



CLIMATE-PROTECTION PROGRAMME

IGCC power plant with carbon capture and storage

WITH ALL OUR POWER: RWE POWER

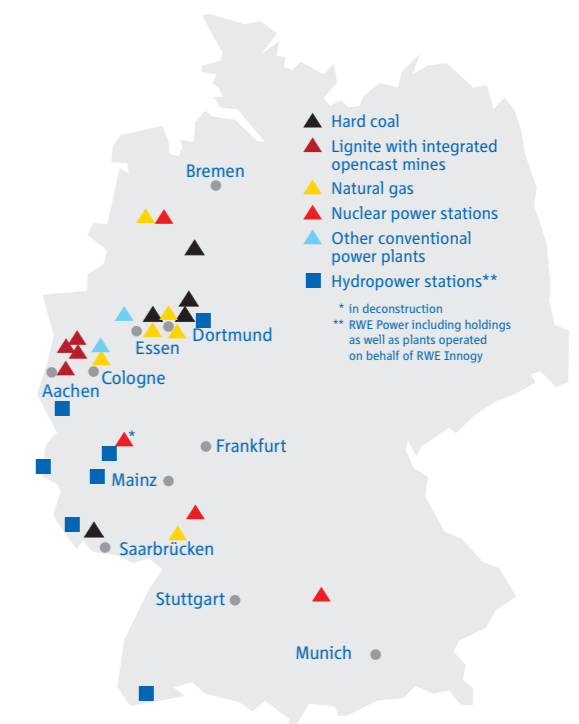
Energy is life. It is the nervous system of modern industrial society. We, the electricity producers in the RWE Group, do our considerable bit to ensure that the wheels don't stand still. We produce electricity and heat, and we extract coal – on a secure, economically efficient and environmentally sound basis. We are a global player today, although our roots lie by the Rhine and Ruhr rivers. We have traditionally had close links with the locations where we operate. That is because we have grown with the regions – and the regions with us. Our commitment rests on this identity. Here, we are talking more than just electricity and heat. As important employers and investors, we underpin economic growth and jobs. In numerous projects and in close partnership with the regions, we support the residents and the economy at our locations.

We assume responsibility for things big and small. So we are just as committed to the environment “on our doorstep” as we are to global climate protection. Being Germany's biggest electricity producers and No. 3 in Europe, we are proactively involved in designing concepts for the energy supply of the future. Our aim: to square the triangle of economic efficiency, security of supplies and environmental compatibility. We provide impetus – with our know-how, innovative technologies and substantial investment in ultra-modern power plants. We are continuously working on making power generation even more efficient, while seeking solutions to the worldwide problem of a rise in energy needs and the growing scarcity of raw materials.

We rely on a diversified energy mix: from hydropower via coal and gas all the way to nuclear energy. With

this balanced mix, we can create the best basis for long-term energy security.

Our power plants, with various output parameters, produce over 180 billion kWh of electricity every year. This enables us to cover some one third of Germany's electricity needs. A workforce of around 17,000 inside and outside Germany give their all for energy supplies in Germany and Europe. With all their power.



Cover photo: Today, a project. But by the end of 2014/the start of 2015, the world's first commercial-scale IGCC power plant with integrated carbon capture and storage is to become reality. The estimated capital cost of this forward-looking major project, a milestone in climate-friendly coal-based electricity generation, is approximately € 2 billion.

Illustration by CCS Werbeagentur

CLEAN-COAL TECHNOLOGIES: MAKING FOSSIL-FIRED POWER PLANTS MORE CLIMATE-FRIENDLY

Coal will go on being an indispensable energy source in the foreseeable future as well. Thanks to its ready availability, its relatively favourable price and the rising global demand for energy, its importance for our energy supply will even grow. This being so, generating power from coal must become more climate-friendly.

The increases in coal inputs must be squared with ambitious climate-protection targets. Avoiding CO₂ is a huge technological challenge: power plant engineering must find new ways to underpin a future-capable, i.e. sustainable, energy supply using clean-coal technologies.

RWE is spearheading this movement with innovations and unique projects. With investment running into billions in modern power plant engineering, we are making the use of valuable resources even more efficient, e.g. within the scope of our power plant renewal programme. However, the modernization of our power plant population is only one facet of our efforts to protect the climate – a task to which we feel committed, not least given our responsibility as a major CO₂ emitter. In the development of clean-coal technologies, we intend to blaze trails and are pursuing three development lines here:

- The centrepiece is the construction of the first large-scale climate-friendly power plant with integrated coal gasification (IGCC) plus carbon capture and storage (CCS). Using this technology, approx. 90% of the CO₂ occurring in the power-plant process can be captured and stored.
- RWE is also improving existing power plant engineering to lower CO₂ emissions thanks to increases

in efficiency while at the same time improving the prerequisites for CO₂ capture.

- The Group is developing concepts with which existing power stations can be retrofitted with climate-friendly technologies.

Our aim is to ensure that the world's first commercial-scale power plant with integrated coal gasification (IGCC) plus carbon capture, transportation and storage goes on stream as early as the end of 2014/the start of 2015. The costs of this future-gearred major project will run into some € 2 billion. RWE has already made € 1 billion available for this. With it, we are underscoring our claim to technological leadership in converting coal into electricity.

In parallel, we are doing research into components that will enhance the efficiency of the power plants going on stream in the coming years, i.e. ahead of the IGCC/CCS technology's maturity. The best examples of this are the first lignite-fired power station with optimized plant engineering (BoA), which started commercial operations at Niederaussem in 2003, and its follow-up project BoA 2 & 3, with a max. efficiency of over 43%, now being built in Neurath. All three together emit up to nine million tons less CO₂ per year than old lignite-based power stations. In the next generation, the efficiency is to be another four



WTA prototype plant for lignite-drying technology at Niederaussem

percentage points higher thanks to the use of dried raw lignite. RWE is perfecting the drying technology required for this in a demonstration plant for so-called fluidized-bed drying with internal waste heat utilization (WTA) which is set to be commissioned in 2008 as an in-house development alongside the Niederaussem unit. RWE is also participating in a series of research projects which, among other things, are testing components designed to withstand main-steam temperatures of 700°C. Higher temperatures would enable even higher efficiencies in coal-based power generation. Finally, RWE is working on solutions for retrofitting existing power plants, or those now being built, to make them climate-friendly: the development of so-called CO₂ scrubbing for conventional plants offers the perspective of retrofitting power stations with CO₂ capture. In the process, the CO₂-containing flue gas

from the power plant is conducted through an absorption liquid that takes up the CO₂. In a next step, the CO₂ is separated from the scrubbing liquid and can then be stored. A pilot plant for this, operated in cooperation with BASF and Linde, will be commissioned at the lignite-based Niederaussem power plant as early as 2009. The specific idea is to trial different scrubbing liquids. Another system is planned at a hard coal-fired power station of RWE npower in the UK. What is more, RWE is building all its new power plants capture-ready. This means that the prerequisites for retrofitting are in place.

Pilot plant for CO₂ flue-gas scrubbing in the BoA unit at Niederaussem



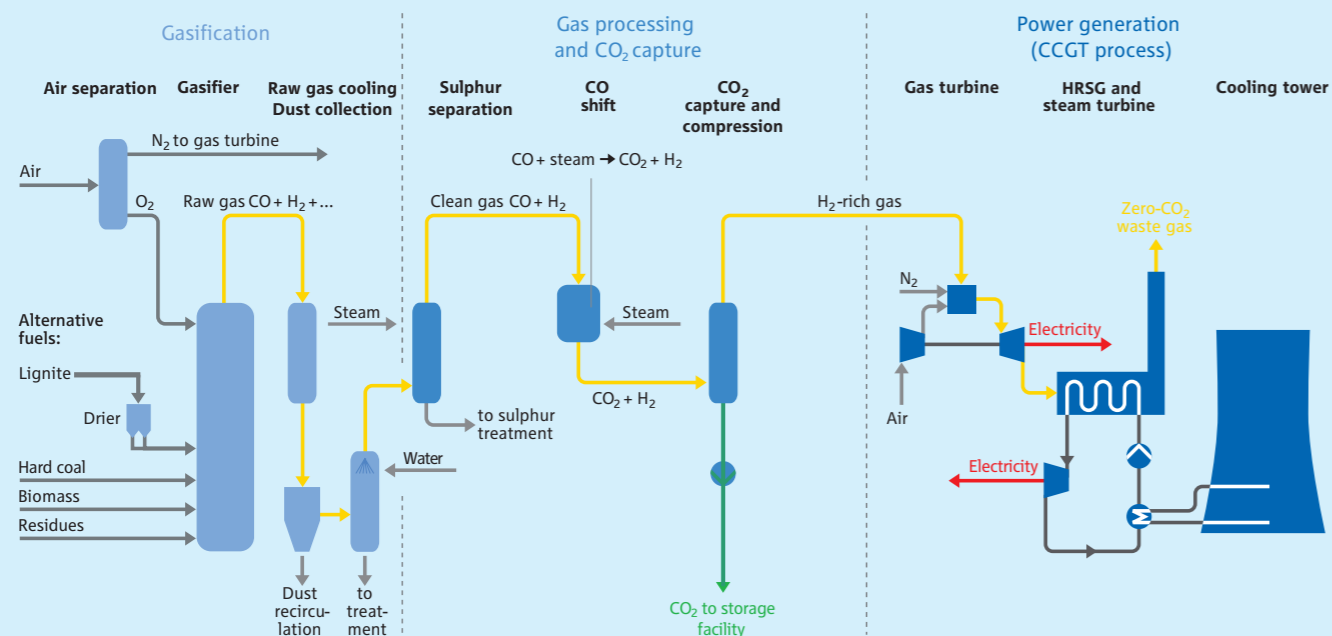
MILESTONE IN SUSTAINABLE CLIMATE PROTECTION: THE IGCC POWER PLANT WITH CARBON CAPTURE AND STORAGE

We are implementing the world's first commercial climate friendly power plant on a lignite basis with carbon capture and storage – and are in the vanguard of the climate-protection movement.

RWE Power is working in depth on innovative technologies to increase efficiencies and on an ecological optimization of fossil-fired power plants. We are vigorously driving forward our beacon project within the scope of clean-coal technology: the implementation of the world's first virtually zero-CO₂ coal-based

power plant with a gross output of 450 MW and integrated carbon capture and storage. It is to be erected at the Goldenberg site in Hürth near Cologne and fuelled with Rhenish lignite. This project secures local jobs and strengthens Hürth as an industrial location.

This is how the climate-friendly large-scale power plant with integrated coal gasification plus CO₂ capture and storage works.



RWE has the know-how needed to tackle the entire commercial-scale process chain for the climate-friendly power plant: from coal gasification for power generation and CO₂ capture, via pipeline transportation, all the way to storage. The Group company RWE Dea has more than 35 years' experience in the comparable technology of natural gas storage.

IGCC technology can be implemented on an industrial scale

In implementing the power plant, we are pinpointedly backing IGCC technology (Integrated Coal Gasification Combined Cycle). This is because, among all the options for power plants with carbon capture, IGCC technology is the only commercial-scale solution that is already available today. The technology is by no means new for RWE Power. In the 1990s already, it was the subject of in-depth research in the company. Then, increases in efficiency were to the fore. Today, we are further developing the IGCC technology owing mainly to the need to achieve long-term climate protection. The reason for this is that – unlike other methods – the CO₂ can be separated with relative ease in the IGCC process, and in addition, efficiency losses are relatively small.

In order to further develop our existing IGCC concepts for a climate-friendly coal-fired power plant, we have supplemented coal gasification and gas processing with process steps that enable particularly efficient CO₂ separation. Using this key technology, we are simultaneously opening up options to make other marketable products, like fuels, in addition to electricity (see page 9).

Technical data

| | |
|------------------------------------------|---------------------|
| Gross capacity | 450 MW |
| Net capacity | 320 MW |
| Stored CO ₂ quantity per year | approx. 2.6 mill. t |

Coal gasification plus CO₂ capture

In our IGCC process, lignite gasification is combined with CO₂ separation and the electricity generated in downstream gas and steam turbines. For this purpose, the coal is not combusted as in a conventional steam generator, but first converted into combustible raw gas in a gasifier at high temperatures and under a pressure of about 35 bar. This gas, whose main components are carbon monoxide and hydrogen, is then purified. In a next step – one that is crucial for preventing climate change – the CO₂ converted into carbon monoxide is separated and permanently and safely stored (see page 8).

The remaining elemental hydrogen is burned in a gas turbine which drives a generator to produce power. The emerging hot waste gases consist mainly of atmospheric nitrogen and pure water vapour; they are used to generate steam. The steam, in turn, drives a steam turbine and a second generator to make electricity. Because the electricity is generated in a particularly effective combination of gas and steam turbine, this power station principle is referred to as "combined cycle power plant".

TECHNOLOGICAL CHALLENGE: PERMANENTLY SAFE CO₂ STORAGE

Permanent and safe storage of CO₂ is a technically demanding task. We are facing up to it – with our own know-how and in cooperation with competent partners.

One of the key technological tasks that must be solved in implementing the IGCC/CCS power plant is the capture and permanent safe storage of the CO₂. The carbon separated in the power plant is then highly compressed and then hauled off by pipeline to the storage facility. In parallel, we are also dealing with options for increased, climate-compatible use and with conceivable bacteriological or photosynthetic conversion of CO₂.

Optimal storage conditions

For the permanent storage of the separated CO₂ underground various options lend themselves. Storage in geological structures is being investigated in depth at international level in scientific research schemes; in various major projects worldwide, practical experience has already been gained in underground CO₂ storage. The world's largest storage potential by far is offered by deep saline formations (see box). Also being considered are depleted former oil and gas deposit sites. The total storage volume in Germany is estimated by the Federal Institute for Geosciences and Natural Resources (BGR) to some 20 billion tons of CO₂. One possible storage facility could be in deep saline formations in Schleswig-Holstein, so that the CO₂ is to be transported to the north of Germany in a climate-protection pipeline some 530 km long at a depth of about 1.5 m.

Our own know-how and outside expertise

With RWE Dea under the same roof in the RWE Group, we have substantial expertise on tap in the exploration of oil and gas deposits and in the storage of natural gas. We use this know-how to implement CO₂ storage as a central component in our climate-friendly commercial power station. We plan to safely store some 2.6 million tons of CO₂ annually – a scale never before achieved. The implementation of CO₂ transportation and storage is a mission-critical part of the overall project for a climate-friendly coal-fired power plant. We wish to bring to full commercial maturity this bridging technology which is so important for achieving ambitious climate targets.

Protection of people and the environment has top priority here. This is true both of the planning for the pipeline route and in general of the transportation and storage of the captured CO₂.

Keyword: Saline formations

Saline formations are deep salt water-bearing sandstone layers which, thanks to their porous formations and the sealing cap rock, offer optimal conditions for the long-term, safe storage of CO₂. Owing to specific physical and chemical conditions, aquifers also have effective long-term retention mechanisms. In Germany, natural gas has been stored in saline formations for over 30 years now. The map gives an overview of their distribution.



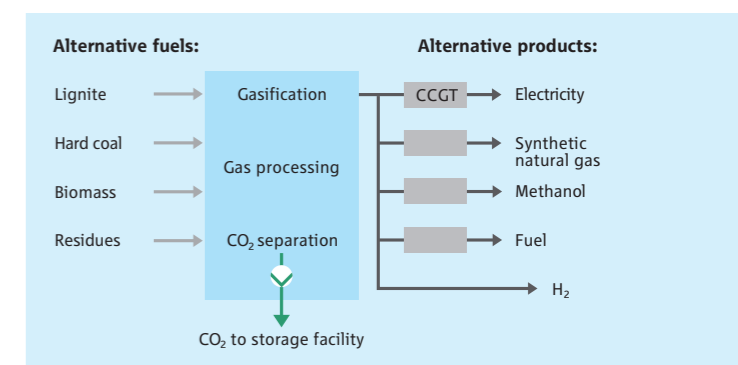
IGCC TECHNOLOGY: NEW PERSPECTIVES FOR SECURE SUPPLIES AS WELL

The technology of the IGCC/CCS power plant makes us flexible – in both input materials and final products. This allows us to tap new market opportunities, while making a contribution toward energy security.

IGCC/CCS power plants can be operated not only with lignite and hard coal, but also with biomass or residues. Worldwide, over 100 refineries and power plants are currently using tried-and-tested gasification technology to generate electricity.

Since the IGCC process produces synthesis gas as an interim product, various chemical products or motor fuels can be made in addition to electricity. The raw gas with its main components carbon monoxide and hydrogen is the basis both for energy carriers and for basic chemical materials and final products.

Hydrogen as an interim product of the IGCC process with CO₂ capture can be removed without any further process steps. This opens up the possibility of using it as a fuel in the transport sector as an alternative to power generation. Other products require additional conversion processes. If they are downstream of coal gasification and gas processing, the power plant can produce, among other things, methanol and synthetic natural gas (SNG), but also motor fuels like diesel and petrol. With the pinpointed conversion of lignite into gas, IGCC technology can also be an interesting



option should bottlenecks in oil supplies occur. The lignite deposits in the Rhenish mining area alone with 50 billion barrels oil equivalent – i.e. nearly 8 trillion litres – are roughly as high as the remaining energy reserves of crude oil and natural gas in the North Sea. So, by constructing and operating an IGCC/CCS power plant, RWE Power will be able to respond flexibly to new market opportunities that go beyond electricity generation. At the same time, this technology will also enable us to provide answers in the medium term to the problem of sustainable energy security.

IMPLEMENTATION: A JOINT TASK FOR INDUSTRY, POLITICS AND THE AUTHORITIES

Implementation of the climate-friendly coal-based power plant with carbon capture and storage by the end of 2014/the start of 2015 calls for huge efforts – and speedy planning and approval procedures.

With the construction of the world's first virtually zero-CO₂ IGCC/CCS power plant, we have set ourselves an ambitious goal in time respects as well. If the power station is to be commissioned at the end of 2014/ the start of 2015, the plant, the climate-protection pipeline and CO₂ storage must be pushed forward in parallel and technically dovetailed.

For the IGCC power plant in Hürth, the raw-material and site decision rings in a multi-year phase of planning, bidding and contract award. At the same time, RWE Power is seeking and solidifying partnerships with technology companies involved in the development of crucial components. The approval procedure for the power plant is set to commence in 2010. A decisive impact on the sequencing of the overall project will come from the planning and approval procedures for the climate-protection pipeline and the storage facility. The regional-planning procedure for the pipeline is to start in 2009. Simultaneously, rock formations suitable for

CO₂ storage will be explored in northern Germany. In order to connect the power plant with CO₂ capture to the grid on time, it is necessary to obtain clarity by mid-2009 especially about the legal and regulatory framework for CO₂ storage at national or, as the case may be, European level. Here we are counting on the support of policymakers and the authorities to meet the ambitious timetable. The overall project requires a huge financial commitment: investment needs total some € 2 billion. RWE has made available € 1 billion for the project. Without cooperation schemes with partners from business, and without research support, it will not be possible to implement the innovative project and to secure for Germany the pioneering role in this climate-protection technology.

CLIMATE-PROTECTION PROGRAMME: ACHIEVING AMBITIOUS TARGETS BY DIALOGUE

- At the G8 summit in Toyako, Japan, the eight most important industrialized countries adopted a resolution in July 2008 to halve CO₂ emissions by 2050. Beyond this, Germany intends to make a disproportionately high contribution toward achieving the EU target of lowering greenhouse-gas emissions by at least 20% by 2020 compared with 1990. RWE supports the federal government in the effort to reach these targets. For our comprehensive environmental-protection programme, we are making available funds running into billions in the years ahead.
- We are facing up to the task of driving forward the ecological optimization of power generation on a fossil basis. The IGCC/CCS process in coal-based power generation enables the indispensable coal to be used in a more climate-sparing fashion in coming decades as well.
- The centrepiece of our clean-coal activities is the commercial-scale implementation of the world's first coal-based power plant with carbon capture and storage, which we wish to switch live at the end of 2014/the start of 2015. Some € 2 billion

- will be invested in this forward-looking project. € 1 billion will be made available by RWE Power.
- The biggest technical challenge is the storage of CO₂. Implementation of this politically desired technology on a commercial scale is viewed by us as a joint task designed to prevent climate change. So, we expect constructive collaboration of policymakers and the authorities, the public and industry.
- With our plans for an IGCC/CCS power plant, we are aspiring to technology leadership and tapping export potentials for Germany. And we are making an important contribution on behalf of our economic location.
- In implementing this innovative and, in scale, unique project, we are counting on the cooperation of all those involved. Transparency, information and constructive dialogue are important concerns here.



Course of the IGCC/CCS* project



*Depending on the actual duration of the approval procedures.
RPP = Regional-planning procedure FPPP = Formal public-planning procedure

