td>Vapour for boiler feedwater heating</td>
</tr>
<tr>
<td>Condensate</td>
<td>Condensate</td>
</tr>
<tr>
<td>Dry lignite</td>
<td>Dry lignite</td>
</tr>
<tr>
<td>Energetic disadvantages:</td>
<td>Energetic improvement:</td>
</tr>
<tr>
<td>&gt; drying at very high energy level</td>
<td>&gt; drying at low energy level (low-pressure vapour)</td>
</tr>
<tr>
<td>&gt; no use made of vapour energy</td>
<td>&gt; use made of vapour energy</td>
</tr>
</tbody>
</table>

**Development in efficiency**

<table>
<thead>
<tr>
<th>Year</th>
<th>Net efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>50 %</td>
</tr>
<tr>
<td>1980</td>
<td>40 %</td>
</tr>
<tr>
<td>2000</td>
<td>30 %</td>
</tr>
<tr>
<td>2011</td>
<td>20 %</td>
</tr>
</tbody>
</table>

- 1) Frimmersdorf: 150 MW
- 2) Frimmersdorf: 300 MW
- 3) Niederaussem: 150 MW
- 4) Neurath: 600 MW
- 5) Niederaussem: BoA 1, 1,000 MW, n > 43 %
- 6) Neurath: BoA 2&3, 1,100 MW, n > 43 %
Answers to these questions are supplied by two more projects that RWE Power is pressing ahead with: the Company is investing about one billion euros, for example, in the construction of the world’s first industrial power plant with integrated lignite gasification, CO₂ capture and storage. The power plant with an estimated gross capacity of about 450 MW is to be built at the Goldenbergwerk location in Hürt near Cologne. In this power plant, the coal is not fired in a conventional steam generator, but first converted into a fuel gas in a gasifier. The pressurized gas is then scrubbed and – this is crucial for prevention of climate change – freed of CO₂. Virtually all that is left is just elemental hydrogen. Only the latter is combusted in a gas turbine. The gas turbine drives a generator to produce electricity. The hot waste gases are used to produce steam, which then drives a steam turbine and a second generator. So, electricity is generated in a particularly effective combination of a gas and steam turbine which is why this power plant principle is referred to as a combined-cycle gas turbine plant (CCGT). Via RWE Dea, the RWE Group has extensive expertise in the exploration of oil and gas reserves and in natural gas storage. We are using this know-how to implement carbon storage.

At the same time, RWE Power is working on solutions for climate-friendly optimization of existing power plants or those under construction: in the centre of interest are two plants for CO₂ scrubbing and, hence, a prospect of retrofitting modern large-scale plants with CO₂ capture. This would involve conducting the CO₂-containing flue gas through a scrubbing solution, which absorbs it, is later separated from it and then sent for storage. Corresponding processes exist in the chemical industry and must be further developed for deployment in power plants. A crucial role is played by the high investment in the technology and by the energetically costly cleaning of the scrubbing solution. What is more, the process can reduce the efficiency of a power plant considerably, so that the profitability of this process must definitely be improved. Together with BASF and Linde, RWE Power is building a pilot CO₂ scrubbing plant at Niederaussem.

In 2008, according to data supplied by the German Utilities’ Association (VDEW), Germany produced 640 billion kWh of electricity. German lignite had a 23% share in this total. Lignite from the Rhineland alone secured 12% of total power generation, so that one in 8 kWh of electricity in Germany came from RWE Power’s lignite-fired power plants.

In the view of most energy experts, Germany’s electricity demands will grow only little in coming decades. In the last 10 years, consumption increased by about 1% per annum.

However, while demand will hardly change, there are signs of major shifts in Germany’s energy mix. Above all owing to the phase-out of nuclear energy – whose share in power generation hitherto has been some 23% – agreed between the Federal government and the energy sector, though questionable as a factor in climate policy and in its impact on the energy sector, huge gaps must be bridged. This is because, as things stand today, the present 140 to 150 billion kWh per-year share of nuclear energy will move toward nil by the year 2030 thanks to the phase-out.
The domestic renewable energy carriers – water, wind, biomass, landfill gas, sun, geothermal energy and waste-to-energy – are at present making a 10 % contribution toward power generation. The Federal government is pursuing the goal of increasing the share of renewables in electricity generation to at least 20 % by the year 2020. By the middle of the century, as much as one half of all energy needs is to be covered from renewable sources.

In the opinion of all experts, natural gas, too, will gain. Today already, this energy carrier secures a good 10% of Germany’s power generation. In the case of hard coal, developments are open to a differentiated view; a minus for German hard coal must be set against a plus in imported coal. What is true of power generation from natural gas and imported hard coal, but also of possible power imports, is that they underpin fewer jobs and less value-add than electricity from domestic energy sources.

The economically mineable lignite deposits in Germany will last for generations to come. The lignite can be extracted under competitive conditions and, hence, get along without any subsidies. PROGNOS, a research institute, has calculated that the contribution made by German lignite toward power generation will increase from 26 % to probably 33 % by the year 2040. In respect, not one ton more of lignite need be burnt or one ton more of CO2 be emitted. This is because electricity generation can be increased merely by improving fuel utilization, and that means boosting efficiency.

Today already, lignite secures one quarter of Germany’s power supply. In future, it may even gain in importance, though not at the expense of the environment or climate protection, but by having more efficient power plants.