



# THE NIEDERAUSSEM COAL INNOVATION CENTRE



## RWE POWER – ALL THE POWER

RWE Power is Germany's biggest power producer and a leading player in the extraction of energy raw materials. Our core business consists of low-cost, environmentally sound, safe and reliable generation of electricity and heat as well as fossil fuel extraction.

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.

A strategy with this focus, underpinned by efficient cost management, is essential for our success. All the same, we never lose sight of one important aspect of our corporate philosophy: environmental protection. At RWE Power, the responsible use of nature and its resources is more than mere lip service.

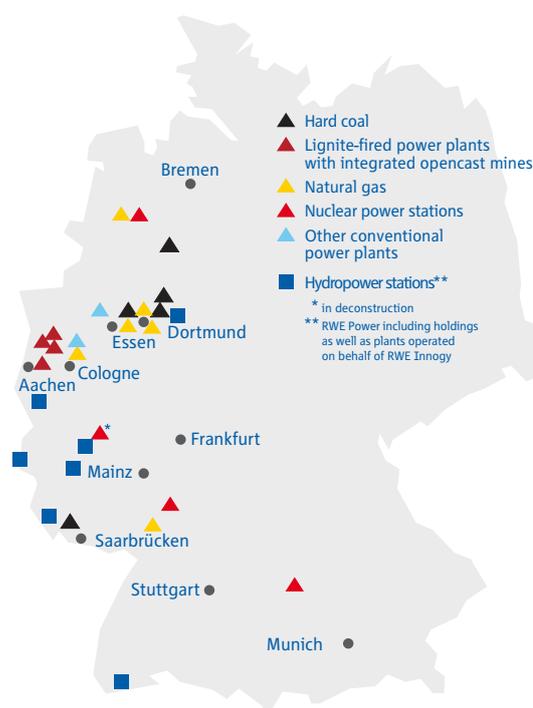
Our healthy financial base, plus the competent and committed support of some 17,000 employees under the umbrella of RWE Power, enable us to systematically exploit the opportunities offered by a liberalized energy market.

In this respect, our business activities are embedded in a corporate culture that is marked by team spirit and by internal and external transparency.

With an about 30 per cent share in electricity generation, we are no. 1 in Germany, and no. 3 in Europe, with a 9 per cent share. We wish to retain this posi-

tion in future as well. That is what we are working for – with all our power.

One of the focuses of RWE Power is on the Rhenish lignite-mining area where the Company mines some 100 million tons of lignite every year, most of which is used to generate electricity. Lignite needs no subsidies, offers work and training to many people in the mining area, underpins spending power with the salaries and taxes the Company pays, so that it is an economic asset for the entire region.





## NIEDERAUSSEM – THE COAL INNOVATION CENTRE

BoA 1, the world's most modern lignite-fired power-plant unit, is at the cutting edge of high-tech activity: the region does the research, the world reaps the benefits.

Germany proposes to increase the share of renewable energy carriers in its power generation to 20 to 30 per cent by 2020, meaning that 70 per cent of the electricity will still have to be produced from conventional energy sources. That is why all experts are agreed that coal will go on playing an important part in our energy mix – not only in Germany, incidentally, but all over the world. On top of this comes the fact that Germany has large coal deposits of its own.

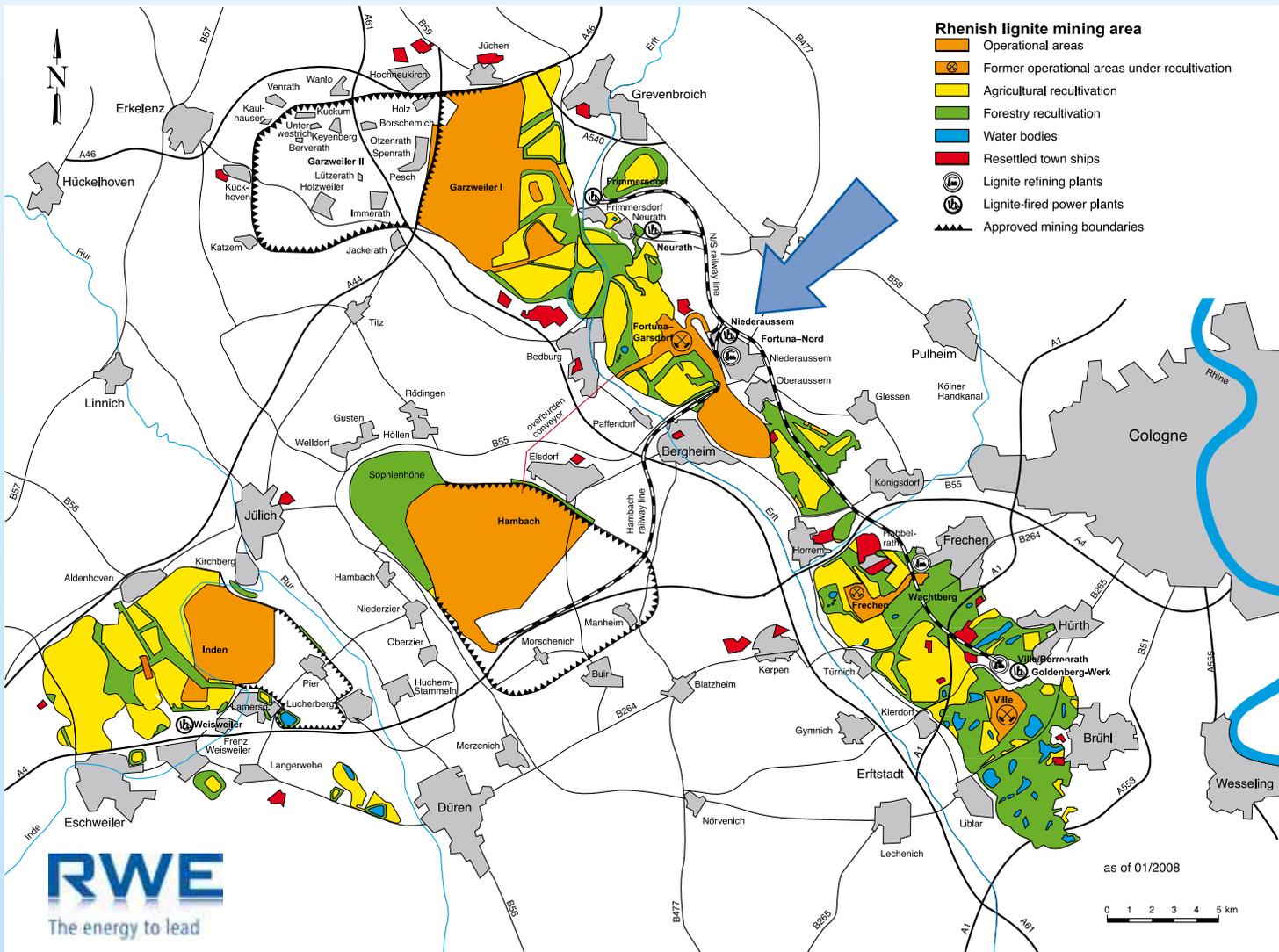
The four German lignite deposits currently secure 25 per cent of the country's electricity supply; RWE Power and its Rhenish lignite-fired power plants cover some 13 per cent of the electricity demand. The figures show: Lignite makes Germany a bit less dependent on imported energies, like natural gas and hard coal, and their price risks.

Yet the undeniable economic advantages alone do not justify using coal. Coal – powered by a technological offensive – also has to become more and more compatible with the environment and the climate, and the CO<sub>2</sub> emissions from lignite- and hard-coal-based power generation must be lowered. To get there, RWE Power is building new power plants costing billions that emit 25 to 30 per cent less CO<sub>2</sub> – depending on the

energy raw material – than old systems. At the same time, the Company is working on technologies and processes that improve coal-based power generation in the interest of efficiency, the environment and profitability.

In a prototype plant, RWE Power is bringing lignite pre-drying according to the fluidized-bed process – a proprietary development – to commercial market maturity. The object is to raise the efficiency of lignite-based power generation by a further four percentage points. Also at the BoA-1 unit, the high-performance flue-gas desulfurization system (FGD, or REA in German) REAplus is being built; the research project, costing € 5.5 million, is designed to open up opportunities for further emission reductions. The CO<sub>2</sub>-scrubbing pilot plant will soon be trialling the capture of carbon dioxide from the flue gas. RWE's algae project, which is unique worldwide, is investigating possibilities for binding captured CO<sub>2</sub> in plant substances and making this usable.

RWE Power is concentrating these pioneering activities at its old-established power-plant site at Niederaussem/Germany, turning it into a "Coal Innovation Centre". In 2003, Niederaussem saw the commissioning of the world's most modern lignite-fired power-plant unit, which goes by the name of "BoA 1". All ongoing research projects are building up on this station and its technology. So RWE Power is gaining not only technological experience, but also valuable insights into practical operations that can be ported to other projects and plants.



## THE HISTORY OF THE LOCATION

Niederaussem went on stream in 1963 with two 150-megawatt (MW) units, viz. as Werk IV of the near-by, older Fortuna power station, which was demolished in 1988.

Between 1965 and 1974, the Niederaussem power plant was extended by four 300- and two 600-MW units to give a total capacity of 2,700 MW. Toward the end of the 1980s, the units were retrofitted at great expense with FGD and denox systems. As a by-product of FGD, thousands of tons of gypsum are obtained year after year and further processed at a facility, built next to the power plant in the early 1990s, to make standard products for the construction-material industry.

In 1994, the power plant's turbines were optimized in their fluid dynamics to enable them to generate more electricity with an unchanged coal input. This increased total installed capacity at Niederaussem to 2,840 MW. The same objective is also served by the planned modernization of the two 600-MW units, upcoming in 2008 and 2009, in which RWE Power will be investing € 130 million.

The Niederaussem power-plant location is of special significance, because this is where the first and, to date, the only BoA unit has been producing electricity in regular opera-



tions since 2003. Built from 1998 to 2002 at a total cost of a good one billion euros, this 1,000-MW plant is currently the most powerful, modern, efficient and environmentally friendly lignite-based unit worldwide. The power station employs some 800 people. To this must be added a similarly high job figure among suppliers and service providers. In the adjacent training centre, RWE Power currently educates some 80 young people beyond its own needs.

## THE POWER-PLANT PROCESS

BoA is a German abbreviation standing for “lignite-fired power station with optimized plant engineering”.

**The physical-technical process of converting the chemical energy stored in lignite into electrical energy is in principle the same in BoA as in older power-plant units, though it takes place with much greater efficiency.**

At the beginning of this process is always the combustion of raw lignite in the power plant’s boiler, also referred to more precisely as steam generator. The BoA unit burns 847 tons of lignite every hour, generating 2,663 tons of steam, which is equivalent to a thermal output of 2,306 MW. The boiler is crossed by numerous water pipes whose content is converted into superheated steam by the released heat. The steam then flows through rows of blades arranged on a shaft in a turbine which, in the case of the BoA unit, has a capacity of 1,012 MW. The steam’s energy sets the turbine shaft rotating, so that the generator connected to the shaft produces power, which is then fed into the supply grid.

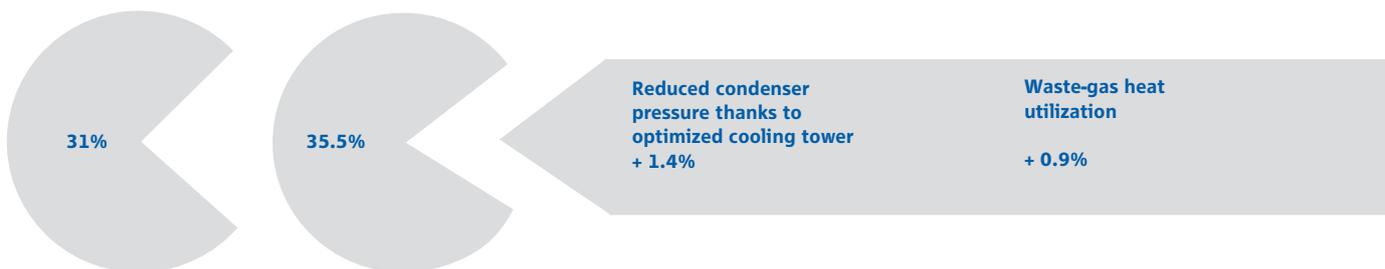
When the steam flows through the turbine blades, it naturally loses pressure and temperature and gives off its energy to the tur-

bine. After going through the high-, intermediate- and, finally, low-pressure sections of the turbine, the steam has relaxed to such an extent that it becomes water again in the condenser installed below the turbine. The water then re-enters the water-steam cycle.

When coal is burnt in the boiler, it is not only steam that emerges, but also flue gases, nitrous oxides, sulphur dioxide and dust. These substances are air pollutants that must not be allowed to enter the atmosphere except in the very low quantities defined by law. The formation of nitrogen oxide is already reduced in the steam generator, namely by a pinpointed addition of combustion air. Ash residues from the combustion are removed from the flue gases by charging the dust particles in the so-called electrostatic precipitators and by depositing on electrode plates. After this treatment, the flue gases filtered in this way have a mere 0.1 per cent of the original dust amount. Desulphurization takes place using a slurry of fine lime powder and water, which is sprinkled on the flue gases in the FGD plant. In the process, lime and sulphur combine to produce gypsum, which is later used by the construction industry. The thoroughly scrubbed flue gases undercut the rigorous German threshold values significantly in places and can now be released into the atmosphere via the cooling towers.

The lignite-fired power station with optimized plant engineering (BoA): Improvements at many points in the power-plant process lead to enhanced efficiency overall, improving the use of the fuel, lignite, while simultaneously lowering CO<sub>2</sub> emissions per kilowatt hour of electricity generated.

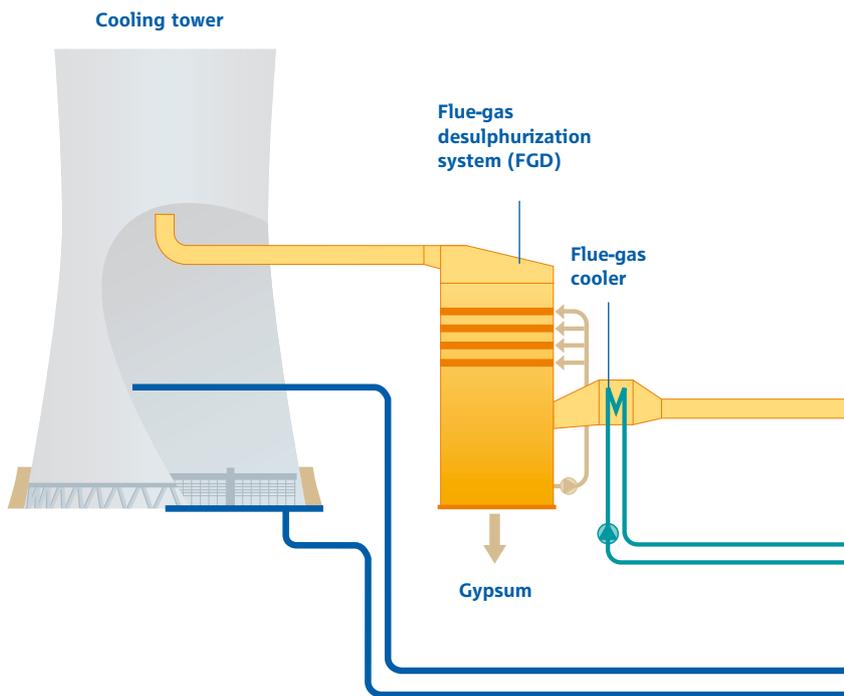
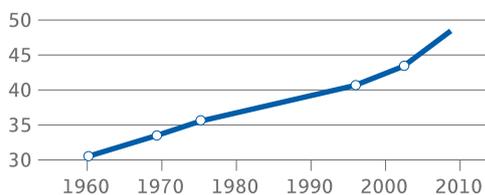
Mean efficiency gain in a 950-MW BoA unit



Year 1957: average net efficiency of a 150-MW unit

Year 1976: average net efficiency of a 600-MW unit

Efficiency [%]



Increase in steam parameters

+ 1.3%

Process optimization

+ 1.1%

Improved turbine efficiency thanks to advanced steam turbine

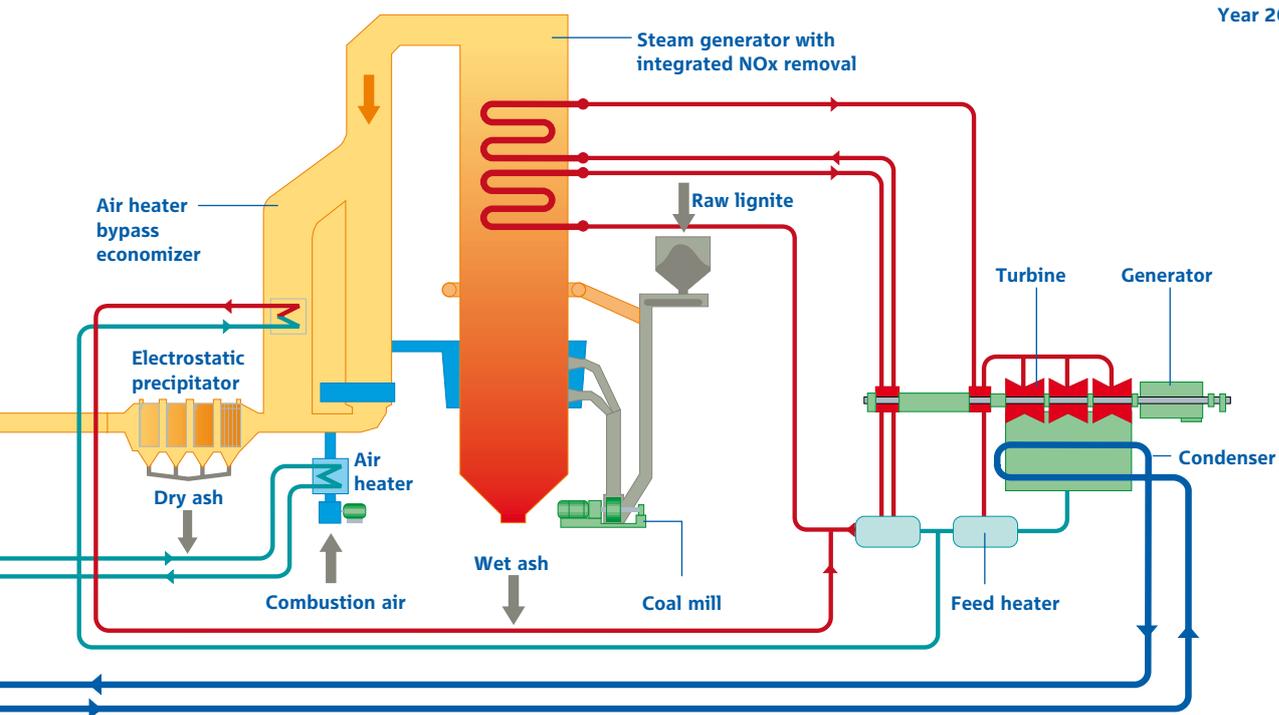
+ 1.7%

Reduced auxiliary power requirements

+ 1.3%

Net efficiency of BoA  
43.2%

Year 2003



## WHAT MAKES BOA SPECIAL

At the core of the BoA technology is an increase in the pressure and the temperature of the superheated main steam.

At 252/60 bar and 580/600°C, the steam values are much higher than for older lignite-fired power-station units. Another essential element: The unavoidable heat losses in the power-plant process are lowered by optimizing practically all process steps. For example, some of the residual heat contained in the flue gases is recovered using additional heat exchangers. The heat is used, e.g., to preheat the combustion air and the circulating boiler feed-water. In older units, the heat required for this stems entirely from the combustion

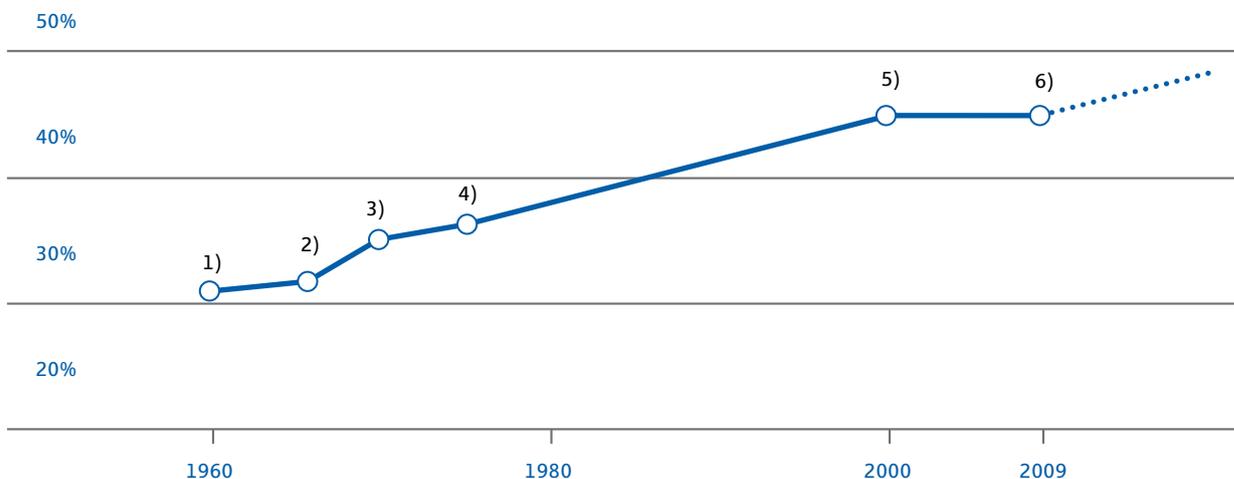
process proper, i.e. it is lost to the actual steam-generation process.

Upshot: BoA makes much better use of the fuel, which sets the plant's efficiency soaring.

Along these lines, all BoA process steps are designed so as to reduce the inevitable heat losses to the technical and economic minimum. The particularly efficient cooling tower, too, makes a contribution here. Besides these heat-technology savings potentials, auxiliary electricity needs, compared with old plants, have been considerably reduced as well.

### Developments in efficiency

#### Net efficiency



1) Frimmersdorf: 150 MW  
2) Frimmersdorf: 300 MW

3) Niederaussem: 300 MW  
4) Neurath: 600 MW

5) Niederaussem: BoA 1, 1,000 MW,  $\eta > 43\%$   
6) Neurath: BoA 2 & 3, 1,100 MW,  $\eta > 43\%$

## BETTER AIR THANKS TO BOA

The BoA process enables an efficiency of a good 43 per cent to be reached, i.e. this percentage of the chemical energy contained in the lignite is in fact converted into electrical energy. Older power-plant units have an efficiency of 31 to 35 per cent.

With the same amount of power generated, therefore, BoA consumes less coal, so that it produces less fuel-related pollutants. This being so, the annual carbon-dioxide (CO<sub>2</sub> for short) emissions of the 1,000-MW BoA unit are up to three million tons lower than in comparable power generation by older systems; dust, sulphur dioxide and nitrogen oxide emissions are down some 30 per cent.

The efforts being made to lower emissions are not confined to the power-plant process alone and to the above air pollutants, but extend to all other possible emission forms and sources, specifically noise and dust formation not related to combustion. All of these – in the auxiliary infrastructure systems as well – are being effectively combatted in line with the relevant statutory specifications.

To this end, all plant sections in the BoA unit have been encased and all building apertures fitted with acoustical packs. With these comprehensive noise- and dust-abatement measures, Niederaussem is setting standards which will apply to other, future BoA locations as well.



## WTA: NIEDERAUSSEM AS MODEL

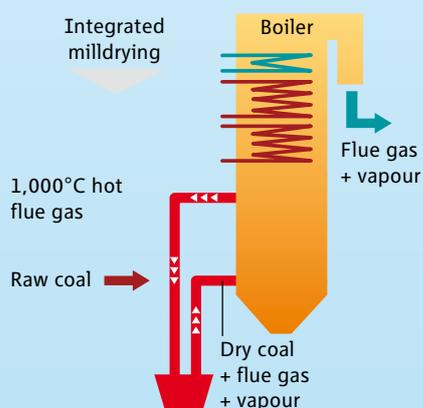
The exertions made by RWE Power to convert lignite into electricity more efficiently and, hence, in a more environmentally friendly manner, do not stop with BoA technology. The next step is already being taken – at Niederaussem.

Raw lignite has a high natural moisture content of up to 60 per cent. This inherent moisture impedes coal combustion, so that – in any industrial use of this energy raw material – it must be dried upstream to remove as much moisture from the coal as possible.

In conventional lignite-based power plants, the coal is dried by withdrawing some of the flue gases which emerge during combustion – and are 900 to 1,000°C hot – from

the power-plant boiler's flue-gas stream and mixed with moist raw lignite. The coal's moisture evaporates and finds its way into the boiler. The evaporation heat expended on drying the coal is lost. This process costs a fair amount of energy which is not available for power generation. The consequence: more coal needs to be burned altogether which, in turn, entails higher CO<sub>2</sub> emissions. This being so, an energetically more favourable drying process would be better in which less waste heat is left unused. We already have such a process and it is expected to prove its worth at the Niederaussem power station.

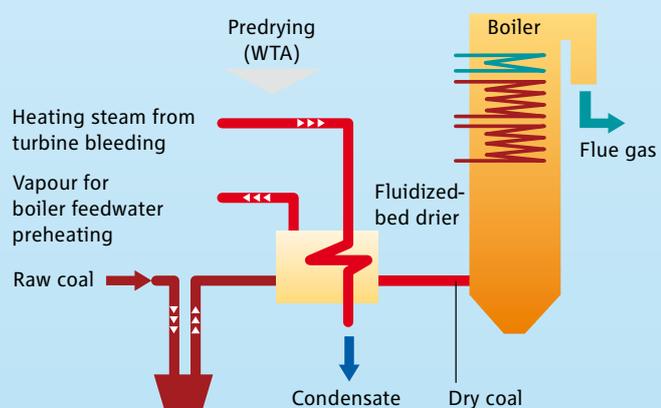
### BoA concept



#### Energetic disadvantages:

- drying at very high exergy level
- no use made of vapour energy

### BoA concept with predried lignite



#### Energetic improvement:

- drying at low exergy level (low-pressure vapour)
- use made of vapour energy



## WTA

The German abbreviation WTA stands for fluidized-bed drying with internal waste heat utilization. WTA technology is a proprietary development of RWE Power. It has been successfully trialled in a small facility on the terrain of our Frechen upgrading factory since 1993 and is being continuously improved. 2008 saw the commissioning of a large WTA prototype plant at the Niederaussem power station that has a price tag of € 50 million. The system, which can process 210 tons of

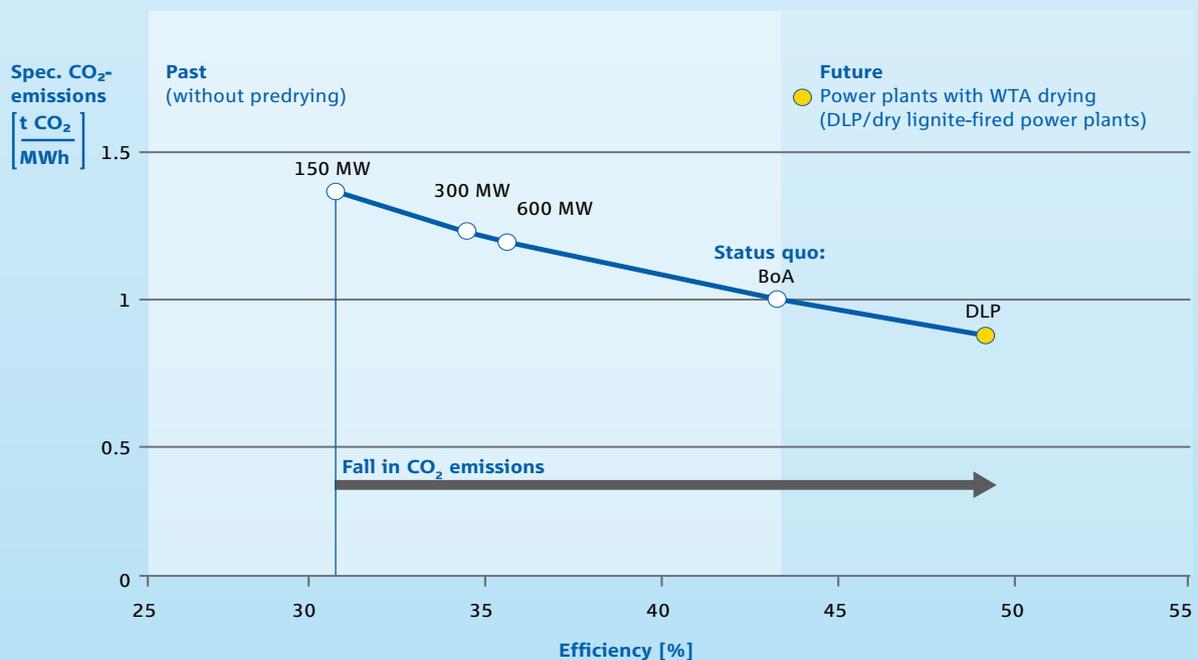
raw coal an hour, has an evaporation capacity of 100 tons of water per hour and is the biggest lignite-drying plant in the world. Located upstream of the Niederaussem BoA unit, its function is to predry some 20 to 30 per cent of the raw lignite destined for the unit in order to furnish evidence of the economic and technical benefit of fluidized-bed drying in continuous operations.

### How WTA works

The central component of the WTA process is the fluidized-bed drier in which the pulverized raw lignite is kept suspended in a stream of gas of already evaporated coal water. In this state, the coal particles can be dried at a temperature of just 110°C. The heat required for this is extracted from the low-pressure steam of the BoA unit. The unit recovers some of the thermal energy since – thanks to the condensation of the evaporated coal water – the condensation heat released in the process is re-routed back to the BoA unit and used there to preheat the

boiler feedwater. The predried lignite now has a moisture content of a mere 12 per cent. It cools off, is placed in interim storage in silos and then co-combusted in the BoA unit.

The WTA process enables much better energetic use to be made of coal and, in future lignite-fired power plants, is set to lead to a further rise in efficiency of some four percentage points to as much as 48 per cent then.



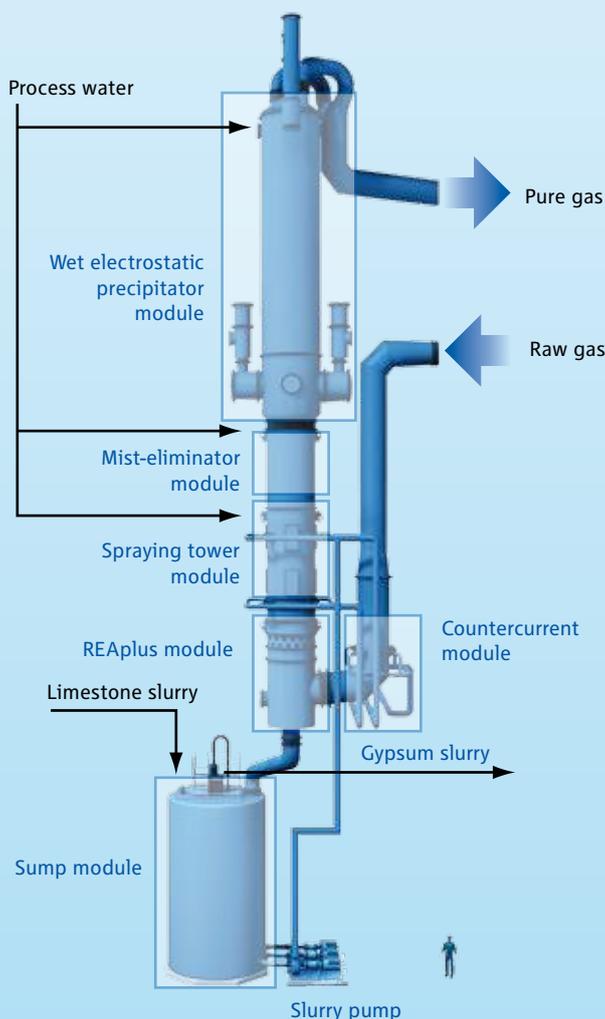
## THE HIGH-PERFORMANCE SCRUBBER REAPLUS

Ever since the 1980s, flue-gas desulphurization plants (FGD) have been filtering sulphur dioxide (SO<sub>2</sub>) out of the flue gas of lignite-based power plants.

The scrubbing process, in which the SO<sub>2</sub> is washed out using a limestone solution, is a well-established approach. Today, over 95 per cent of the desulphurization systems in power stations and industrial facilities worldwide are reliably and successfully operated on the basis of this process technology.

At RWE Power, though, the high efficacy of today's flue-gas scrubbing is no reason for the company to sit back and relax, but rather an incentive to develop new processes designed to make the conversion of coal into power even more climate-friendly in future. This is also where the REAplus concept comes in. RWE Power is implementing this in a pilot plant at Niederaussem along with a proficient plant builder, Austrian Energy & Environment (AE&E). This concept involves further optimization of the chemical processes in the desulphurization to achieve the highest possible degree of SO<sub>2</sub> separation.

The flue gas is withdrawn from the flue gas stream of the BoA-1 power-plant unit and then enters the lower area of the pilot plant's absorber horizontally. There, the SO<sub>2</sub>-containing gas flows upward and is heavily sprinkled with a lime slurry of water and pulverized limestone dissolved in it. The water and the gypsum produced in a reaction from lime and sulphur collect in the so-called sump of the plant where the chemical process of gypsum formation is concluded by blowing in air. The slurry is then thickened in hydro-cyclones and the gypsum it contains is subsequently dewatered on vacuum belt filters to a residual moisture of 10 per cent and made available for further processing.





The desulphurized flue gas leaves the absorber and then flows through a mist eliminator which removes any remaining droplets of the limestone slurry from the gas. The scrubbed flue gas leaves the plant in this state and re-enters the flue-gas route of BoA 1.

In the REAplus plant, AE&E and RWE Power can fall back on the tried-and-tested design of the cylindrical absorber tower with integrated scrubber sump to make gypsum. This has been successfully deployed at BoA 1

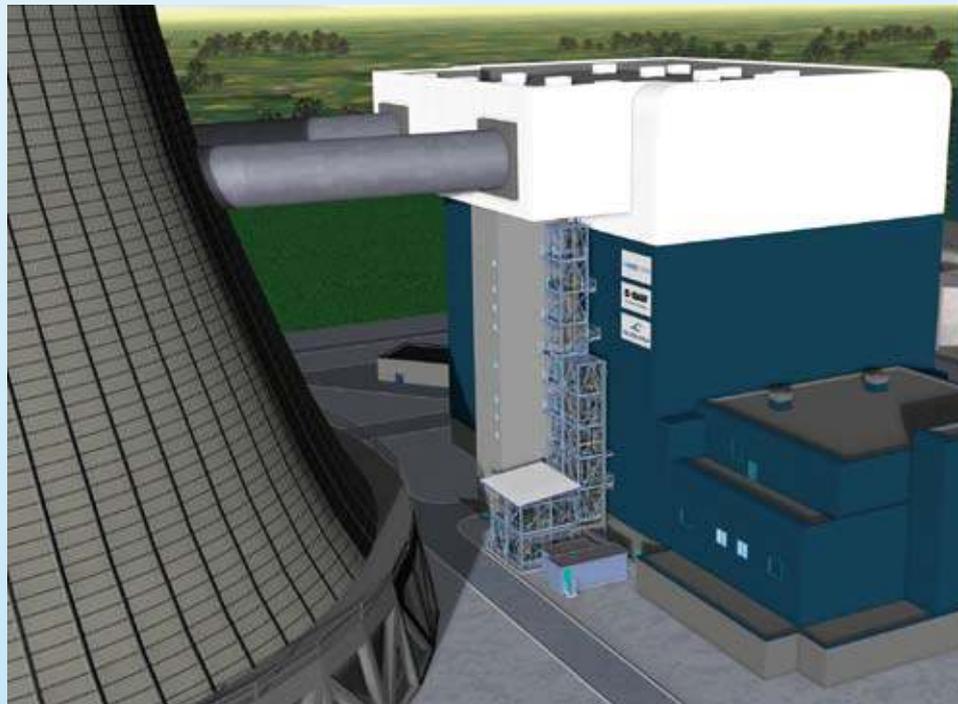
for years already. The progress compared with previous methods lies in a staggered sequence of the scrubbing process and improved contact between the lime slurry and the flue-gas  $\text{SO}_2$ . The highly efficient REAplus desulphurization renders superfluous any pre-treatment of the flue gas in the  $\text{CO}_2$ -scrubbing pilot plant, which will likewise soon be linked up with BoA 1. The combination of REAplus and post-combustion capture creates conditions at Niederaussem that are unique worldwide for trialling modern, forward-looking power-plant technology.

Illustration: CCS  
Werbeagentur

## THE CO<sub>2</sub>-SCRUBBING PILOT PLANT IN NIEDERAUSSEM

One thing is clear: Lignite is an important, indeed indispensable pillar in Germany's electricity supply.

With BoA and WTA, RWE Power is currently taking important measures to enhance the efficiency of lignite-based power plants and, hence, lower CO<sub>2</sub> emissions in the long term. The future holds even greater challenges in store because, in view of ongoing climate change, the industrial use of fossil fuels is expected to take an even more environmentally friendly shape than it has today. The aim is for carbon dioxide, which emerges quite inevitably in combustion processes, not to reach the atmosphere at all, but to be captured first. One way of doing this is by so-called CO<sub>2</sub> scrubbing.

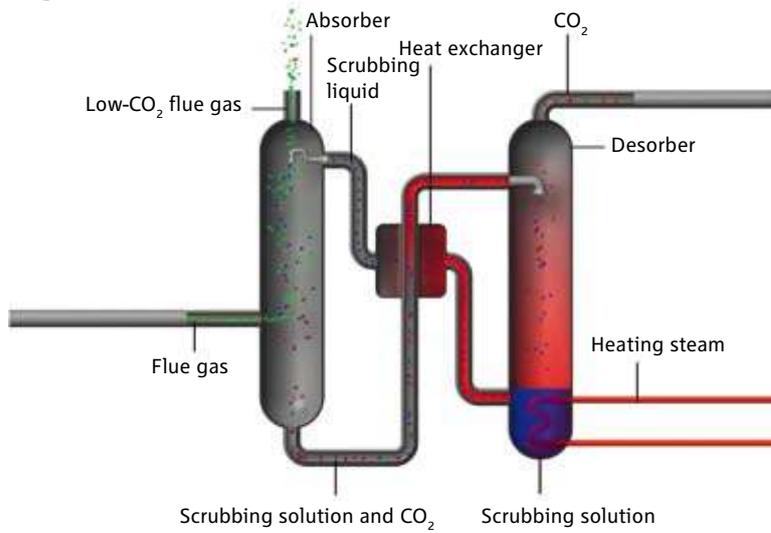


### How CO<sub>2</sub> scrubbing works

In the chemical industry, CO<sub>2</sub> scrubbing is a tried-and-tested method with which carbon dioxide has been produced for years, e.g. for the beverage or fertilizer sectors. In the energy industry, however, the process is new. CO<sub>2</sub> scrubbing kicks in at the end of the power-plant process, i.e. after

the flue-gas cleaning systems customary today. At the core of a CO<sub>2</sub>-scrubbing facility is an absorber containing a scrubbing liquid, e.g., a solution of amines (a group of organic substances) which takes up carbon dioxide at low temperatures and releases it at high temperatures. The cooled down flue gas flows through the absorber bottom-up and there encounters the scrubbing liquid which flows top-down, taking up the CO<sub>2</sub> in the process. The low-CO<sub>2</sub>

Illustration: CCS Werbeagentur

**CO<sub>2</sub> flue-gas scrubbing**

flue gas is sprinkled with water before leaving the absorber in order to remove scrubbing liquid residues; it then reaches the atmosphere via the cooling tower, whereas the scrubbing liquid saturated with CO<sub>2</sub> is fed into a so-called desorber where it is heated to approx. 120°C, which causes it to become detached again from the liquid; it is now available in high purity.

**The CO<sub>2</sub>-scrubbing pilot plant in Niederaussem**

The BoA unit at Niederaussem with its upstream WTA is ideal for testing CO<sub>2</sub> scrubbing under ultra-modern conditions. Within the scope of a cooperation scheme with the companies BASF and Linde, RWE Power is erecting a pilot plant here that is set to be commissioned in mid-2009.

At this pilot plant, all aspects of CO<sub>2</sub> scrubbing are to be trialled for 18 months under real power-plant conditions to examine their functioning state and gain experience for later commercial-scale systems. Mainly used here are improved CO<sub>2</sub>-scrubbing liquids from BASF and optimized process technology. One aim is to minimize the energy outlays for capturing the CO<sub>2</sub> from the scrubbing liquid. To operate the pilot plant, a small amount of the flue gas is diverted from the BoA unit (approx. 0.05 per cent) and fed into the pilot plant that has all the requisite technical facilities of a large-scale system. The height of the CO<sub>2</sub>-scrubbing pilot plant of roughly 40 metres is equivalent to a later commercial system, so that all important process-technology data can be precisely established. In the envisaged configuration, the pilot can capture up to 300 kilograms of CO<sub>2</sub> an hour which is equivalent to a separation efficiency of 90 per cent for the flue-gas amount processed.

The big advantage of the CO<sub>2</sub>-scrubbing process described is that power plants could be retrofitted with corresponding systems. RWE Power is designing all new coal-fired power stations to be built for a retrofit with CO<sub>2</sub> scrubbing.

For the CO<sub>2</sub>-scrubbing pilot project at Niederaussem, which is promoted by Germany's Federal Ministry of Economics and Technology, planning calls for spending of € 9 million, 40 per cent of which borne by the Ministry.

## RWE'S ALGAE PROJECT

The CO<sub>2</sub> that emerges during the combustion of lignite (and other fossil fuels) can be turned to good account, and with little environmental impact at that. One example of this is RWE's project for binding CO<sub>2</sub> by micro-algae in a pilot plant at Niederaussem that is unique in the world.

Micro-algae are single-cell or multi-cellular plant-like beings which need carbon dioxide to grow. Like all plants, micro-algae absorb CO<sub>2</sub> via photosynthesis, i.e. with the aid of light, but in doing so grow about 10 times faster than land-based plants. Micro-algae on land can be produced in open or closed systems, also using residential waste water or brackish water. For the facility, genuine fallow land can be used on which plants can no longer be cultivated. An increased growth rate can be achieved by the controlled addition of CO<sub>2</sub> using carbon-dioxide sources that have a higher CO<sub>2</sub> content than air. Hence, flue gases from power plants are ideal for producing algae. No costly separation of the CO<sub>2</sub> from the flue gas is necessary, since the flue gas can be used directly.

Before any large-scale micro-algae production can commence, however, the required technology still has to be tested in depth. For this purpose, RWE Power, in cooperation with experienced partners, erected at the Niederaussem power-plant location a facility for binding carbon dioxide from the power station's flue gases; it was commissioned by North Rhine-Westphalia's premier,



Dr Jürgen Rüttgers, in November 2008. In its final extension stage, the plant will occupy some 1,000 square metres. Here, the CO<sub>2</sub> contained in the flue gas is dissolved in an algae suspension and taken up by the algae for growth. The algae biomass produced is harvested, analysed and then examined for optimal conversion into an energy source, fuel or construction material, with a view to lowering CO<sub>2</sub> emissions.

### The plant

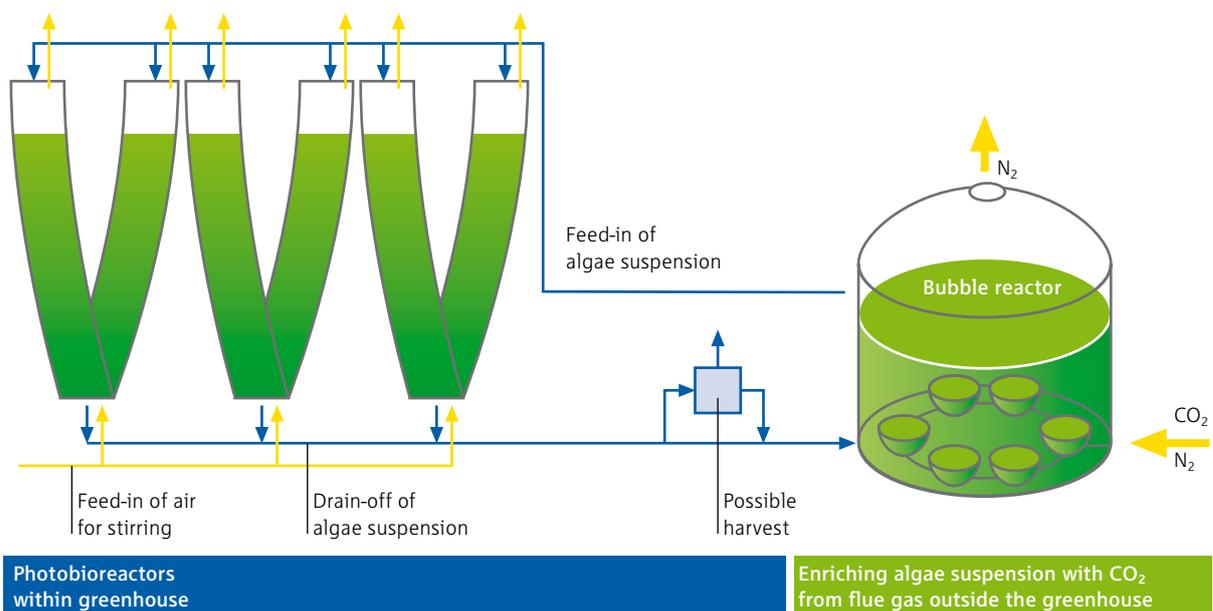
The process starts with the removal of flue gas from the Niederaussem power plant. The flue gas is diverted downstream of a unit's flue-gas desulphurization system (FGD), so that it is in a cleaned state when it is normally released into the atmosphere.

To ensure that the water vapour in the flue gas does not condense in the flue-gas pipe connected to the algae-production plant and clog the pipe, the gas is first cooled for drying and then compacted in a compressor. The flue-gas pipe is of plastic and some 750 metres long.

It ends in a premixing tank, the bubble reactor, next to the greenhouse of the algae-production plant. This tank contains the algae suspension, consisting of water with a salt content of max. 3 per cent and the micro-algae living in it. Mounted at the bottom of the bubble reactor is a nozzle base through which the flue gas flows into the tank. The flue-gas bubbles pearl through the slurry which takes up CO<sub>2</sub> in the process.

The flue gas liberated from some of the contained carbon dioxide reaches the atmosphere via a stack, while the algae suspension enriched with CO<sub>2</sub> is conducted to the greenhouse, in which optimal temperature conditions can be set the year round for the algae's growth. The heat required for this must have a very low temperature level, so that it can be made available in a climate-sparing fashion in the form of unused cooling-tower waste heat.

The algae suspension flows into numerous so-called photobioreactors, V-shaped transparent plastic tubes in which the algae can grow exposed to light. The micro-algae dissolve the CO<sub>2</sub> from the slurry and convert it via photosynthesis. Each photobioreactor contains approx. 30 litres of algae suspension, with small tubes continuously letting in slurry from the top, discharging it at the bottom and feeding it back to the bubble reactor. Optical density is measured to establish the algae share in the slurry. As soon as it is high enough, the algae can be harvested and used for other purposes. In this way, the algae-production plant in Niederaussem can process up to 6 tons of algae (dry matter) per year, binding 12 tons of CO<sub>2</sub>.



### The study programme

The first phase of the project is designed to investigate an increase in biomass yield using different algae cultures and improved greenhouse technology. Another aim is to minimize the energy outlays for the entire process to optimize effective CO<sub>2</sub> binding.

A further focus of the study programme is on the development of concepts for utilizing the algae. Among other things, this involves basic investigations into hydrothermal carbonization, a process to convert the algae biomass into energetically usable products, and into fermentation. Further promising conversion paths will be established for a follow-up project phase.

## RWE POWER'S CLEAN-COAL STRATEGY

CO<sub>2</sub> scrubbing and REAplus are components in the so-called clean-coal strategy which RWE Power is pursuing to make coal-based power generation clean and, hence, future-proof. This strategy, which is designed for the long term, follows ambitious climate-protection goals on three time horizons.

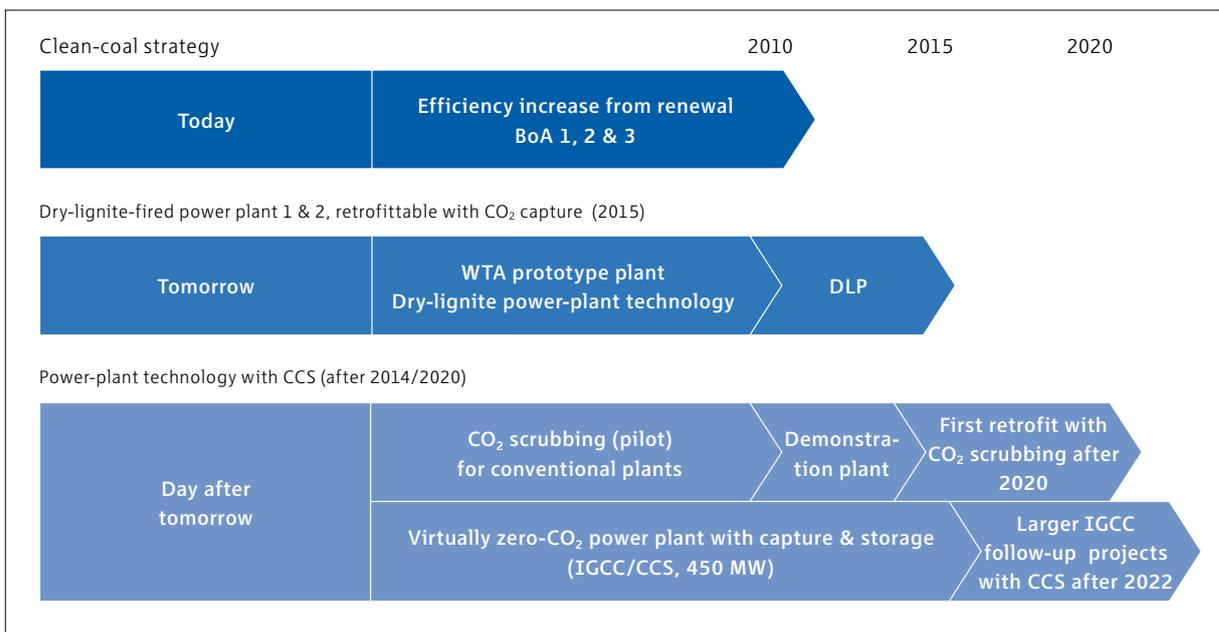
The projects in the first horizon involve those that are being driven forward now, specifically the renewal of RWE Power's power-plant fleet, involving the construction and deploying of modern, efficient BoA power-station units, as in Niederaussem (BoA 1) and Neurath (BoA 2 & 3, under construction). The increase in efficiency to 43 per cent obtained here alone saves 3 million tons of CO<sub>2</sub> per unit and year compared with old systems. To this must be added new, highly efficient hard-coal-based power-plant units at other locations.

The second time horizon stretches to about 2015 and comprises projects like lignite drying using WTA plants, e.g. the system at Niederaussem. Such plants are to be deployed later on a commercial scale in new power-station units and will bring a further gain in efficiency for the units concerned to some 48 per cent. Another project being pursued in parallel to fluid-

ized-bed drying within this time horizon is the so-called 700°C power plant. It involves using new materials for operating lignite- and hard-coal-fired power stations with hotter steam and higher steam pressures. Steam parameters of 350 bar and 700°C permit a rise in efficiency to about 50 per cent in the power plant concerned. The aim of both projects is ongoing better utilization of the fuel by having a lower coal input – and, hence, lower CO<sub>2</sub> emissions – while generating the same amount of electricity as old systems.

The third horizon is geared to the period 2015 to 2020. This is where RWE Power is definitely pursuing the most ambitious goal in its clean-coal strategy: the low-CO<sub>2</sub> power plant. Here, too, work is on two different technology approaches.

On the one hand, there is the already mentioned CO<sub>2</sub> scrubbing, which is being trialled technically at Niederaussem for the first time. This process is, as described, downstream of the power-plant process and is envisaged as retrofit solution for modern dry-lignite power stations, as at Niederaussem.



Much greater complexity is found in the second process, known as IGCC/CCS (Integrated Gasification Combined Cycle and Carbon Capture and Storage), which is to be translated into practice as a technological beacon project at the Goldenbergwerk location in Hürth, North Rhine-Westphalia. Here, CO<sub>2</sub> capture is not downstream, but a central component in the overall technical process. In coal gasification, after a further

interim step, a mixture of hydrogen and carbon dioxide is produced. It is easy to separate the CO<sub>2</sub> from this for compression and transport by pipeline to a storage site. The remaining hydrogen is combusted in a gas turbine, the heat driving a steam turbine in the downstream power-plant process. Alternatively, further conversion processes can also use the hydrogen to make synthetic natural gas or fuels, like crude oil or diesel.



## HAVE SHOVEL - WILL TRAVEL

Lignite is abundantly available in the Rhenish mining area, although it can only be extracted with great technical and financial outlays.

The coal seams, which measure 70 metres in places, are covered by even thicker overburden layers of sand, clay and gravel. The loose, yielding soil structure in the Rhineland makes lignite mining in opencast operations necessary, the most important tool being the bucket-wheel excavator (BWE). The total of 20 BWEs that RWE Power deploys in its three opencast mines are a central component in a highly developed, efficient extraction method that has proved its worth over the last 50 years and more.

After first removing the upper fertile soil layer consisting of loess and humus, followed by the overburden, the BWEs begin mining the exposed lignite. The biggest BWEs in the mining area are 240 metres long, just under 100 metres high and weigh 13,500 tons. Thanks to its electric drive with a converted HP of up to 21,700, such a mobile giant unit moves through the opencast mine around the clock and mines up to 240,000 bank cubic metres of lignite or overburden in one day. The coal first reaches the coal bunker via

kilometre-long conveyor belts on the opencast-mine terrain to be transported bit by bit using the Company's own heavy-duty railways to RWE Power's stations and upgrading plants situated between Grevenbroich in the north and Hürth in the south of the mining area.

The 500 million cubic metres or so of overburden extracted in the mining area every year are sent via the same conveyor belts to huge spreaders which backfill the material in the depleted areas of the three opencast mines. Immediately afterwards, RWE Power starts the sustainable recultivation of the used landscape. So the Niederaussem power plant was once within sight of the Fortuna-Garsdorf opencast mine. At one time one of the biggest mines on earth, we now find extensive fields, meadows and forest areas there today.

## OPEN FOR DIALOGUE – INFORMATION ON THE MINING AREA

If the need to use lignite is to be appreciated, but also accepted, you must provide broad-based information on both the benefits and the problems of this industry. For this purpose, RWE has set up, among other things, a visitor centre in the more than 400-year-old Paffendorf castle near Bergheim (Rhein-Erft county), which displays all aspects of lignite mining and lignite-based power generation.

Paffendorf castle and the Niederaussem power plant with its BoA unit are just two of nine stops on the “Energy Trail” which familiarizes cyclists and motorists with various features of power generation and reclamation. In addition, viewpoints and information panels have been installed at all opencast mines. Also, several times a year, the Company invites visitors on coach tours of the Garzweiler mine. RWE Power wishes to provide the most comprehensive information possible.

The aim is to obtain agreement on facts. Using these facts as basis, assessments can then be made. And if they differ, this need come as no surprise, given the multi-faceted nature of the subject.

We look forward to welcoming you!

Please check the Internet for opening times, route planners and further information at [www.rwepower.com](http://www.rwepower.com) (download brochures on the subjects of opencast mines, reclamation and lignite-fired power plants).

[www.innovationszentrum-kohle.de](http://www.innovationszentrum-kohle.de)

[www.braunkohle.de](http://www.braunkohle.de)

[www.braunkohle-forum.de](http://www.braunkohle-forum.de)

[www.forschungsstellerekultivierung.de](http://www.forschungsstellerekultivierung.de)

[www.strom.de](http://www.strom.de)

[www.paffendorf-erft.de](http://www.paffendorf-erft.de)

[www.rhein-erft-kreis.de](http://www.rhein-erft-kreis.de)

[www.rhein-erft-tourismus.de](http://www.rhein-erft-tourismus.de)





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